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The Small Ruminant Collaborative Research Support Program in West Java, Indonesia: Small Farmer Technologies and Economic Returns to Investments in Research

Final Report

by

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The Small Ruminant Collaborative Research Support Program in West Java, Indonesia: Small Farmer Technologies and Economic Returns to Investments in Research - Final Report

Summary

In West Java small ruminants are raised by every fifth farmer, and they contribute between 15 and 25 percent to household incomes. Increases in productivity have an important impact on the welfare of rural families and consumers. Sheep act as a savings account and means to accumulate capital. Approximately 64 percent of West Java farmers have sheep, and 45 percent of the sheep of Indonesia are in West Java. Of the 62.5 million people employed in Indonesia, 35 million are in agriculture. Meat accounts for 25 percent of the protein consumption from non-plant sources. With positive growth in per capita income and population, red meat demand is expected to increase. Commercial fattening operations are starting to develop in the region, further increasing the demand for sheep. Development of tools (basic research, technology, human capital, institutions) will contribute to the economic welfare of smallholder families that raise sheep, especially women and children. This is essential for the development of an economic and social base that can sustain economic and political liberalization in the developing world, and can complement the process of structural adjustment, market oriented policies and free trade. All these facts show the relevance of small ruminant research.

The SR-CRSP was created in recognition that poor farmers in the developing world raise small ruminants as a complementary or sole source of income. Small ruminants are raised in marginal areas of the developing world where subsistence living conditions and high levels of risk persist. Assessing the SR-CRSP is a difficult task because traditional tools are not suitable to assess basic and development research, as well as human capital and institutional developments that are important products of this program. In a changing donor environment where short term impacts are expected, the products of long term research such as breeding are in question. The approach we take in this evaluation is to see if the products of short and medium term research, such as management, nutrition, and reproduction, can help finance basic research, genetics and training, which have longer term development impacts and adoption lags.

North Carolina State (nutrition), University of California, Davis (breeding), University of Missouri-Columbia (rural sociology) and Winrock International Institute for Agricultural Development (economics) from the United States, in collaboration with the Research Institute for Animal Production (RIAD) in the Central Research Institute for Animal Science (CRIAS), Agency for Agricultural Research and Development (AARD) of the Ministry of Agriculture in Indonesia participate in the West Java Prolific Sheep Component of the SR-CRSP, the area being assessed. Goals of the program concentrate on technological development that will increase the welfare of families that produce small ruminants, and human capital development through training and research. The program carried out research on-station and on-farm plus short and long-term training between 1981 and 1990 in West Java. Breed characterization and mode of

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inheritance of the prolific gene were determined in Javanese Thin Tail Sheep. Nutrition research focused on the development of feeding technologies, such as supplementation with tree legumes, agricultural by-products and minerals; and testing feed sources available to the farmer. The characterization of production systems, bio-social roles, and marketing channels and farmer strategies, as well as adoption and willingness to pay for technologies, were areas of research for economics and sociology.

On-farm testing through the Outreach Pilot Project (OPP) included management, reproduction, nutrition and marketing strategies, and the analysis of producer responses resulted in a technological package for small producers in a cut and carry system, that has been published in Indonesian, Javanese, Sundanese and English. Use of these technological packages increased yield by fifty percent. This report presents some of the accomplishments of the SR-CRSP in West Java Indonesia, and evaluates the impact of the OPP management, reproduction and nutrition package. An economic surplus model was used to evaluate the OPP and the SR-CRSP research in West Java. All program costs were considered. These included training of Indonesian and U.S. students, as well as research and travel costs in Indonesia and the U.S. They were discounted against the net benefits of the OPP technological package evaluated for West Java. The results presented do not include the benefits of the breeding program being developed by the SR-CRSP. A very conservative adoption rate (20 percent), with peak adoption reached in 12 years for West Java, gave an internal rate of return of 19.24 percent. A faster adoption rate (peak adoption of 20 percent in ten years) resulted in a 22.9 percent internal rate of return. If research spillovers of 19 percent to other provinces are considered, the return is 24.8 percent. The net present value of the latter, considering a 10 percent interest rate was $5,013,874. The distribution of the gains from research, given the market conditions, i.e. a responsive demand for meat, resulted in producers capturing a greater proportion of the surplus generated (77 percent) than that obtained by consumers.

The above mentioned returns do not include the benefits of human resource development, an important goal of the program. Indonesian researchers involved with the SR-CRSP received 23 graduate degrees, 12 at the M.S. level and 11 at the Ph.D. level. Of these, 19 were funded by the SR-CRSP. The four U.S. institutions of the West Java Research Component, funded training and/or graduate research for eleven U.S. doctoral students and fourteen U.S. master students. Research facilities constructed with SR-CRSP funding are being used by graduate and undergraduate students in the United States every year. Faculty experienced in research in developing countries prepare U.S. students for the global economy. Farmers in North Carolina are benefiting from hair breeds and crosses that are adapted to the climatic conditions of the U.S. South East. Seven producers have purchased 250 hair sheep for breeding stock and resistance to internal parasites. This evaluation shows that returns to the management, nutrition, and reproduction technological package finances the costs of basic research and human capital development, and that this technology will benefit both producers and consumers.

I. Introduction

The preliminary results of this project focus on the evaluation of production technology applied in a farming systems research setting, for smallholders in the rural area of Bogor in West Java. The analysis presents qualitative and quantitative information to assess the technology developed to manage small ruminants in a cut and carry system, and the institutional impact through training of scientists (short and long term training) in West Java. It also presents some information on the research investment by the government of Indonesia in small ruminant research. The Indonesian Small Ruminant Collaborative Research Support Program (SR-CRSP) is composed of four U.S. universities working in collaboration with the Indonesian Research Institute for Animal Production (RIAP).

Assessing Research in Indonesia and Other SR-CRSP Countries

There are several points that must be considered when assessing the impact of the SR-CRSP in the development of technology for small ruminants[1], especially because traditional research and development programs in agriculture are being questioned by donor agencies. A "new paradigm" based on the promotion of free trade, market oriented policies, democracy, private enterprise and structural adjustment programs, are forcing long term research and institutional development programs in agriculture to revise their agendas. Research projects are expected to produce immediate impacts in very marginal areas of the world where farming is often of a

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[1]Alan B. Durning and Holly B. Brough. "Taking Stock: Animal Farming and the Environment" Worldwatch Paper 103. July, 1991. "Livestock are also wise investments. On farms that raise animals with crops, livestock shield farmers' incomes from vagaries of the market and the weather. Their milk and meat provide supplemental cash, and if a crop fails, animals can eat the unharvestable plants. When the nearest bank is miles away, cattle become savings accounts. A six-year study os Lesotho found that investing in cattle earned farmers the equivalent of a 10-percent interest rate, while a bank account lost 10 percent because of inflation." (P. 8) "The world's goats and sheep, often disparaged as lowly and environmentally destructive, are actually a critical link in the poor's struggle for survival. Gandhi, for example, dubbed the goat the "poor man's cow." From meager rations, goats provide meat in more manageable quantities than cows, as well as milk, fiber, hides, and manure. They are also readily traded for goods or cash." (P. 9, op. cit.) Poor women's source of income in Africa and Asia tend to be sheep and goats.

subsistence nature, and for research to increase productivity one has to take into account the subsistence conditions of families, and the levels of risk are often very high. Moreover the research products are expected to result in long-term sustainable systems, both for the families and their environment.

Small ruminant research was based on the recognition that poor families in the world usually raise small ruminants as a complementary or sole activity. Important numbers of people, especially women and children, are involved in raising small ruminants. Traditionally they do not have access to government services and/or policy decision making[2]. The research program developed a series of long term goals that are in conflict with the short term goals of donor agencies.

The SR-CRSP, like most agricultural research projects, focused its efforts on research and institutional development. Experience has shown that this will not have a significant impact if the "macro environment" cannot absorb the research results. Developing the technology and institutions that will sustain research once the program has been completed, are among the goals of the SR-CRSP. Years of research and institution building will only be successful if mechanisms are in place to insure that farmers are part of the research process, and that institutions (government extension, non governmental organizations) have the resources for the development and adoption stages. The social science role in the SR-CRSP has focused on

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[2] It is important to understand what the mission of the SR-CRSP is, and what its expected role in Peru, Indonesia, Kenya, and Morocco was. A study of Peasant Dynamics in Latin America (Alain De Janvry and Steven Helfand The Dynamics of Peasant Agriculture in Latin America: Implications for Rural Development and Agroecology" Ch.8 in Agroecology and Small Farm Development) "Emergence of a dynamic class of "farmers" in Latin America is thus not a middle class phenomenon but a transformation of the old agrarian establishment into a class of modern large entrepreneurs which is able to monopolize the benefits of growth while peasants and middle farmers are increasingly marginalized from the market" Agriculture has been absorbing employment at a greater rate, because the rural population has not been able to find placement in the industrial sector. "A clear identification of the survival strategies of peasants and of their specific resource and institutional constrains is thus a meaningful research agenda for agroecologists" (P. 69)

participatory research, which is a crucial part of the research process, at the household and aggregate level. Understanding of markets, regulations and incentives, as well as the government's economic and social policies that are in place, need to go hand in hand with the biological research for the latter to be effective.

Evaluation of a program like the SR-CRSP presents a challenge that is not easily solved. Basic research, development research, and human resource development are a major portion of the SR-CRSP efforts. Research on breeding and animal physiology[3] have long time lags between conducting the research and using the knowledge for transformation into viable technologies. No immediate economic values can be determined. Their impacts will be known in the long run, ten to thirty years from today. In a donor environment, where short-term impacts are now expected, questions arise about the validity of long-term research and institutional development investments as a donor funded activity.

Management, nutrition, and reproduction research tends to have impact that is evident in five to ten years. In many cases the results of this research alone is enough to justify financing long-term research and training. Does this justify the existence of long-term research projects within these programs, that as in the case of breeding, may produce relevant results for future generations? These are some unresolved issues to keep in mind so that economic impact assessments can be put into perspective. Impact assessment answers some questions, but not necessarily all the relevant ones.

Background to Small Ruminants in Indonesia

Small ruminants are an important complementary activity in densely populated areas of Indonesia such as West Java, and are of potential use in other regions of the country, like Sumatra, where

[3] The SR-CRSP is involved in the development of the Kenyan Dual Purpose Goat, prolific sheep and hair sheep in Indonesia, and prolific sheep in Morocco, and has contributed to knowledge of alpaca reproduction and diseases with basic research in Peru. Civil unrest in Peru did not permit the testing of small ruminant technologies on-farm, making it very difficult to predict the type of adoption patterns that might take place.

they are currently being promoted. Small ruminants provide between 15 and 25 percent of the family income in these regions. One out of every five farmers in Indonesia has small ruminants. There were 1,317,929 households raising sheep in Indonesia in 1983, with 841,025 of them located in West Java where the SR-CRSP worked from 1981 to 1989. In a developing country with rapid population and income growth, demand for red meats is expected to increase. Small ruminants are a source of protein for consumers and act as a means through which income is redistributed from urban areas to the rural population. All these factors point to the relevance of small ruminant research, and the contribution that the SR-CRSP can make to Indonesia and other countries in Asia that have similar production conditions.

Structure of this Report

This report will assess the West Java Prolific Sheep Research Component. This component has several sub-projects, including breeding, nutrition, economics and sociology; and a farming systems project to test and develop technologies for small farmers, the Outreach Pilot Project (OPP). This report will present an overview of the research done by each project of the West Java research component of the SR-CRSP, and will concentrate its present evaluation on the benefits of technologies developed and tested on reproduction, and management and nutrition in the OPP. The benefits of these components will be the only ones considered in the present report. The benefit stream from training and institutional development, and those from breeding research will not be included. The costs considered will be all those incurred by U.S.AID-SRCRSP funds in the Indonesia Program in West Java (research and training) and all the costs of research in the U.S. by each institution[4]. Part II presents a description of the Indonesia Program and the research projects. Part III contains the review of the literature on economic impact assessments and economic returns to research, concentrating on developing country literature. Part IV presents the methodology chosen to calculate the returns to research, the information and data used in the evaluation and the results and impacts found. The costs of

[4] All the U.S. institutions working in Indonesia worked in 1-3 additional countries. All U.S.-based costs by these institutions was attributed to the Indonesia program which further overstated overall program cost. A correction was made to add the costs of four full time Indonesian scientists whose salaries were paid by RIAP.

research and training, as well as the people trained, and investment in research by the Indonesian government on small ruminant research after the component phase-out is presented. Part V presents information about the research component collaboration, institutions involved, and researchers that participated in this project. Part VI presents sources of funding for this project, and part VII discusses the future impacts that this component could have.

II. The SR-CRSP in Indonesia: Technological Progress and Institutional Development

Indonesia in Numbers

The population of Indonesia in 1989 was 179 million, with an average per capita income of $430. Approximately 62.5 million people were employed in 1985, of which 34.2 million were in agriculture, 9.3 million in commerce, 8.3 in public services, and 5.8 million in industry. Oil is one of Indonesia's main exports. Mining is also important, employing 425 thousand people. In 1988 41.7 million tons of rice, 15.2 millions tons of cassava, 6.2 million ton of maize, and 20.8 million tons of sugar cane were produced. Coconuts and copra yielded 12.8 million tons, soybeans 1.3, rubber 1.1, coffee 0.4, vegetable 3.2, fruits 5.6, tea 0.144, and tobacco 0.147 million tons, respectively. Livestock being raised in the same year included 6.5 million cattle, 3 million buffaloes, 722 thousand horses, 5.4 million sheep, 12.7 goats, 6.5 million pigs, and 439 million poultry. The forest area represents 67 percent of the land. Increasing exports outpaced imports between 1985 and 1989, ending with a positive balance of trade. Gas and oil, forest products, manufactured goods, rubber, coffee, fisheries, copper, tin, pepper, palm products, and tea are the main exports. Japan, USA, Singapore, Germany, Australia, and The Netherlands are the main destinations for Indonesian exports. Imports come primarily from Japan, USA, Singapore, Germany, Australia, Taiwan, China and France.

Current and Potential Demand for Small Ruminant Meat

Changes in meat demand in Indonesia take place through income and population growth, changes in meat prices, or the growth of exports due to demand from other countries. A study that reviews the Indonesian marketing system for small ruminants[5] shows strong demand projections for red meats (including sheep and goat). Dramatic increases in the demand are typical during Idul Adha, an Islamic Holiday. Prices double and can triple during this period. In the case of

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[5] H. C. Knipscheer, M. Sabrani, T.D. Soedjana and A. J De Boer "The Small Ruminant Market System in Indonesia: A Review" In Agricultural Systems 25(1987) 87-103.

Indonesia there is a potential demand from the Middle East, because the demand requirements are the same; good quality rams, males that are not castrated[6]. This is not the standard characteristic of mutton produced in other parts of the world.

Meat accounts for 25 percent of protein from non-plant sources for consumers in rural areas. Consumption of all meat in 1983 was 4.32 kg per capita, which is low, indicating a potential for increase (Knipscheer et al. 1987) At that time only ten percent of the meat supply was provided by red meats. An increase in income[7] should induce an increased consumption of red meat, and simultaneously help transfer income from consumers that have high incomes to the animal producers that are usually poor.

Concentrating research on small ruminants targets two government goals; the first being self-sufficiency in red meats, and promoting exports; and the second is helping the poor in densely populated areas as well as creating additional income incentives (by raising sheep) in the transmigration areas such as North Sumatra.

Of the total meat production in 1983, 9.5% was from sheep and goat combined. Price trends according to Knipscheer et al. (1987) also show strong demand for red meats. Red meat prices tripled between 1977 and 1982, and the differential between this and poultry prices is increasing. From the average 1986-1988 meat production that includes beef, mutton, and poultry, 10.17

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[6] Estimates of demand for 500,000 head of small ruminants in Middle Eastern countries (Saudi Arabia for the Idul Ada festival) is mentioned by Soedjana, T. "Economics of Raising Small Ruminants" Ch. 8 in Goat and Sheep Production in Indonesia, Book manuscript. ed. Wodzicka-Tomaszewska, et al.) Limitations with respect to export of live animals and meat processing for exports exist at the current time.

[7] Income elasticity of demand for meats in Indonesia was estimated by several authors. Sabrani's estimate from time series data in 1979 was 2.08. Mutton estimated by Chernichovsky and Meesook in 1984 from cross section data was 1.2. Other elasticities are also quoted in Knipscheer at al 1987. J.S. Sarma "Cereal feed use in the third world: Past Trends and Projections to 2000", 1990 estimated the income elasticity of mutton to be 1.6 in the third world in general.

percent is from goat and mutton according to the Indonesian Central Bureau of Statistics. In 1987 the estimated population of sheep in the country based on the national household survey (SUSENAS) was 5,364,000 head. Of these, 2,423,318 sheep were in West Java, and 1,248,834 were in Central Java. Meat production in this region, according to estimates developed by the Indonesia Study AARD-ISNAR[8] shows meat supply in West Java growing from 8,096 metric tons in 1983 to 10,264 metric tons in 1988, a 27 percent growth in 5 years.

The population of Indonesia has grown from 147,490,298 people in 1980 to 179,136,110 in 1989. The annual population growth rate is estimated at 1.8%[9]. Currently all production is consumed domestically. There is ian ntention to promote exports, although this will require a change in government regulations.

The potential increase of sheep supply in West Java depends on two different sources: the first is improvement of the management of existing sheep with alternative nutrition, management, reproduction and health practices. The second source of increase is by adjusting the prolificacy of sheep to the feed sources available. This allows for a reduction in mortality, especially at lambing and before weaning, and increasing survival rate and weight at lambing which is positively correlated with weight gain.

Small Ruminant Production in West Java

"Most sheep and goats are raised by smallholders in highly intensive, crop/livestock production systems with a herd size rarely exceeding five head. Larger herd sizes are found in areas where dry land farming is practiced."[10] The Javanese Thin-Tail (JTT) sheep is found in West Java.

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[8] Indonesian Agricultural Research Priority Project, Dr. Philip Pardey. International Service for National Agricultural Research.

[9] International Financial Statistics Year Book, 1991 and Winrock International Project Profile "Indonesia Economic Analysis of Small Ruminant Production and Marketing Systems" April 1991.

[10] Partners in Research: A five year report of the Small Ruminant Collaborative Research Support Program ed. by R. D. Blond. p. 56. 1985.

Important crops in the region are rice, coffee, tea, cocoa, rubber, spices and intensive vegetable production systems. "The relatively poor productive performance of sheep and goats in Java suggests that there is ample room for improvements even within the context of the smallholder system."[11] Cirebon (low-land, rice producing along north coast), Garut (highland, mixed crop system), Ciburuy (intermediate elevation, near large rubber plantation) were the field worksites of the SR-CRSP in Java.

Sheep in West Java are raised in either a zero-grazing or cut and carry system. Most of the sheep in these agricultural areas are in barns with raised floors. The average farmer has five to six animals. Feed resource is a constraint imposed by the ability of the farmer to collect feed and by the size of the farm. About 30 percent of the feed comes from off-farm sources. Feed is composed of grasses (80% in Garut), tree leaves (8.5% in Garut), and agricultural by-products (9%, rice and bean straw, cassava and corn leaves in Garut) and shrubs (2%) (Suparyanto et al.[12]). The average litter size is high at 1.7 lambs per parturition, but mortality rate is also high when triplets and quadruplets are born. Daily weight gain of pre-weaned lambs is 96 grams, and 51 grams for weaned lambs. Lamb weight at birth is an average of 2.7 kg., 5.7 kg. at 30 days and 8.7 kg. at 60 days. Weaning usually takes place at about 90 days at an average weight of 11.3 kg.

Raising sheep is a family activity. Women's labor accounts for 46 percent of the production activities. Grass is cut and fed to animals twice a day. Selling and buying animals is a male activity. Women have a higher participation in livestock activities when the household is poorer, and can spend up to 2.5 hours collecting forage, and taking care of both crop and livestock, and instructing their children on these activities. (Wayhuni, "Social Structure of Small Ruminant Farm Facilities", Blond, R.D.).

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[11] Ibid.

[12] "Sheep Raising practices in Indonesia" by Agus Suparyanto, I.W. Mathius, and Dwi Priyanto in "New Technologies for Sheep Production in West Java, Indonesia".

On average, there are 14 rams per 100 ewes in West Java, or one ram per seven ewes. In many cases rams are borrowed for the mating season. Puberty of the animal in Java is reached at six to eight months. Males reach a weight of 14.5 to 18.9 kg. Females reach a body weight of 16.8 to 24 kg. Single lambs seem to reach puberty faster. The lambing interval that is considered optimal is 240 days. High mortality rate is a problem. Lambs weaned per ewe per year is approximately 27 percent, far from the potential of 110 percent. Estimates of actual and potential productivity are developed by Ruth Gatenby et al.(1988)[13] Actual is the productivity at the village level and potential is the one obtained at the research station. Table 1 shows these productivity coefficients.

Pre-weaning mortality varies from 5% to 39%. Creep feeding to increase the survival rate should be introduced between the second and third week (Tiesnamurti). Insufficient milk is a problem associated with lamb mortality. High pre-weaning mortality is due to high mortality at birth and during the first month. JTT from Garut produced 3.37 lambs per dam per year, and weaned 2.14 (Tiesnamurti). JTT sheep in Bogor produced 2.84 and weaned 2.14. Improved feeding and management practices can reduce lambing interval and reduce pre-weaning lamb mortality.

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[13]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 Tech. Report No. 97.

Table 1

Actual and Potential Productivity Coefficients for Javanese Thin Tail Sheep

	Actual	Potential	Ratio
Litter size (no.)	1.4	1.8	0.78
Lambing Interval (days)	520	240	0.46
Age first Lambing (days)	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	0.69
Weaning rate (per year)	0.73	2.32	0.31
Productivity per year %	27	110	0.29
Average growth (g/d)	87		
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 Tech. Report No. 97.

The SR-CRSP Research Project in Java

The SR-CRSP is a joint effort between the Republic of Indonesia and the United States Agency for International Development (USAID), and U.S. Universities. The program concentrated in West Java during the first nine years. The collaborative effort on the U.S. side was carried out by four institutions involved in research and institutional development in four disciplines: genetics and breeding by University of California, Davis; nutrition by North Carolina State; economics by Winrock International Institute for Agricultural Development; and sociology by the University of Missouri-Columbia. The counterpart institution is the Research Institute for Animal Production, (RIAP) or Balai Penelitian Ternak BPT within the Central Research Institute for Animal Science (CRIAS) part of the Agency for Agricultural Research and Development (AARD) of the Ministry of Agriculture. The management entity is the University of California, Davis. The research goals, objectives and results for the four disciplines and the Outreach Pilot

Program (OPP) are presented. Only the research developed in West Java is included.

Genetic Improvement of Sheep and Goats for Smallholder Production

This project is carried out between University of California, Davis and the Research Institute for Animal Production.

Objectives of this project are now set out:

"Improving genetic potential of livestock in production traits is generally an efficient and highly cost-effective method of improving productivity, especially in populations not recently subjected to selection for performance. Genetic improvement can be effected with no new inputs other than some simple records, and in some cases, with no changes or only modest changes in management. While gains per year are relatively very small, they are cumulative and permanent."[14]

Initial goals:

a. To establish research capability on small ruminant breeding in Indonesia in order to identify those traits most in need of genetic improvement.

b. Initiate genetic improvement programs and assess the merits of selecting within local breeds and types vs. introducing new germ plasm through exotic breeds.

c. Long term goal is to initiate genetic improvement programs adapted to local needs.

"Because genetic improvement is a long-term undertaking, it must be continued well beyond the life expectancy of any specific aid program if it is to realize its full potential for increasing productivity. Training of host country personnel to enable them to carry on the work following termination of the SR-CRSP is therefore an integral part of this project plan." [15]

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[14]p.58 "Genetic Improvement of Sheep and Goats for Smallholder Production" by G.E. Bradford in Partners in Research A five year report of the small ruminant collaborative research support program ed. by R.D.Blond

[15]Ibid.

Specific objectives set by the breeding project are the following:

1. Characterize reproduction and growth rates of Indonesian sheep and goats to identify constraints to production and potentials for genetic improvements under experiment station and village conditions.
2. Investigate Javanese Thin-Tail prolificacy and identify desirable and undesirable effects on management and productivity.
3. Training.
4. Information base development for improved small ruminant production practices.

Accomplishments:

Subandriyo, Inounu and Sitorus have studied the high prolificacy of the JTT sheep, finding that litters of 3 and 4 are very common and litters of 5 and 6 occur rarely. Also a higher incidence of single births than expected were found. High variability of litter size and high mortality rates in large litters (Inounu) was found while growth rates were low.

Extreme variability presents management problems because feed requirements vary according to the number of lambs being carried by the ewe. Efficient utilization of the high prolificacy trait requires that producers have a high proportion of ewes producing 2 or 3 lambs. When feed is a limiting factor one would want ewes that rear no more than two lambs. Efforts to identify the prolificacy gene have been successful, but at present it requires three lambing cycles for ewes and three years for the progeny tests to identify rams that are homozygous and that do not carry the prolificacy gene.

"Controlling this variability, which is almost certainly genetically determined to some extent, requires that we know the mode of inheritance of litter size in these sheep. Litter size is generally inherited as a quantitative trait of low heritability, which means that it can be changed by selection, though rather slowly."[16] Ovulation rate sets the limit to litter size.

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[16]Ibid, p.59.

A related productivity problem is the long interval between parturitions, relative to achievable lambing intervals of 8 to 9 months (Bell and Inounu). Failure to mate ewes seems to be the problem, probably because of few rams and lack of rotation. A ram rotation scheme has been developed to help overcome this problem.

Economic Significance of Findings

By reducing the lambing or parturition interval from 15 to 9 months, lamb production per unit of feed fed to each ewe would increase approximately 58 percent. Inounu obtained mortality figures of 16.7, 18.4, 35.5, 42.9 and 60 percent for lambs born in litters of 1, 2, 3, 4, and 5 respectively. This gives 133 lambs from 100 ewes. Gains from reducing variability of litter size were approximately 16 percent (Blond, 1985). This reduced variability in the litter size translates into reduced variation in birth weights and weaning weights. Determining the mode of inheritance of this trait is required to achieve this improvement. Work concentrated on native sheep breeds, the process of inheritance of prolificacy, nutrition, and growth rate studies on lambs and by species.

By 1986-87 the breeding project was involved in:

1. Studying the inheritance of prolificacy and other traits in Javanese sheep at the Cicadas Station, West Java.
2. Comparison of performance of hair sheep, local sheep and crosses grazed on rubber plantations in North Sumatra.
3. Evaluation of the performance of sheep and goats and of farmer acceptance of animals of different genetic potential in villages in West Java Outreach Pilot Project (OPP).
4. Estimation of genetic differences among populations of sheep and goats in different parts of Indonesia.
5. Studies of dairy goat crosses at the Cilebut Station, West Java.

The Cicadas project had difficulties in the gene carrier study and no conclusions were reached. New testings were done (Tiesnamurti). Breeding started taking a more active role at the OPP working on record collection, mating plans, and farmer attitudes towards sheep and goat.

A criterion[17] was identified to distinguish the F^jF^j (high prolific) trait from the + + (low prolific) trait. The objective is to develop two lines, a highly prolific line for rams and a standard line. The most important achievement stated was the development of a criteria for identifying homozygous (F^jF^j) ewes[18]. Sheep were transferred to the Bogor RIAP research station in 1990, to study the means of controlling the prolificacy of the JTT in order to reduce the high mortality rate of large litters[19]. Research at Cicadas lead to identification of a single gene as the main genetic determinant of the variation in prolificacy. Lines of high and low prolificacy have been developed to isolate gene carriers and determine their genotypes.

The production potential of the Javanese sheep was evaluated in 1989. The following are lambing performance results. The overall lambs per ewe lambed was 1.8, while per ewe available was 1.54. The distribution is the following: high dams (F^JF^J) 14, medium dams (F^J+) 30, and low dams 80. Low dams (+ +) yield 1.39 per ewe lambed, and 1.07 per ewe available. Eight months between lambing interval are obtained at research station facilities.

Weight changes of ewes during gestation were found to be determinant for birth weight and survival rates. The potential for lambing output and survival in research stations is greater in Bogor than Cicadas. Total output and survival for litters of 1, 2, 3, and 4 lambs is presented

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[17] The 1989-1990 Annual Report.

[18] Setiadi, B. and L. Iniguez. 1990. Reproduction performance of small ruminants in an on-farm research evaluation of village farms in West Java. Working Paper, SR- CRSP, Bogor.

[19] Sheep Prolificacy SR-CRSP CRIAS and RIAP, Progress Report 1990-1991, Bogor, July 1991.

in table 3 of the 1991 Bogor July Sheep Prolificacy Progress Report (Inounu and Iñiguez[20]). Feeding trials on gestating ewes, and litter and individual lamb weights in the research station with supplementation are reported[21].

According to Inounu, et al. (1991), "High prolificacy is a condition that significantly compromises the physiology and production performance of ewes and their lambs. Larger litter size imposes a serious challenge for ewes during pregnancy and lactation and eventually translate into poor ewe body condition and (or) low birth weights for their lambs. These, in turn, may result also in an increase in embryonic losses and perinatal mortality, as well as lower pre-weaning growth rates. The biological and economic implications of high prolificacy in the populations of Javanese sheep have not yet been thoroughly assessed."

Some conclusions on what effects performance of ewes: first, lambing performance has little merit in classifying Javanese sheep carriers of the postulated gene for prolificacy. The high prolificacy line had the lowest survival rates during all nine years of the study. There is a need to ensure better conditioning of ewes at lambing. An observation was made; lamb survival rate at Cicadas was lower than on small-holder farms, implying that there is a management project that needs more study before defining optimum litter size level and optimum genotype (P. 18, op. cit.). High prolificacy led to poor body condition to support lactation and therefore to critically lower lamb birth weights. Recommendations were given for the nutrition and management project to concentrate on these problems to compensate for this effect.

"A single gene affecting ovulation rate and litter size has been identified in the Javanese sheep

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[20] "Sheep Performance at RIAP's Bogor Research Facility (1991) by Ismeth Inounu and L.C. Iñiguez. in Sheep Prolificacy Annual Progress Report 1990-1991. Bogor.

[21] Some breeding research is being carried out in Bogor by the SR-CRSP.

(Bradford, Quirke, Sitorus, Inounu, Tiesnamurti, Bell Fletcher and Torrell).[22] Tiesnamurti and Iniguez worked to identifying the low prolificacy and high prolificacy sheep with different types of experiments. DNA research is currently underway.

Two prolificacy lines, high and low, can be used with two different management levels, with optimal strategy defined by the amount of resources available. Kilograms of lamb per ewe is the criterion for optimum litter size and is equal to litter size. This is multiplied by the survival rate where ninety days weight = kilograms of lamb per ewe. When lower levels of feeding and management exist, farmers are better off with a litter size of one or two. Total kilograms of lambs weaned per ewe in different management system[23]. The ++ is recommended in the average scenario of Java.

Table 2

Type of Management According to Prolificacy Trait in Javanese Thin Tail Sheep

	Average Quality Forage			Good Quality Forage + Concentrate		
Litter size	**Survival rate**	**90 day weight**	**Kg Lamb per ewe**	**Survival rate**	**90 day weight**	**Kg Lamb per ewe**
1	0.82	12	9.8	0.90	15	13.5
2	0.70	9	12.6	0.85	13	22.1
3 or >	0.40	7	8.4	0.75	11	24.8

Source: L. Iñiguez, E. G. Bradford and Subandriyo, "Basis for a Program of Sheep Genetic Improvement in West Java" Small Ruminant CRSP Working Paper 131, Dec. 1991.

[22] Bradford, Quirke, Sitorus, Inounu, Tiesnamurti, Bell Fletcher and Torrell. "Reproduction in Javanese sheep: evidence for a gene with large effect on ovulation rate and litter size." J. Animal Science (63): 416-419; and Bradford, Inounu, Iniguez, Tiesnamurti and Thomas. 1990 "The Prolificacy gene of Javanese sheep." in J.M. Elsen (ed) Proceedings of a Workshop on Major Genes for Reproduction in Sheep, July 16-18, 1990 France, quoted in "Effect of PMSG injection on ovulation rate of puberal Javanese sheep" by Bess Tiesnamurti.

[23]Bess Tiesnamurti "Utilization of High Prolificacy in Javanese Thin Tail Sheep" p. 96 in "New Technologies for Sheep Production in West Java, Indonesia," (draft "techpack" for SR-CRSP and RIAP, December, 1991).

A breeding plan for smallholders and large scale production has been proposed by the SR-CRSP and RIAP that will entail the participation of different types of organizations. Since RIAP is a research institution the extension links need to be established with the Directorate General of Livestock Services and other non governmental organizations, and through CRIAS, which has a research-extension linkages project. A plan for different prolificacy lines according to the resources available is defined, and the breeding program proposed. A basis for a program for genetic improvement was developed by Iñiguez, Bradford and Subandriyo.[24]

Nutrition and Feeding Research Systems

This project is carried out through the collaboration of North Carolina State and RIAP. The nutrition research in Java has concentrated in three areas. The first line of research is evaluation of both traditional and alternative feed resources to replace the diminishing supply of local grass. Legumes as a protein source and cotton seed as a concentrate are some examples. The second area studied is mineral deficiencies in sheep and supplementing with these trace minerals[25]. A third area of research is developing the nutrition requirements in tropical regions for small ruminants, because mature ewes in Indonesia weigh 30 kg, while in the US they weigh 50 kg. Two different sets of requirements are being developed, those for prolific sheep and for those that only have one lamb. The objectives[26] of the nutrition project are to identify what kind of materials are used as feeds in villages, find the productivity of animals related to feed quantity and quality (analysis of crude protein, cell wall fiber constituents, important minerals, and in vitro digestibility of the dry matter and fiber).

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[24] Iñiguez, L., E.G. Bradford and Subandriyo. "Basis for a Program of Sheep Genetic Improvement in West Java" Working Paper No.131, Univ. of California Davis, December, 1991.

[25] A technology developed is a piece of bamboo into which the minerals are introduced and the animals use it as lick. This technology was tested in the OPP.

[26] Source is W.L. Johnson "Nutrition and Feed Systems Research" in Partners in Research.

Some findings:

a. A baseline survey of 374 families showed differences in feeding practices. In Garut (highland) only sheep in confinement were kept while in Cirebon (low land) sheep primarily graze. Ninety-five percent of farmers use native grasses, 28% banana leaves and 18% cassava leaves (Djajanegara et al, 1982).

b. Village monitoring results : The three sheep production systems monitored were Garut upland (sheep in complete confinement), Cirebon coast(sheep graze rice stubble) and Ciburuy large estate crop(grazing in rubber plantations). "Results indicate that the most important constraint to flock size is the amount of fodder a farmer and his family can collect daily. If increases in animal performance are important, improvements in feed quality rather than quantity will be necessary".[27] Crude protein levels increased during the wet season. Additional supplementation is not a common practice.

c. Growth trial of JTT sheep with different feeds showed that Gliricidia, wilted and fresh, is preferred by animals. Weight gains and dry matter intakes were higher. Cassava, a common cash crop throughout West Java, has palatable foliage high in crude protein. The roots are a highly digestible energy source, but have little protein. Lambs initial weight averaged 11.6 kg. Weight gain with gliricidia for six weeks is 107g/daily, intake per kg of weight of DM is 63 g gliricidia.

Significance of this research: Crude protein levels of village diets for small ruminants seem appropriate while digestible energy intake appears to be a limiting factor in villages. Probable causes of the low degestible energy is a high content of cell-wall fiber in tropical grasses which are slowly digested and a ceiling is imposed on DM intake. Wilted cassava leaves (55 g/day) and Gliricidia foliage (90 g/day) both contributed to weight gain.

Research then focused on the optimum level of native grasses supplemented by crop by-products and tree legumes (Leucaena and Gliricidia) in supplementation studies. The 1988-1989 report indicates that research with cassava root peelings, cotton seed hulls and linters as well as native

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[27]Ibid.

grasses and leguminous forages were analyzed. Weight gain of 196 g/day with a diet of cotton seed hulls and linters as compared to 20 g/day for a group fed with grass was found. This research is experimental. These feed resources are not readily available.

Nutrient requirement tables are being compiled. Technological packages on feeding have been developed. These technologies are being evaluated on-farm. The nutrient requirements, chemical composition and mineral requirements have resulted in a technological package publication with feed recommendations for smallholders in the humid tropics. Farm testing was carried out through OPP.

Researchers in nutrition are developing their own set of nutrition requirements for sheep in Indonesia. Haryanto analyzed families' traditional feed sources, how much they cut and how much they feed. Commercial operations are testing the technologies, and have been incorporating them, and designing fattening schemes. These commercial operations purchase lambs from the farmers, feed them for 60 days and then sell to local markets. They represent approximately 1 percent of small ruminant owners. In an Indonesian News Letter[28] Bess Tiesnamurti interviewed one commercial farmer. They purchase their sheep from smallholder farmers. Commercial producers are working with researchers at RIAP in testing nutrition technologies.

Use of Gliricidia, a leguminous tree, and the effect of timing, i.e. at what times feeding is more gain from Gliricidia according to the time of day it is fed. The amount of cassava skin available is questionable as a feed source. Mathius carried out research to determine the nutrition requirements of pregnant and prolific Javanese ewes. Gestation and lactation define lamb

[28] Bess Tiesnamurti. "The ISRN Interview Pak Karianto: A Profile of a Sheep Fattening Farming System in Bogor." Indonesian Small Ruminant Network, ISS 0854-0063 Vol2, No.2 1991.

production per ewe at weaning.[29]

Cottonseed hulls and lint as substitutes for grass was studied by Haryanto, Yulistyani, Rangkuti and Pond (Preliminary Report, 1991). They showed these products can be used with advantages in the feeding of sheep to supplement diets. Other alternatives studied as supplements were rice bran, rubber seed, Leucaena, Caliandra, Albitzia, and Acacia. These were tested at the OPP sites.

Diwyanto and Haryanto studied effects of dietary crude protein concentrations and found that levels and timing of energy-feed supplementation with respect to the forage feeding time was important for efficient nutrient utilization. Feeding a mixture of Napier Grass and Gliricidia foliage offered ad libitum, and supplemented with energy-feed five hours after forage feeding time, gave the best results for feeding growing lambs. A cost-benefit analysis is underway. Haryanto experimented on weight gain and carcass results by feeding Gliricidia foliage and Napier Grass. Energy feed supplements (tapioca waste and corn) fed after 5 hours of feeding a mixture of Napier Grass and Gliricidia foliage resulted in higher proportion of meat in carcass (P. 47).

Sample diets for sheep and lamb are presented in P. 38 of Scholz et al. Native grass, rice bran and cassava leaves are considered. Both phosphorus and calcium and their balance are important in sheep diets. Basal mixed forages supplemented with rice bran can be recommended as an inexpensive feeding practice for post weaning ruminants, while fine rice bran-based supplements may be more appropriate for pre weaning, pregnant and lactating small ruminants to enhance productivity.

Comparing coconut, corn meal and rice bran, the latter gives the lowest weight gain (16g/d) but it is also the least cost one. Rice bran, according to the techpack, can be used as a feed

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[29]"Strategic forage-based regimes during gestation and lactation of Javanese TT sheep: progress report," The 1990-1991 Preliminary Report.

supplement and the amount and impact are presented in the technical package. Haryanto, in the techpack analyses the use of cotton by-products for small ruminants. "Feeding cotton by-products should be economically feasible if the animals are near to cotton production areas. A mixture of cotton by-products with molasses and foliage is advisable".[30] Gliricidia can be used as a forage source for ruminants. It has many other uses. Sun drying or wilting can reduce the smell and make it more attractive for the small ruminants. Weight gain of 88- 111 g/day as a sole feed have been obtained. High nutrient content makes Gliricidia a promising forage.

Mathius also found that King Grass does not produce enough protein for small ruminant maintenance, but it can be fed if supplemented with a protein source. Leucaena was also reviewed. It was rated as a good source, but is being destroyed by insects. Wilted cassava leaves as a protein supplement are usually fed by the farmer. Greater weight gains have been obtained when sheep are fed elephant grass with wilted cassava leaves.

Cassava root peelings as an energy source was also analyzed. This is a by product of tapioca and the dried cassava chip industry. Animals not fed cassava root peelings consumed 745 g/d of grass with weight gain of 98 g/d. Those eating root peelings at 60 percent consumed 704 g/d and gained 91 g/d. Digestion coefficients are lower.

Economic Analysis of Small Ruminant Marketing and Production Systems

Winrock International (WI) is the U.S. institution responsible for economic research in collaboration with RIAP.

"Although the subsistence needs of farm families are primarily met by food crops, animal production is often the primary means by which farmers accumulate cash, store capital, provide inputs such as traction and manure for crop activities and/or provide high quality food for the

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[30] "The Use of Cotton By-Products for Small Ruminants" by B. Haryanto in "New Technologies for Sheep Production in West Java Indonesia"

household."[31] The Java sheep population declined by 0.5% between 1967 and 1976 (from Sabrani et al. 1982)[32]. Every fifth farmer has small ruminants (Knipscheer and Soedjana, 1983[33]).

Goals of the economics project[34]:

a. To establish institutional capacity to carry out a range of studies related to constraints on increasing income from small ruminant farming.

b. To develop a farming systems research methodology appropriate to the needs of RIAP and the participating farmers.

c. Assist with the development of national research and development programs for small ruminants.

Objectives to achieve the above stated goals:

1. Characterize small ruminant production and marketing systems to assist in the identification of productivity levels and resource use.
2. Develop appropriate economic methodologies for analysis of traditional and improved production systems.
3. Construct agro-economic profiles of selected livestock farming systems to identify the on-farm testing program required.
4. Carry out policy oriented studies identifying pricing, marketing, and investment needs to encourage technological change.

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[31] A.J. De Boer "Economic Analysis of Improved Small Ruminant Production Systems" in Partners in Research A five year report of the Small Ruminant Collaborative Research Support Program ed. R.D. Blond, California.

[32] "Laporan Survey Baseline Ternak Kambing dan Domba (Mimeo SR-CRSP/BPT)

[33] The Productivity of Small Ruminants in West Javanese Farming Systems SR-CRSP Technical Report Series 13.

[34] A.J. De Boer "Economic Analysis of Improved Small Ruminant Production Systems" in Partners in Research A five year report of the Small Ruminant Collaborative Research Support Program ed. R.D. Blond, California.

5. Develop institutional capacity within RIAP through formal and on-the-job training, research planning, and professional meetings.
6. Carry out studies in other areas (outside Java) of Indonesia to identify potential and needs for small ruminants and increase institutional expertise in RIAP sub-stations.

Findings about Household Production:

Differences between upland and lowland farming systems were described as well as relationships between the resource base and small ruminant production, and income generated by small ruminants. Constraints to expanding productivity and numbers of sheep were identified. Later, work focused on specific topics such as low reproductive rates, impact of animal distribution schemes, demand for sheep and goat meat, seasonal changes in meat prices and efficiency of traditional marketing systems.

In general farm size and animal flocks are small. Farmers keep a high proportion of adult males to females. Two implications of farm analysis were that small ruminant research will have more impact for small and landless farmers, and small ruminant sales represent a means of transferring income from the rich to the poor. The percentage of farmers that keep sheep and goat is twice as large in upland than in lowland areas. Share cropping of animals and droppings were studied. The main cause of stagnant small ruminant population is believed to be modest productivity rather than numbers. The village trader plays on important role in markets, prices and technology transfer (De Boer).

Significance of the Findings

a. Animal Performance: poor offtake weights seem to be caused by long lambing periods. Production and performance by commercial producers with access to supplements have greater production performance. Low willingness to purchase inputs for small ruminants is a constraint that needs to be considered in policy formulation.

b. Economic Performance: estimated income from small ruminants in Java's research sites vary from 10 to 25 percent of the total family's income.

The economic role and importance of small ruminant production in Indonesia is that about every fifth farmer has small ruminants (mentioned above) and typically provide between 15 and 25 percent of the income. Impact on increasing production through animal distribution schemes seemed directly related to the elasticity of roughage feed supplies[35]. Use of marketing agents in the technology transfer function may be a feasible strategy for technological innovations. Farming systems research has been the approach used at the village level. Work concentrated on improving offtake and weight gain with a given small flock size. Research focused on changing breeding practices and reducing lambing interval. Analysis of the levels of economic response and market integration were done; the Village Intensive Production Schemes is an ongoing project (1992) that addresses the question of market orientation and intensification.

Review of Research Activities

A survey was carried out in West Java to determine the willingness to pay for new technologies in 1983. This showed that willingness to pay for treatments is below the cost. Capital and labor constraints exist, especially when grasses collected are far away. In addition, reproductive performance of ewes tested was not significantly different from the farmers'. This suggested that there was a need to develop economically viable and acceptable mechanisms to disseminate technology (1985-86 Annual Report Indonesia).

The economics project reported an increase in the number of adopting farmers in 1985. Gliricidia at the time was not used at its full potential. A survey to study pre-OPP performance of high prolific sheep was carried out to be used as bench mark for evaluations. A review of trends in interprovincial marketing margins trade and prices show that local markets have become integrated to national markets. Problems with input markets will not be overcome in the short run implying a constraint to new technologies (Knipscheer, H., M. Sabrani, T.

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[35] "The Economic Roles of Sheep and Goats in Indonesia: A case study of West Java." Knipscheer, Sabrani, De Boer and Soedjana.

Soedjana and J. De Boer)[36].

"Market Oriented Production Schemes in the Villages of West Java" is a project that started in recent years. Demonstration schemes were developed to illustrate the technical and economic feasibility of small ruminant market-oriented production and to determine if these marketing schemes are socially acceptable. The objective is to demonstrate and determine if it is possible to increase the income of small ruminant farmers through production testing schemes. Production, marketing, management, breeding and feeding schemes are developed and tested to propose different strategies according to resources and available animals. These are tested for economic profitability, technical feasibility and social acceptability.

The techpack (Scholz et al) presents an "Analysis of the Factors Affecting the Farm-gate Price for Small Ruminants in West Java" by Soedjana and Priyanti. Cut and carry systems are found in upland areas, while extensive grazing with partial confinement is found in lowland areas. Labor is a constraint in livestock production. Farmers often sell when cash is needed, and replenish stock when lamb prices are high. Holiday, gender, and weight were the variables contributing to the farm gate price changes. This is important if farmers purchase lambs instead of breeding them. Average prices for animals is between 40,000 and 50,000 rupiah (1989). The exchange rate as of March, 1991 was 1,928 rupiahs per dollar. Each additional kg is 1,440 Rp. Male sex adds 2,000 Rp. and holidays add 11,000 Rp. per animal.[37]

The economic/marketing project also assisted in analysis of the technology packages: OPP farmers were exposed to what is believed to be economically optimal weights to market and price formation and also provided estimates of farm gate prices per kilogram of live animal.

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[36] "The Small Ruminant Market System of Indonesia: a Review." Agricultural Systems, 1987.

[37] See also A. Priyanti, T. Soedjana, S. Handayani and P. Ludgate. "Characteristics of High and Low Performing Sheep and Goat Farmers in the District of Bogor, West Java" Proc. Ruminant Seminar CRIAS. 1988.

However, better information did not modify their marketing behavior. Factors affecting the performance of OPP farmers were measured by litter size, percent of lamb mortality and lambing interval in the breeding program, while economics and marketing performance was measured by animals sold at optimum market age. (Setiadi, B and L. Iñiguez)

A study to determine factors affecting the success of OPP farmers, including smallholder livestock production was carried out.[38] Preliminary results were reported in the Annual Report of 1990, which reviews the OPP performance necessary. The survey showed that only 30 percent of the OPP farmers sold their sheep and/or goats at the "economically" optimum age. Almost 60 percent of the farmers sold their animals after this period to take advantage of the holiday. Only 33 percent of the OPP farmers sold animals directly to the market. Farmers did not have time and did not want to take the additional risk of not being able to sell their animals at the market and have to return them to the village. This suggests that the marketing strategy may be efficient.

Sociological Analysis of Small Ruminant Production Systems

The University of Missouri-Columbia (MU) is the U.S. institution responsible for research in sociology in collaboration with RIAP.

The Goal of the Sociology Project:

To develop an understanding of the social and cultural contexts in which small ruminant production takes place to determine the likelihood of acceptance of new technology.

Objectives to achieve the goal:

1. Determine how small ruminant producers allocate resources and make decisions.
2. Study the role of women, non-small ruminant producer characteristics, the village trader, and animal sharing arrangements.
3. Develop sociological research capacity.

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[38] Tjeppy Soedjana, Atien Pryanti and Muchji Martawidjaja participated in the evaluation. They shared with us the information collected and processed.

A remaining question is if the existing extension institutions are capable of delivering the technologies developed. Sociology concentrated on training of Indonesian scientists in the U.S. and in-country[39] and testing technologies on-farm[40]. Areas of research were the role of women in production[41] and in decision making[42] on small ruminant production, the sociology of animal health[43], analysis of the socio-economic aspects of small ruminant production[44], and OPP evaluations in terms of income generation and labor availability[45]. Adoption of technologies, especially Gliricidia Maculata, a leguminous tree was evaluated by the sociology project[46]. General findings in sociology indicated that surveys are sensitive to gender, and adoption of technologies through the OPP varies. OPP adopters of Gliricidia Maculata rose from 7% to 67% in two years, and was used as a supplement. Earlier, the technology was being under-

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[39] Thomas Conelly and Miriam Chaiken conducted a workshop of Farming Systems Research in Indonesia in the summer of 1990.

[40] P. Bilinsky and M. Gaylord. "Outreach Pilot Project: Small Ruminant Research and Extension in Java" in Plants, Animals, & People Agropastoral Systems Research ed. Constance M. McCorkle. Westview Press: Colorado. 1992.

[41] S. Wahyuni, D. Priyanto, A. Suparyanto, P.J. Ludgate and T.D. Soedjana. "Baseline Data for Research Regarding The Sociological Impact of Women Focused Strategies for Improving Small Ruminant Production" SR-CRSP WP 121. November, 1990.

[42] Sri Wahyuni, H.C. Knipscheer and M. Gaylord. "Women's Decision-making Role in Small Ruminant Production: The Conflicting Views of Husbands and Wives" in Agricultural Administration and Extension 24(1987) 91-98.

[43] Wahyuni, Sri, T. Murdiati, Beriajaya, H. Sangat-Roemantyo, A. Supariyanto, D. Priyanto, Isbandi, E. Mathias-Mundy. "The Sociology of Animal Health: Traditional Veterinary Knowledge in Cinangka, West Java, Indonesia-A Case Study".SR-CRSP, Balitnak, Bogor, Indonesia, July,1991.

[44] K. Suradisastra and T. Soedjana. "A Comparative Study on Socio-economic aspects of Small Ruminant Production in West Java". SR-CRSP Working Paper 114. April, 1990.

[45] A. Priyanti, T.D. Soedjana, S.W. Handayani, and P.J. Ludgate. "Characteristics of High and Low Performing Farmers in OPP Villages". SR-CRSP WP 95. January, 1989.

[46] S. Mawi, Paula Bilinsky, A. Wilson and Marwan Rangkuti. "On-farm Performance of Small Ruminant Technologies in West Java: Evaluation of the Introduction of Gliricidia Maculata to OPP Farmers. SR-CRSP WP 92. February, 1987.

utilized. In the case of purchased inputs, problems exist because of low willingness to pay[47].

The Outreach Pilot Project (OPP)

Purpose

"The small ruminant production potential of the OPP animals was constrained by genetic, environmental, and management factors. Generally, under village conditions, animal productivity is low which is reflected by low body weights, high pre-weaning mortalities, long lambing/kidding intervals, and the unavailability of rams/bucks for breeding. In order to minimize the negative effects of these constraints and to improve the productivity of the smallholder farmers, the Outreach Pilot Project (OPP) was begun in 1984."[48]

The objective of the OPP was to improve farmer management of sheep and goats by introducing testing, at the farm level, of technical packages developed at the research station.[49] The Outreach Pilot Project is a demonstration project in Bogor, West Java that integrates the expertise and insights of all four biological and social science projects[50]. It showcases the results of research into small ruminant nutrition and breeding in the humid tropics. There are treatment and control groups that receive technical assistance. Breeding, economics, health,

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[47] Amir, P., H. Knipscheer, S. Mawi and G. Spinhoven. "On farm performance of Small Ruminant Technologies in West Java: Implication for Technology Transfer and Design". SR-CRSP W.P. 69, 1986.

[48] P. J. Ludgate and Atien Priyanti (ed) "Outreach Pilot Project On-farm research activities annual report for 1988-1989" WI, MU and RIAP. SR-CRSP Working Paper 109, Feb. 1990.

[49] 1986-1987 Annual Report "Sociological Analysis of Small Ruminant Production Systems" in Indonesia Program Year Eight 1986-1987.

[50] Paula Bilinsky and Mark Gaylord summarize the history of the OPP and the role of farming systems research in West Java. Chapter 8, "Outreach Pilot Project: Small Ruminant Research and Extension in Java" in Plants, Animals, and People ed. C. M. McCorckle. Westview Press,: Colorado. 1992.

management, nutrition and sociology participated. Though the OPP started in 1984, it became an intensive activity in 1988. On-farm trials were done before this period.

Three functions are expected of the OPP:

1. Testing ground for new technologies.
2. Use of a demonstration farm to spread knowledge.
3. Establish a breeding multiplication center.

Several studies were developed by sociology and economics at the village level. Some studies on ethnoveterinary practices, women participation and knowledge of medicine, and reproduction and management were evaluated showing that there is room for women to learn more about sheep[51]. Knowledge by women of small ruminant reproduction is limited[52]. Discussions on the probabilities of extending knowledge and impact on sheep output are necessary. It is necessary to assess the time and resources for women to participate in training with respect to veterinary, reproduction and management aspects. Sri Wahyuni and Evelyn Mathias-Mundy were involved in "Changes in Women's Small Ruminant Management and Their Impact on Family Labor Patterns". A research question that remains unanswered is the impact that could be obtained in terms of increased productivity from training women. Measurement of production coefficient differences could be used to test this hypothesis.

These field laboratories received sheep and goats in order to use them as a testing ground for technology, demonstration and multiplication centers. The objective was to increase farmers' awareness of improved management practices. JTT and Etawah grade goats were distributed by OPP. Only 3 out of 34 farmers received goats. Average flock size in 1989 and 1990 was 10.3 head. Medium farms (5-10 head) are 17, which is 50 percent of the total. Large (more than 10 sheep) farms are 41.2 percent of the sample. The number of participating farmers grew to

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[51]1990-1991 Bogor High Prolificacy Progress Report.

[52]Dwi Priyanto, Sri Wahyuni and B. Tiesnamurti. "Women's Knowledge of Small Ruminant Reproduction".

42. In March of 1988 bi-monthly visits were started. Groups of farmers increased from 17 to 19. There were one to three groups per village, and 2 to 3 farmers in each group. RIVS (Research Institute for Veterinary Sciences) and RIAP SR-CRSP participated in the project. There were sixteen groups that received one ram and 5 adult ewes, and three groups that received goats.

Findings of significance were that farmers are reluctant to purchase inputs (which may reflect the scarcity of working capital) in small scale farming; women take care of an important part of the day-to-day raising of sheep which should be recognized in extension services[53], stating that there would be gainsin production by concentrating on technology transfer for women, although the differences in productivity have not been measured; and there is concern about the extension service capacity to deliver the technology.

Methodologies used in determining the role played by women in sheep production are in question. Research in North Sumatra by Ralph Brown and Sri Wening Handayani introduced participant observation to test methodologies (1992). The major technologies introduced to the farmer groups were drenching, leguminous trees, alternative fodder (Gliricidia Maculata[54]), mineral blocks for small ruminant nutrition, and management and reproduction. Several OPP Evaluations were done by the OPP team[55]. A consistent methodology was used to evaluate the

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[53] There is variability in the amount of time that women dedicate to small ruminant production that has to do with the type of production systems (low, mid and upland, as well as level of income). Information varies, some researcher report that women do not play a major role in small ruminant production (Suradisastra, K. "Social Aspects of Goat and Sheep Production" in Goat and Sheep Production. Manuscript) while others point out their involvement in lowland production (Soedjana, T. "Economics of Raising Small Ruminants" in op. cit., and Wahyuni, S., R. Gatenby and M.F. Nolan. "Women and Small Ruminant Production in Indonesia A Case Study in West Java").

[54] Mawi, Bilinski Wilson, and Rangkuti. 1987. On farm performance of Small Ruminant Technologies in West Java: Evaluation of the Introduction of Gliricidia Maculata to OPP farmers SR-CRSP Working Paper No. 92. Bogor, Indonesia.

[55] The OPP team was composed of Bambang Setiadi (Breeding), Tjeppy Soedjana (economics), Atien Priyanti (economics), Abdul Adjid (health), Muchji Martawidjaja (management), Budi Haryanto (nutrition), I Wayan Mathius (nutrition), Dwi Yulistiani (nutrition), and Sri Wening Handayani (sociology). All these researcher are member of RIAP. Other researchers in the first evaluation were Kedi Suradisastra (sociology) and Syahir Mawi.

:onditions (biological, economic, and sociological) of the OPP farmers.

Summary Evaluation of the OPP by Disciplines

'ummary of the results from the breeding project of the technology information packages were eveloped by Bambang Setiadi (W.P. 109). "The number of ewes available per month per farm - the best estimator of the flock size with regard to the flock's reproductive potential."(P. 6, op. cit.) This can be seen in table 3.

Table 3

Reproductive Performance of Javanese Thin Tail Sheep

Ewes Available	E.A.(X)	L.S.	LWEA (%)
1-3	2.3	1.45	157
3-5	4.0	1.47	157
>5	6.0	1.69	142

Source: Working Paper 109 SR-CRSP. LS equals lamb survival, LWAE lamb weaned per available ewe and EA equals ewe available per farm.

However, the ratio of lambs weaned per ewe available declines with increasing flock size indicating decreased survivability as flock size increases. Lambing interval (intensity of production of lambs per ewe per year, the minimum is 240 days) was 246 days in 1988/89, it was 292 and 291 in 1986/87 and 1987/88 lamb. Mortality rate increased with average feeding practices when litter size was greater, as is shown in table 4.

Table 4

Litter Size and Lamb Mortality

Class Size	Frequency	LS	M%	LWEA	EA
1-1.4	35.3%	1.19	5.3	111	3.6
1.4-1.8	50.0%	1.59	12.3	155	4.0
1.8	14.7	2.11	21.4	245	5.1

Source: Working Paper 109. LS=litter size, M=mortality and LWEA's as defined in table three.

There were some lambing intervals reported that were below the minimum. For example 168 days was reported. Average litter size is 1.53 (61.8% of the farmers). The reproductive performance of small ruminants of each OPP farm can be seen in page 8 of WP 109, 1990.

Summary of results from the health project of the technology information packages are presented by Abdul Adjid in the Annual Report of the Outreach Pilot Project for 1988-89. Comparison of the period 1987-88 and 1988-89, (before and after transferring the techpacks on health) was carried out to observe changes in disease prevalence.

The economic project of the technology information packages was summarized by Tjeppy Soedjana and Atien Priyanti. During sale of animals at Idul Adha, almost 60 percent of the farmers sold at 18 months of age. Only 30 percent sold at optimum age (12-18 months). A total of 130 animals were sold from the herd population of 350 animals. Average weight and selling prices are presented in P. 13 of the report. Optimum selling weights are 22.18 to 28.38 kg for males of 12-18 months, and 21 to 24 kg for females of 12-15 months. Selling price is 50,060 Rp. to 72,250 Rp. for optimum males and 40,000 for females. During Idul Adha it was 78,440. Thirty-three percent sold to the market directly (33%0), but most sold to village

collectors or middlemen within their area.

The results from the nutrition project of the technology information packages[56] were presented by Budi Haryanto, Wayan Mathius and Dwi Yulistiani. The evaluation was on the quantity and quality of feed, minerals, and water. Around 60 to 70 percent of the farmers had carried out adequate feeding practices. Compared to 1988, the results are slightly better. Approximately fifty percent of the farmers fed fresh, mature forage. Only 5 percent of the farmers provided the appropriate type of feed (grass plus legume tree forages). Most OPP farmers provide drinking water for their animals, and 44 percent provide animals with salt.

Summary of results from the management project of the technology information packages were presented by Muchji Martawidjaja. "A system for keeping the animals in the barn that is not based on separating the animals by physiological status may cause inbreeding, breeding at too early an age, fighting and difficulty in providing feed according to individual physiological status requirements. With these negative conditions, the probability for improving productivity will be low. Along with this, cleaning the barn is closely linked with animal health and will significantly influence productivity." (P. 19) There has been an increase in number of barn separations. Barn cleaning is an accepted practice. Physiological status was very good/good in different categories.

Patrick Ludgate et al.[57] conducted an evaluation of the OPP's five years of on-farm testing using three discipline parameters:

1) Breeding/reproduction that include ewes available per month on farm, lambing intervals, litter size and mortality;

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[56]Nutrition research results are also presented in "Pragmatic Approach to Improving Small Ruminant Diets in the Indonesian Humid Tropics" by W. L. Johnson and A. Djajanegara in Journal of Animal Science (1989):3068-3079.

[57] P.J. Ludgate, T.D. Soedjana, A. Priyanti and H.C. Knipscheer "Technology Development in Integrated On-Farm Animal Research: Farmer Groups in West Java, Indonesia" Working Paper No. 122, November, 1990.

2) Economic/marketing information such as selling age, average weight at time of sale, selling price, and marketing channels; and

3) Management that includes barn separations, separation of the animals by physiological status, and cleaning barns.

Some criteria were not included such as feeding practices and manure collection. The first is important to determine cost increases, the second because it is an additional source of income for the farmers. S. Mawi et al.[58] shows the economic importance of goat and sheep manure and its value. Production capacity per farmer is 811 kg/farmer, with an average price of 3.89 Rp./kg in Srogol (OPP village) and 17.21 Rp/kg in Rancamaya. Appropriate management of manure as shown in the techpacks increases their productive value. This fertilizer is used by the farmer in crop production, and is also sold.

Lamb mortality rates decreased from 20.5% to 9.3% among participating producers in the first year of providing the communication package, and rose to 11% afterwards. This was considered an acceptable level by the researchers. Lambing interval at the OPP was reduced to 246 days. This can be of 360-450 days in traditional animal management. Reduction of the lambing interval implies the possibility of three lambings in two years, instead of the traditional one lambing per year. Setiadi and Iñiguez[59] state that there is a fifty percent increase in yield per ewe. In many cases an absence of rams is a problem.

Calculating the potential impact of research, Ludgate et al estimated a population of 2 million adult ewes in West Java (although sheep numbers are 2'423,320 according to Indonesian statistics for the 1987 census. With only one lamb per lambing and a survival rate of 85%, an increase in production of 1.7 million more lambs is possible. This potential impact assumes one

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[58] S. Mawi, M. E. Yusnandar, T.D. Soedjana and P.J. Ludgate. "Marketing and Utilization of Goat and Sheep Manure in the Bogor District" W.P. 106, August 1989.

[59] B. Setiadi and L. Iñiguez. "Reproduction performance of small ruminants in on-farm research evaluation of village farms in West Java" SR-CRSP/RIAP. Bogor. 1990.

hundred percent adoption by the farmers,[60] which is questionable, because a large problem in Indonesia is the insufficient extension service manpower, and therefore there are limitations to introducing the techniques developed.

In other cases the problems are socio economic. In some cases farmers have no rams which means that a sharing systems needs to be devised in order to reduce this lambing cycle. Sharing of rams was part of the technical package developed through OPP. The first socio-economic evaluation (Priyanti, et al.[61]) pointed out that 88 percent of the farmers agreed with the sharing system. Traditional methods of sharing rams also exist (Sabrani et al.[62]) Assumptions to attain the above mentioned impacts include: that 3 lambings take place in two years increasing productivity by 50 percent. The required additional inputs, and labor, as well as ram availability to obtain this increase were not presented by the authors. Barn separations by physiological status (No. 3) and barn management improved, and recommendations were adopted by 88 percent of the farmers. Overall evaluation of the OPP by Ludgate et al. indicates "An analysis of the OPP research data indicates the farmers' success in improving productivity and suggests areas where further research is needed. The success of the OPP on-farm research model has provided further support to the contention that farmers should actively participate throughout the technology development process" (W.P.122, P. 26).

Recommended feeding practices and management[63] practices were developed and tested in the

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[60] In how many years can one hundred percent adoption be reached?

[61] A. Priyanti, S. Mawi and Kedi Suradisastra. "Farmers Responses to the Outreach Pilot Project (OPP): First Socio-economic Evaluation". SR- CRSP W.P. 94. Bogor, 1988.

[62] Sabrani, M. and H.C. Knipscheer. "Small Ruminants for Small Farmers". Indonesian Agricultural Research and Development Journal. 4(1982): 86-90.

[63] M. Martawidjaja, A. Priyanti, B. Setiadi and P.J. Ludgate. "Barn Management Systems of the Sheep and Goats by OPP Farmers". SR-CRSP W.P. 112. NCS and BPT. 1990.

OPP. Yulistiani et al.[64] presented and evaluated the four technological packages: physiological status and feeding barn separation, roughage feeding throughout the year, salt and water, and legume tree planting. The evaluation on the nutrition techpack in 1990 by B. Haryanto[65] show seasonal variation in the adoption of the feeding practices, especially in the provision of water and salt.

Adoption

Follow up surveys were carried out during the period of the OPP and after it terminated. Various practices were adopted in varying percentages when the monitoring was in place. Adoption practices ranged from five to 88 percent depending on the season and the nature of the technique. The average yields obtained through OPP have been reported and show this wide range of adoption. Soedjana, Priyanti and Mujchi collected and processed surveys for the six month evaluation after the OPP expired, and kindly shared that information with this project. This showed that 84 percent of the farmers give enough feed, that 40 percent feed grasses and tree legumes or grasses and feed supplement, while 48 percent feed grasses and agricultural by-products, with similar percentages of feed availability for young animals, ewes, pregnant and lactating ewes, and rams. Feed quality given was fresh to medium for 84 percent of the farmers, salt availability was 48 percent and water availability (clean in bucket) was 28 percent. Barn separation and soundness was 44 percent for the four separation type. Another survey done recently showed that purchased inputs are still a constraining factor.

Technical Package Development

As a result of the breeding, nutrition, management, health, and socio-economic research a technological package has been produced. There is another being currently edited for

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[64]D. Yulistiani, Wayan Mathius and Muchji Martawidjaja. "Effect of Technology Packets with the Outreach Pilot Project (OPP) Farmers" SR-CRSP W.P. 101. 1989. NCS and BPT.

[65]B. Haryanto, Dwi Yulistiani, I.W. Mathius and M. Martawidjaja. SR-CRSP W.P. 111. NCS and BPT. 1990.

publication. On-Farm Research on Small Ruminants,[66] a collection of training materials was prepared and published in English, Indonesian, Javanese, and Sundanese. Two hundred copies of each language was printed in the first edition. A second edition was printed in all these languages, and no more copies are available. Requests for more copies are received from the provincial extension services. The "techpack" publication is in demand. It was mentioned that it is being translated to Malaysian. In interviews with the extension people at Dinas Peternakan for Bogor in West Java they mentioned that they use the "techpack".

[66] Kumpulan Peragaan Dalam Rangka Penelitian Ternak Kambing dan Domba Di Pedesaan. Ed. by Patrick Ludgate. Balai Penelitian Ternak/Small Ruminant Collaborative Research Support Program, Pusat Penelitian dan Pengembangan Peternakan, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian. 1989.

III. Methods for Agricultural Research Impact Assesment

There are several approaches to evaluate the impact of technological development, training programs and development programs. A review of the different approaches is presented in the following pages. This review does not intend to cover, because it is beyond the scope of this project, the returns to education and the returns to research for the National Research Programs. Its intent is to provide some background and the tools that will allow an evaluation of some technologies developed by the Small Ruminant Collaborative Research Support Program in Indonesia, and at a later stage, in other countries that SR-CRSP has participated in. The analysis developed for Indonesia will concentrate on technologies developed for West Java that were introduced, tested and monitored with small producers near Bogor through the Out-reach Pilot Program (OPP). The review will look at the different approaches and variants of economic impact assessment, and will also look at evaluations done for livestock research in various countries. General theoretical assumptions will be reviewed briefly in order to remind ourselves of the assumptions made when any model or approach to analysis is selected.

Evaluation of Research

Horton[67] raises important questions when it comes to evaluating research. He distinguishes two types of evaluations. The first and most common, focuses on the production impact of research. This evaluates the results of research in terms of production and yields. Another input that should be evaluated is research and development impact. "Impact assessment is most useful when it is conducted within a management framework that clearly specifies the intended clients of research systems and their technology needs." (P. 43) Underinvestment is shown by the high returns to research, but at the same time poor management seems to contribute to low impact of research, states Horton(1990).

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[67]Douglas E. Horton. "Assessing the Impact of International Research: Concepts and Challenges" in Echeverría ed. (1990).

World Bank projects were analyzed by Horton to determine which activities had greater success and they coincided with those sectors unrelated to education, agriculture, and services. This is not surprising because these sectors tend to receive the lowest portion of government budgets, and tend to be cut when economic crises arise. Agriculture, rural areas, and education suffer when there is a crisis in the macro economy. The thesis postulated by Horton states that impact assessment is most valuable as a management tool when it is conducted as an integral and continuous part of the research process. Production technology generates a production impact, and research and development technology an institutional impact.[68] Research and development technology is defined by Horton as "organizational strategies and methods used by research and extension programs in conducting their work" (P.51). It is important to define the mission and clients in every evaluation.

The SR-CRSP produces both types of technologies, as training and institutional strengthening are part of its mission in the countries it is involved in. Much of the research developed through the SR-CRSP can be viewed as research and development technology because it is more involved in research programs that do not have an immediate impact on farmers, such as basic research, building research capacity, and genetics and biotechnology research. In understanding the role of new approaches to research that have greater chances of impact, especially in poor countries that are both research and institutionally poor, the following statement is true:

"It has gradually been recognized that the type of breakthrough represented by the discovery and rapid spread of high-yielding varieties of rice and wheat is the exception, not the rule, in the agricultural R&D. Nevertheless, most international centers maintain that breeding and genetics are the most important programs, with other activities considered as complementary.

As evidence of the lack of impact of many breeding programs mounts, attention has shifted

[68] Examples of research and development technology in agriculture are germplasm research, tissue culture (virus testing techniques for example), Principles of Integrated Pest management. Production technology examples mentioned by Horton are new varieties developed, improved seed, and a recommended IPM system; all derived from the research and development research.

somewhat to the 'softer' sciences and technologies." (Horton, P. 53). Baker and Norman[69] state that... "In the face of lagging agricultural productivity growth, rapid population growth, and modest growth of formal sector employment opportunities, many countries initiated farming systems projects during the 1970s and early 1980s." (P. 91) According to their measures of success they affirm that significant results are only realized after 10 to 25 years and this has to do with the success of the dissemination process.

In the late 1970s and 1980s, research centers experimented with on-farm and farming systems research (FSR) approaches as ways to improve the practices and welfare of small farmers in the absence of high-yielding new varieties. In some instances, on-farm research techniques were also used to identify farmers' problems and enlist farmers' participation in the generation and diffusion of new technologies." Baker and Norman[70] also point to the use of the farming systems approach during those decades, and note that today FSR approaches have changed. FSR is not the panacea to all problems, as non-agricultural activities and the macro economy have impacted the system, overshadowing the contributions of research to the production system. There is a growing belief that for this type of research to be effective, it needs to be adopted by the national research institutions.

The FSR approach has, according to these authors, helped to identify interventions that can further productivity in agriculture. Better agricultural methods, improvement in institutional performance, documentation of factors affecting the farming system and promotion of farmers' perspectives are mentioned by the authors. They mention that the harsher the production environment the fewer the interventions identified. The role of livestock in manure production, the interactions between agriculture and livestock, the use of labor and competing activities are issues that are known today in the SR-CRSP because of the framework taken. It is important

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[69] D.C. Baker and D.W. Norman "The Farming Systems Research and Extension Approach to Small Farmer Development" in Agroecology and Small Farm Development by Miguel A. Altieri and Susana B. Hecht. CRC Press 1990.

[70] Ibid.

for this approach to be introduced into existing institutions, rather than creating new ones (Stoop[71]).

A lack of technologies for particularly harsh environments meant that diagnoses, design and development or adaption became the responsibility of FSR (Baker and Norman). They conclude that on-farm research is a needed complement of on-station research and social science perspectives are needed to complement the technical biological research. The SR-CRSP was no exception to this need. On farm research was conducted in Kenya, Indonesia, and later in Peru, in recognition of the fact that research with sheep and goats would require the understanding of the role of these animals in the production system. In the case of Peru a reassessment of the importance of production in peasant households resulted in the incorporation of a "community project". With farmer's involvement this research was tested and redirected towards areas of most need and interest.

"Ex-ante and ex-post assessments are far less useful in the case of research, which is best treated as a long-term process rather than a discrete project. Research is as much an art as a science. Research processes cannot be clearly specified in advance they evolve as discoveries are made. The time frame is unpredictable. The practical outputs are difficult to anticipate and generally they are unmarketable. Serendipity is an inherent characteristic of the research process. The better the research, the more abundant the fortunate accidental discoveries."(Horton, P.54) Clients change such as was the case in Peru. Research is redirected and can have unexpected results and products, such as the case of double cobber maize in Kenya. The technology had an important impact on human consumption, but also influenced animal production due to the stripping technology introduced, which augmented feed supplies. Needs change[72], as controlling

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[71]Stoop, W. Organization and Managerial Implications of a "Farming Systems Approach" for NARS, ISNAR, The Hague, Netherlands, 192. in Baker and Norman (P.99)

[72] Priority settings need to be an adaptive process with frequent revision as more is known of the farming system. Priority setting must be adaptive. George Antony and J. Brian Hardaker, 1990. "Formal Priority Setting in Farming-Systems Research" . Paper presented at the Asian Farming Systems Research and Extension Symposium "Sustainable Farming Systems in 21st Century Asia". Asian Institute of Technology, Bangkok, 19-22 November, 1990.

prolificacy in Indonesia, and institutions need to be established to allow for research development.

Research, responsive to needs, requires constant monitoring and redirection when necessary. A shift from breeding to nutrition took place in Peru after an assessment was made of the program. This is why both production and institutional impacts should be measured (Horton). Responsibilities for these assessments have usually been undertaken by donors but not necessarily by the National Agricultural Research Institutions. De Frahan[73] shows that FSR investment must be accompanied by investments of on-station research, public investment in extension, and marketing of input and output investments to become profitable.

According to Kumar (1987), "Apparently USAID...[a client of the SR-CRSP]... still does not appreciate the importance of institutional impact, and focuses its assessments on production, income, consumption, and the (physical) environment" (Horton, P. 64). Production research can be developed but if no institutions are in place to absorb these technologies the potential impacts will remain only potential. In that sense the role of the SR-CRSP in development

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[73] Bruno Henry de Frahan. 1990. "Potential Effects of Institutional Reform on the Expected Rate of Return to Farming Systems Research in Semi-Arid Northeastern Mali" Association for Farming Systems Research-Extension, 10th Annual Symposium. East Lansing, Michigan. October 14-17, 1990. He points to three conditions for making FSR profitable: 1) performance of on-station research generating improved technologies that FSR can draw from; 2) performance of the marketing system in reducing marketing margins and seasonal price variation for inputs and outputs; and 3) an institutional setting for transferring technology. All of these conditions have proven crucial to the adoption of technology after development phase. Other important functions that do not show up in the evaluation are 1) improving research relevance through a better conveyance to researchers of farmers' needs; 2) informing policy makers and planners about the measures that could generate and transfer improved technologies (these go hand in hand with strengthening disciplinary research and extension). The author combines the calculation of returns to research from farming system with on station research, enterprise budgets of the FSR technical packages and investment to promote improvements in marketing and fiscal policy reform. By doing this the returns went from 2 to 14 percent (IRR). These other areas considered contributed to the adoption rate of the technology. By promoting improvements in the agricultural marketing system and fiscal policy the IRR was 18 percent, with average ROR of 21 percent.

research is central to the presence of impacts on yield and productivity.

Sanders[74] points out that when a new technology has been successfully introduced, life is easy and everyone is happy. But in developing countries economic analysis is usually important to estimate the potential impact of new technologies and identify the constraints to their introduction. In low income countries extension service is usually divorced from the scientific community, farmers ability to obtain information is minimal, and losses among farmers have severe consequences on their livelihood. In this setting, analysis of variance performed by researchers is a standard of quality control. [75]

Methods of Estimating Returns to Research

The SR-CRSP started its program in Asia, Africa and Latin America at the beginning of the eighties, concentrating on sheep, goat, and South American camelid production research and development technology, as well as production technology. Rubén Echeverría[76] points out that many studies of returns to research have been done for Latin America and Asia but not for Africa. Two traditional methods to measure economic returns to research exist, one is the

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[74] John H. Sanders "Impact of New Technologies in Burkina Faso and the Sudan and Implications for Future Technology Design." May 1992. Paper presented at the Workshop on Social Science Research and the Collaborative Research Support Programs (CRSP), University of Kentucky, Lexington, KY. June 1992.

[75] Sanders also raises a basic question in his research: are women worse off by the introduction of new technologies? His evidence shows that they are not. Other have shown that when conditions worsen women result worse off because resources are taken away from them. A. Ferguson presents a very interesting approach to understanding the impact of technology on women that includes class and ethnicity as variable that tend to be left out, showing that gender should not be "normalized" in her paper "Gender, Class, and Ethnicity: What Difference do They Make in Agricultural Technology Development Programs?" prepared for the "Workshop on Social Science Research and the CRSPs". Kentucky. June, 1992.

[76] "Assessing the Impact of Agricultural Research" in Echeverría, R. G. ed. 1990. *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research* Vol. II, *Assessing the Impact of Agricultural Research*. The Hague: ISNAR.

econometric approach that treats expenditures in research as a variable to the production function estimated and allows for estimation of the marginal returns on investment. The other approach, the economic surplus model, estimates the average returns to investment by determining the movement or shift of the supply function due to research and estimates the changes in consumer and producer surplus. The return to investment in research can be expressed as an average rate (internal rate of return) for an entire project, given specified expenditures. Echeverría, Daniels et al., and Norton and Davis[77] discuss the economic surplus approach. Echeverría summarizes the studies done in the past to assess research in various areas, and finds that most of these show high rates of returns, and that investment in agriculture is productive. They also show that the amounts invested in agriculture have been far from optimal. The literature has progressed introducing changes to the original models of economic surplus analysis, such as integrating input markets, the external (trade) sector, modifications with respect to perfect competition (market distortions), and gains of research at the household level. The shift has been towards determining the distribution of gains between producers and consumers as well as between different income groups.

The assessment that interests us at the moment is that of production technology which affects farmers, marketing agents, and consumers as defined by Horton[78]. Daniels et al[79] in their review of returns to research studies among other things, conclude that success of research depends on the existence of complementary structure, institutions, and government policies, which they view of importance particularly for Africa due to the variability of their institutions. They also point

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[77]George W. Norton and Jeffrey S. Davis "Evaluating Returns to Agricultural Research: A Review" AJAE 63(1981): 685-699).

[78] ("Production technology refers broadly to all methods that farmers, market agents, and consumers use to cultivate, harvest, store, process, handle, transport, and prepare food crops and livestock for consumption;..." Echeverría 1990, p.23)

[79] Lisa Daniels, Julie Howard, Mywish Maredia, James Oehmke and Richard Bernsten. "The Impact of Agricultural Research: A Review of the Ex-Post Assessment Literature with Implications for Africa" Department of Agricultural Economics. Michigan State University, July 1990.

to an area of evaluation that is important for all the Collaborative Research Support Programs, keeping in mind that their goal is "to benefit the poorest of the poor" (a stated target audience of the SR-CRSP). This is the distribution of the gains of research. It is not only important for the governments of the host countries, but also for the CRSPs to know the target audience and how the research contributes to their welfare.

Echeverría[80] and Daniels (P. 42) present summaries of rates of returns obtained by several research projects in Asia, Africa, and Latin America, as well as in developed countries. Both reviews yielded similar results. Most of the livestock (dairy, beef and pastures) returns to research were calculated for the United States Canada and Australia. For less developed countries both found the same study by Wennergren and Whittaker[81] done originally for sheep, and that later incorporated wheat in Bolivia with returns that fluctuate between 44 and 48 percent. The approach used was an economic surplus model. [82] The authors evaluated the returns to investment of the U.S. Technical Assistance Program between 1965 and 1974, using conventional benefit - cost analysis. The objective of the program was to assist with development of the highland areas, where sheep, llama and alpaca were the principal agricultural enterprises. The program emphasized: a) introducing improved management practices, b) upgrading the genetic base of livestock, c) increasing forage production, and d) improving and developing product markets.

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[80] "Assessing the Impact of Agricultural Research" in Ruben Echeverría ed. 1990. Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research Vol II Assessing the Impact of Agricultural Research. The Hague:ISNAR

[81] E. Boyd Wennergren and Morris D. Whitaker. "Social Returns to U.S. Technical Assistance in Bolivian Agriculture: The Case of Sheep and Wheat". in American Journal of Agricultural Economics 1977 (59):565-69.

[82]The advantage of this approach is that economic policies that affect the returns to agricultural research can be introduced. Sensitivity analysis can be done to handle uncertainty, it can quantify public and private sector interactions, and calculates average rate of return, but cannot be used to evaluate basic research (Davis and Norton).

The program included applied research and extension, institution building, training and equipment. An assumption utilized in measuring the returns was that opportunity cost of labor was equal to zero. The rate of return calculated is to marginal U.S. investment in the technical assistance program because it did not include the costs to the government of Bolivia. They assumed that increases in net returns to farmers were a result of the marginal U.S. investment.[83] Returns to sheep research vary from 44.1 to 51.5 depending on the assumed scenarios.

Echeverría reviewed the Seré and Jarvis[84] assessment of pastures in Latin America, showing 15 - 20 percent returns with an eleven year lag. Their analysis looks at the returns to research (ex-ante) and measures the impact of improved pasture research in different scenarios, assuming increased free international trade and the role of poultry in the demand for beef in the tropics of Latin America.

Schwartz and Oehmke[85] developed a paper with guidelines to returns to research calculations. Returns are calculated as the benefits to consumers and producers. The authors propose the benefit/cost analysis approach that yields average returns generated by the investment in research, as opposed to others such as the production function approach. They suggest to keep in mind that economic policies affecting relative prices at the producer and consumer level will affect the rate of return of research in agriculture. The rate of return calculation requires defining an acceptable level which is based in the cost of funding. In developed countries this is around 10 percent (it does not account for inflation).

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[83] These assumptions were made on the basis that real government budgets for sheep research were declining during this period and the ineffectiveness of previous research.

[84] Carlos Seré and Lovell Jarvis." The Betting Line on Beef: Ex ante Estimates of the Benefits of Research on Improved Pasture for the Latin American Tropics" in Echeverría ed. (1990).

[85] Lisa Schwartz and James Oehmke "Applying a benefit/cost approach of rate of return analysis to specific CRSP Projects" Proceedings of the International Research Meeting of the Collaborative Research Support Program April 30 to May 3 ,1990, Michigan State University East Lansing.

"The rate of return is the maximum interest that a project could pay for resources used if the project is to recover its investment and still break even" (Gittinger, 1982 by Schwartz et al). In their evaluation of the bean/cowpea project they consider the gains from yield increases, as well as the returns to education by computing the cost of education versus the cost of importing expertise and returns to training, both monetary and non monetary benefits. Both point out that it is important to list those benefits, intangibles, that are not considered in a classical rates of return analysis. They obtain a rate of return of 63 percent, that is greater than the World Bank's (8-15 percent) and USAID's (11 percent) acceptable range. Economic surplus models are a step up because assumptions of constant prices are dropped, and market conditions as well as policy distortions can be introduced (Norton, Pardey and Alston).

Outline of returns to research assessment

Goals and Objectives: Defining the goals and objectives of the research program is very important because these are the ones that the project should be measured against. For example, if the goal is to raise the average level of well being, the appropriate measure would be the average income, and how it changed with the existence of the project. The goals and objectives for each SR-CRSP project being evaluated should be stated clearly, and the means and measures of obtaining these should be specified (Norton, Pardey, and Alston).

The program goals need to be identified and presented to be used for the assessment. This leads to the type of products developed by each project and how they meet the defined goals. The role of social science research should be analyzed to define how it contributed to the direction of the research, the acceleration of the adoption process, the use of resources in an effective way[86]. Training is considered to pursue human capital and institutional development. A list the

[86] Two questions are considered in the case of Indonesia: 1. How did social sciences contributed to a more effective nutrition and breeding program, and 2. How would results be influenced by higher or faster adoption rates.

people trained, publications, capital investment, costs of training, and expenses of having resident scientists overseas need to be included. Constraints to this report is the availability of information. In order to assess the value of the program, the following question can be posed: What percent of productivity increase would be required to cover the costs of the research program?

The model used to evaluate these products: The election of the approach is constrained by the type of data available. Estimates of time-specific changes in the value of production or inputs saved due to the research are needed. There are different variants of the analysis depending on the availability of information. The analysis can be of the simple variant to the most complete form. Time and resources will determine the approach used. The simple variant identifies yields and per unit cost effects, attaches probabilities of success to the research as well as the adoption and adoption ceiling. This approach is appropriate for project evaluation of improved technologies. Information required consists fo base prices and quantities.

The intermediate variant, used for ex-post studies or priority setting of research, requires estimates of commodity specific price elasticities of supply and demand, of the quantities traded internationally, and agricultural policies. A more complete variant includes detailed information on the distributional effects through the marketing chain. In the case of the intermediate variant of the economic surplus model the price elasticity of demand and supply are needed. An estimate of K (the cost change where K is the vertical shift of the supply curve), J (yield) and the probability of success of the research, as well as estimates of adoption rate need to be included. A shift back of the supply curve (C) is the change in cost of the inputs, roughly:

$$J-C=K$$ [87]

Total economic surplus in each year is:

$$TS = KPQ(1+.5KZ)$$

where:

$$Z= en/(e+n)$$

[87] George Norton provided this information.

here e is supply elasticity and n is own-price elasticity of demand.

The natural increase in demand every year is equal to

$$D = p + mg$$

here

is growth rate of the population, m is income elasticity of demand, g is gross domestic product GDP) per capita growth rate. The cross price elasticity effects with respect to quantity of other products could be included if price changes in substitutes are anticipated.

The next step is to identify the market and the policies that influence the output. Is the market closed, open, or restricted? Are there policies affecting the prices or quantities of the products assessed? Are there other substitutes affecting the products and their value? All these questions need to be answered in order to define the setting for the evaluation.

Collecting the data and information: Quantities and prices of the research commodity being analyzed for a base year, the elasticities of the identified markets, and interviews with scientists to determine yield changes, cost changes, research success, adoption rate, and ceilings in adoption are necessary[88]. Because of variability, an average of four or five years is more appropriate than one year values. Information on prices and quantities produced at the regional level may be collected to identify differences between region. Trade (import and export information) statistics and regulations are necessary to define the market setting. Collection of consumption information (especially if an effect exists on the price), and policies affecting prices of commodities produced are need to model the markets properly.

Price elasticities of supply and demand as well as income elasticitieis of demand are required for those commodity prices influenced by the research. Excess supply and demand elasticities are required for those commodities for which a country can influence world prices. If only income elasticities of demand are available. Theoretical assumptions and conditions can be used to determine the size of other elasticities. For example, the sum of income cross price and own

[88] An example of the questionnaires used in interviews appears in the appendix.

price elasticities is equal to zero, own price elasticity of demand is negative, the sum of cross price elasticities is positive and income elasticity of demand is positive. This means that own price elasticity has to be slightly greater than income elasticity. When expenditure elasticities are available the demand elasticity (n) is equal to

$$e_i(A_i - (1 - A_i e_i/w))$$

where:

e_i is the expenditure elasticity of demand for commodity i (roughly equal to e_I, A is the proportion of budget spent in commodity i, and w is the money flexibility. This is the approach used by Valdivia[89] to estimate missing textile demand elasticities.

The formula for excess supply elasticity when an open trade market is considered is

$$e_x = e(S/X) + n(D/X)$$

where:

e is supply elasticity and n is demand elasticity. Excess demand elasticity is $n_x = e(S/M) - n(D/M)$ (import of the commodity is M). This fromula is relevant in the case of SR-CRSP modeling in Kenya and Peru. In the case of Indonesia, it could be considered if policies to develop exports of mutton [90] become a reality in Indonesia. However, given the rapidly increased imports of meat, this is not likely.

The appropriate discount rate to determine the social opportunity cost of research funds must also be adressed. The rate should be a real rate of interest discounted for inflation (five to twelve percent). This should also reflect any restrictions placed in alternative uses of the funds (Alston, Pardey and Norton). World Bank and USAID rates will be considered. Research costs

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[89] Valdivia, Corinne "Impact of Government Policies on the Small Ruminant Sector of Peru" Unpublished Ph.D. dissertation. University of Missouri Columbia. 1990.

[90] Soedjana, Tjeppy. "Economics of Raising Small Ruminants" Chapter VII in Draft of Potential SR-CRSP Publication formerly Goat and Sheep Production in Indonesia edited by Manika Wodzicka-Tomaszewska, Susan Gardiner, A. Djajanegara, and T.R. Wiradarya. Sponsored by Directorate General of High Education, International Development Program of Australian Universities and Colleges, and Gramedia. Indonesia. Forthcoming.

considered in this analysis are those invested in the SR-CRSP from 1981 through 1990. Norton, Pardey and Alston suggest considering percent consumption at home of the commodities produced, when distributional issues are considered.

Expected per unit cost reduction or yield increase:

Estimating and calculating the cost reductions of a yield increase will be based on two sources, the research already developed, and estimates of cost changes gathered from the experience of researchers if no previous analysis has been done. In some cases it is possible to develop commodity enterprise budgets with old and new technologies. Proportionate cost reductions can be calculated with this information. If yield changes can be computed, scientists should be asked what additional inputs are required to obtain this yield to net out the additional costs. If there are quality changes, different prices should be considered. In the case of Indonesia's Outreach Pilot Project cost calculations are made with the economist that participated in the project.[91]

The probability of research success depends on a large array of factors including the characteristics of the commodity in its particular locations, the type of research envisioned, the quantity and quality of research workers available, level of support etc. Scientists are the best source for this type of information. In the case of Peru, the probability of research success depends on changing the conditions of research in the highlands, combined with the amount of resources available for research. For ex-post studies, probabilities of success are known since the research has been completed. When research has not been concluded, this estimation is necessary. Level of adoption that considers geographical spread, and the time rate of adoption are needed to determine level and distribution of benefits. It is important to know site specificity and recommendation domain.

In the specific case of this study, scientists and extension workers were asked to predict the ceiling of adoption, and what the likely pattern will be. Questionnaires to gather the information were prepared. Information was collected on research costs to determine if the national research

[91]Atien Priyanti, MS, University of Arkansas and researcher at RIAP.

institutes are able and willing to take over the research when the SR-CRSP phases out.[92]

Estimating the Returns of Research to Producers and Consumers

Norton et al. [93] derives the equations used to calculate the distribution of the gains or returns to research. Total surplus, as well as consumer and producer surplus were calculated as a function of base prices and quantities, demand and supply elasticities, and the vertical shift in the supply curve, measured as a unit cost reduction. Parallel shifts are assumed. The equations are:

Change in consumer surplus:

$$CS' = PQZ(1 + 0.5ZN)$$

Change in producer surplus:

$$PS' = PQ\,(K-Z)(1 + 0.5ZN)$$

where: $Z = (ke)/(e+N)$

e:supply price elasticity

N: demand price elasticity

K: vertical shift of supply function expressed as percentage of initial price

P: original price

Q: original quantity

': change

If a pivotal shift of the supply curve is assumed the CS and PS are as follows:

$$CS' = ZPQ\,(1 + 0.5ZN)$$

$$TS' = 0.5KPQ\,(1 + ZN)$$

$$PS'' = TS' - CS'$$

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[92]Key questions asked;

- What is the probability that the research will be successful?
-If the research is successful, how soon will the results be available, how widely applicable will the results be, and how long will they be used/
-Once adopted, how much will the results of research contribut to changes in productivity?

[93]Norton, G., P. Pardey and J. Alston (forthcoming).

When working with more than one level in the production chain, total surplus will be the same, but depending on which part of the chain one chooses to do the analysis, who falls within the producer surplus and the consumer surplus will then be defined; in other words it will determine whose benefits are included in producer and consumer surplus.

With multistage production systems, like in the case of multimarket settings, the elasticity of substitution between marketing services and farm products in determining the distribution of research benefits between the three stages of production is important. The model developed by Freebairn et al.[94] is not restricted to linear supply and demand curves, and does not assume a zero elasticity of substitution. A parallel shift of the supply curve due to research is a assumed as well as a perfectly elastic supply of marketing services. The relative size of the elasticity of substitution between inputs and the demand elasticity for the product will determine who receives the benefits of research. If there is a downward shift in the supply of marketing inputs as a result of research, and the elasticity of demand is greater that the elasticity of substitution, farmers loose. To calculate gains or losses, a linear demand function and a parallel supply shift are assumed. The supply of marketing services is perfectly elastic. The gains to farmers are:

$$Gf = F\ Pf\ EPf\ [1 + 1/2\ (EF)]$$

where:

F is level of farm output, EF is proportional change in farm output, EPf is the proportional change in farm price, Pf is the farm price, and G are the gains to farmers.

The gains to consumers:

$$Gc = -QPEP\ [\ 1 + 1/2\ (EQ)]$$

where:

Q is total output, P is consumer price, EP proportional change in consumer price, and EQ is proportional change in output.

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[94]J.W. Freebairn, J.S. Davis, and G.W. Edwards. "Distribution of Research Gains in Multistage Production Systems: Comment AJAE 65(1983): 357-359.

The authors show that as there are differences in the distribution of research depending on the origin of the shift due to research, it will make a difference if the shift is a result of research in the marketing chain or at the farm level. "Farmers may benefit from research beyond the farm gate, but they may lose - even in a world of parallel shifts of linear functions. Farmers will obtain a greater proportion of total benefits from research at the farm level than from research which causes an equivalent shift of the supply of marketing services, whenever elasticity of substitution is not zero." (Alston and Scobie[95], P. 356) Farmers then should not be indifferent to which stage of the production the levies are paid, because all are not affected in the same manner. Transfers from farmers to consumers, when research at the marketing stage is financed by levies at the farm level, can take place. It is important to understand the impact of the coefficients when there is interest in determining the distribution of research gains.

When estimating returns to research, it is important to understand that lags exist between the research and development of technology and its adoption. These lags tend to be larger in the case of livestock research, due to the nature of the multiplication process, and it will also vary depending on the nature of breeding, health, management and nutrition requirements. Some of the technologies developed can be introduced faster than others. The faster they are introduced and the greater the impact in the first years, the larger the returns will be. The pattern of adoption will also have an impact on the size of the returns; if a greater weight is put in the first years it will have a greater impact than if the opposite is true.

In animal breeding, two elements are crucial: the length of the research (being able to reproduce numbers is constrained by the reproduction cycle), and the multiplication factor that shows a geometric pattern with a greater weight as time increases. All these factors must be taken into account when estimating or predicting the patters of adoption once the research lag and development lag have been overcome. The research lag is a result of the research process and generation of pre-technology knowledge, the development lag corresponds to the time when the

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[95]J.M. Alston and G.M. Scobie. "Distribution of Research Gains in Multistage Production Systems: Comment" AJAE 65(1983): 353-356.

pretechnology results are incorporated into useful technologies, and the adoption lag is the period between the release of the technology and maximum adoption by the producers. Net annual benefits of research are negative (costs) in the two first stages and in part of the third stage, until benefits offset the costs of research. (Norton, Pardey and Alston)

The supply shift selected for this study is parallel and vertical. The theory behind this selection as well as the theories reviewed on the selection of the type of shift are presented. The nature of the supply function used in the analysis is also reviewed. For partial and multimarket models several assumptions about the behavior of markets are made. The intent of the following review is to spell out these assumption and their implications. When multimarket evaluations are done, several assumptions are made about the industry production function and about the type of supply shifts. In the next two sections a brief review of the theories that support the use of supply functions and the shifts is presented.

The Nature of Supply Shifts

Lindner and Jarrett[96], Rose[97], Wise and Fell[98], and Freebairn, Davis and Edwards[99] describe the nature of the shift of the supply function. The center of the discussion is the type of supply shift that takes place, either parallel or pivotal and the importance of this in the measurement of the gains to producers and consumers. The implications of assuming imperfect competition is addressed by the last three authors. They affirm that the assumption of perfect competition is

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[96] Lindner, R. and F. Jarret. "Supply Shifts and the Size of the Research Benefits" AJAE 60 (1978): 48-58.

[97] Rose, R."Supply Shifts and Research Benefits: Comment".AJAE 62(1980): 834-837.

[98] Wise, W. and E. Fell. "Supply Shifts and the Size of Research Benefits: Comment" AJAE 62(1980): 838-840.

[99] Freebairn, J., J. Davis, and G. Edwards. "Distribution of Research Gains in Multistage Production Systems" AJAE 64(1982): 39-46.

a good approximation to all markets. This needs further discussion since the nature of the markets in Peru may be imperfect. The authors imply that the structure of the market and the level at which an innovation is introduced will not distort the orientation of the benefits. Lindner and Jarret recognized that the nature of the supply shift impacts the total benefits obtained. Davis and Norton[100] show how the computation of the surplus has changed so much, depending on the size nature and assumptions made about the shifts of supply. Divergent and pivotal shifts result in fewer benefits to producers, and Duncan and Tisdell[101] show that producer's impact is negative when demand is inelastic.

Renkow[102], analyzes the welfare effects of technical change in developing countries with a simulation approach, focusing on the impact of technological improvements by regions. He assumes a parallel shift of the supply function in the region due to a technological innovation. He adheres to the findings from the discussion of Lindner and Jarret, and Rose that conclude that the only realistic strategy is to assume that the supply shift is parallel.

In order to measure the returns to research a crucial issue is to establish the size of the supply shift. Besides the discussion with respect to the type of shift, either parallel or pivotal, there is also a discussion about measuring the shifts horizontally or vertically. Many project level evaluations use yield information obtained at the experiment station level to calculate the shift of the supply curve. This is defined as the horizontal shift, and it is used without understanding the relationship that exists between it and an actual supply shift. Davis and Bantilan [103] review

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[100]They also show the nutritional impact approach to evaluating research.

[101]Quoted by Davis and Norton, Duncan R. and L. Tisdell "Research and Technical Programs: The Returns to Producers" Econ. Res. 47(1971):124-129.

[102] Renkow, M. "Differential Welfare Effects of Technical Change in Developing Countries: A Simulation Analysis" AAEA Meetings, July, 1989.

[103] Davis, Jeff and Ma Cynthia Bantilan "Agricultural Production response and cost structures: Cost Reduction and Output Increasing Linkages for Research Impacts". Australian Center for International Agricultural Research and International Service for National Agricultural Research (ACIAR ISNAR Project Papers). February 1992.

the history behind the use of horizontal and vertical supply shifts. Vertical shifts are determined by estimating the cost reduction at the pre-research output level, while horizontal shifts are estimated by the output increase at the pre-research price level. Akino and Hayami[104] approximate the shift by using the following relationship:

$$h = (1+es)g$$

where:

h is the proportional horizontal shift in the aggregate supply (price is held constant)

es is the own price elasticity of supply;

g is the rate of shift in the production function (assuming same level of inputs).

Edwards and Freebairn [105] stressed the importance of using the vertical shift showing the relationship that existed between it and the horizontal shift:

$$k = h/es$$

where:

k is the proportionate reduction in unit cost of production taking pre-research cost as the base;

h is the proportionate increase in production with the pre-research production level as a base;

es is the own price supply elasticity (Davis and Bantilan).

This implies that if k=h the supply elasticity is equal to one. In many countries this is not true. They point out also that this relationship is very sensitive to the type of coefficient that is used, which is a problem when there are difficulties estimating it or when secondary sources are used. When difficult to estimate, Edwards and Freebairn indicate that it is preferable to use the cost

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[104] Akino, M and Hayami, Y. "Efficiency and Equity in Public Research Rice Breeding in Japan's Economic Development" American Journal of Agricultural Economics. 57 (1975):1-10.

[105] G.W. Edwards and J.W. Freebairn "The Social Benefits from an Increase in Productivity in a Part of an Industry" Review of Marketing and Agricultural Economics, 50 (1982):193-210.

analysis approach. Arguments in favor of this position were given by Lyman and Jones[106]. These include the Akino and Hayami equation which assumes constant elasticity and neutral technical change of the production function; that usually supply elasticities are difficult to estimate and analysis relies on secondary information; and that use of experiment station information on production response in many cases has proven to be a poor estimate of actual output increases due to research. In this latter case an argument may be made for coefficients developed on farm trials, as these may be better approximations of the actual output increases due to research.

Davis and Bantilan review the relationships between h, g, and k. They show that h is different from g and k, and maintain that a cost reduction shift is a better approximation to gains of research. The supply elasticity coefficient, the price used to estimate cost reduction (if it does conform to price=marginal cost at the farm level, or if it includes other costs), cost reductions greater than a hundred percent, g is smaller than h are factors pointo to a unit cost approach. Approximations of k can be obtained by having estimates of total costs before and after technical change at original level of output but lower level of inputs (assuming only one variable input).

Research experiments often assume some inputs fixed, others assume some inputs free (labor for example) and others assume neutral technical change when this is not the case. All this leads to caution when choosing yield information, cost information and trying to establish the relationship between this and the true shift of the supply function as a result of research. Some information can overestimate h, and in other case using g can underestimate h. This means that caution should be used when using h as the source of information for the shift of the supply function. They conclude that the scope of error is reduced when using vertical supply shifts. Care should be taken to understand the relationship between unit price observed and the unit cost.

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[106]Lyman, J.K. and P.G. Jones "The Measurement of the Gains from Agricultural Research, Again" Mimeographed Report CIAT, December 1985, cited by Davis and Bantilan, 1991.

Norton, Pardey and Alston[107] point out that "A key piece of information for any research priority setting study is the expected per unit cost reduction or yield increase that would result from successful completion of the research". These cost reductions can be calculated using budgets for the old and new technology. In many cases of exante evaluations, a survey is conducted to get rough estimates of cost reduction or yield increase, and the additional cost that this involves.

In developing models for surplus evaluation, the nature of supply shifts, market behavior and dynamics of the system are analyzed. In many cases the supply and demand coefficients are not available for the market level being analyzed. Knowledge of the market behavior, for example the derived demand, can be used to calculate unknown demand coefficients. Hall, Lan, and Schmitz[108] analyze the wholesale retail marketing margin and the concentration of the beef industry. They find that the degree of concentration in the market does appear to influence the price-cost marketing margin. Freebairn and Rausser[109] analyze the effects of changes in the level of beef imports. This product is not a substitute of fed beef. They develop an econometric model of simultaneous equations, analyze stability conditions and find the impact multipliers to analyze the change in the import quota level. They deal with the problem of undersized samples. Whipple Glen and Menkhaus develop a supply response model for the U.S. sheep industry. Their model is dynamic, at least their theoretical model is.

The development of the methodology and the procedure to obtain the multipliers is explained by Reutingler (1966), "The Analysis of a Dynamic Model, with Particular Emphasis on Long Run

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[107] Science Under Scarcity: Theory and Practice for Agricultural Research Evaluation and Priority Setting by George W. Norton, Philip G. Pardey and Julian M. Alston (expected published date 1992).

[108] "Beef Wholesale-Retail Marketing Margins and Concentration" Economica 46(1979): 295-300.

[109] Freebairn J. and G. Rausser. "Effects of Changes in Level of U.S. Beef Imports" AJAE 57(1975): 676-688.

Projections".[110] Gardner[111], in the farm-retail price spread in a competitive food industry, addresses the problem of input substitution and the effect of policy, as opposed to the case where substitution is assumed to be zero. A comparative statics frame work is used for this analysis.

Training and Institutional Development

On measuring the returns to training several problems have to be taken into account. Many studies which tried to measure these returns have found these are negative in developing countries when only salaries are considered. Measuring the externalities that accrue to society are difficult to measure[112]. Salaries in government research institutions and national universities are set and controlled by the government (Shoresman). In many cases there is the added problem of high inflation rates that reduce, in estimation, the real value of their salaries. Hence this becomes a difficult variable to measure returns to education or training. An added problem in measuring impact is the time factor. Human capital development and capital goods investment contribute to economic development with a lag of 5 to 10 years according to McMahon[113]. Many reasons are pointed out for this lag, such as searching for job on return to their countries, time to reach decision-making posts, etc. Measures of productivity such as journal articles and publications, and consulting activities can be used as proxy.

Schwartz and Oehmke's paper mentions an approach to introduce the returns from training by

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[110] Reutingler, S. "The Analysis of a Dynamic Model, with Particular Emphasis on Long Run Projections" Journal of Farm Economics 48(1966): 88-106.

[111] Gardner, B. "The Farm-Retail Price Spread in a Competitive Food Industry" AJAE 57(1975): 399-407.

[112] Michele Wagner Shoresman "Returns to Education: The University of Illinois --People's Republic of China Visiting Scholars Program" Unpublished Ph.D. Dissertation. University of Illinois at Urbana, Champaign. 1989.

[113] Walter McMahon, Earl Yates et al. "Economic Analysis of Human Resource Development" and "Cost estimates and Financial Plan" in Malawi Institutional Development Project Paper ed. McMahon, Yates and others (Washington D.C.:USAID Mission, Malawi, July 1987).

omputing the salary and other benefits received by the graduate degree trainees that return to heir institution and consider the latter the lower bound in the supply of researchers (price). nformation on expatriate researchers that are hired when local researchers are not available should also be used to determine the upper bound of the value of trained scientists. Included in this cost should be moving and housing expenses as well as transportation in country. The ssumption is that a perfectly elastic demand and an upward supply curve of labor exist. The cost of training in the US, host country labor services required to replace nationals being trained, and expatriate supply costs are all imputed costs. Schwartz and Oehmke considered a 20 to 30 year stream of benefits, assuming that scientists return and stay active in the same area of research or within agriculture.

If the labor market is believed to be efficient, then the salary base should be used and a percent equivalent to that produced by the returns to agricultural research in the area of specialty should be added. If you believe the markets are not efficient then use the above mentioned method to estimate the lower and upper bounds of price of trained researchers[114]. At present, information about investments on expatriates and people trained will be presented. An evaluation of returns to education is beyond the scope of this report.

Measuring the Return to Research Through Training

Many products can be listed, although a value cannot be assigned to all products. Some outcomes, such as training can be measured as savings in expatriate researchers as a result of returning graduates, or in terms of the private returns. But if social returns are to be assessed, probably a measure to be used is to demonstrate that researchers trained abroad generated research which increased production at the national level by one percent. Another method is to determine how much increased production would be needed to pay off the training costs. In this case it may be more appropriate to list the people trained, the publications generated, the costs of the program and define what will be the percent increase in productivity required to pay the

[114] Conversation with James Oehmke, papers follow.

cost of the program. The products that can be listed may include some that contribute to knowledge and may contribute to increased productivity in the future but not at the present.

Social Science Contribution: The time dimension, lags and returns to research evaluation

Important points are raised by Schwartz and Oehmke that apply to farming systems projects, especially that of management time in Peru. The main contribution of the community project was to look for effective means of introducing technological change by identifying institutions that could accelerate that process, and hence shorten the time between the research and development phases and the beginning of the stream of benefits. A second point is to recognize that economic policies affecting relative prices of both farm inputs and output, subsidies and exchange rates all have an effect on the returns to agricultural research (P.80). A point to keep in mind when using their approach, as they mention, is that their methodology does not separate out returns for each project. This is crucial because having projects of such a different nature (time wise) such as breeding, health, nutrition, and management, as well as training, does not enable us to identify which areas of research are more effective for each country.

ommodity and research area lists for each project should first be outlined. In the case of ndonesia results from the Outreach Pilot Program (OPP) and breeding for high prolificacy sheep Java will be evaluated. Cirebon, Garut, and Ciburuy are locations where on-farm trials were arried out. The OPP farmers are located near Bogor. The purpose of the research was to ncrease income from small ruminants through improvement of management practices, breeding of high and low prolificacy lines, and increasing feed resources other than native grasses in an environment where high population density and land scarcity are constraints. Although the research was developed for sheep and goats initially, the research being assessed will only cover heep. An important goal, especially for the breeding program, was to build human capital to continue research on small ruminants when the SR-CRSP was closed in Indonesia.

Research in Indonesia started both in goats and sheep, but the interests of the Indonesian researchers emphasized sheep, turning the program in Bogor towards the study of prolificacy and nutrition. An understanding of the farm feeding practices and the development of alternative feed sources was carried out in Java and continues to be studied in Sumatra under different production conditions. On-farm research was conducted in West Java and management practices were introduced at the farm level through the Outreach Pilot Program. SR-CRSP research now continues in North Sumatra.

Evaluation Model

Selection of the approach is constrained by the type of data available. Estimates of time and specific changes in the value of production or inputs saved due to the research are needed. The economic surplus model (intermediate variant[115]), used for ex-post studies or priority setting of research, requires estimates of commodity specific price elasticities, of supply and demand, quantities traded internationally (if there is an open economy) and agricultural policies. An

[115]Norton, Pardey and Alston, (forthcoming).

estimate of the cost change (K, where K is the vertical shift of the supply curve), J (is yield change due to the technology) and the probability of success of the research (if the research has not concluded), as well as estimates of adoption rate need to be included. K is calculated by determining the unit change in the cost of production due to the introduction of the technology at the original level of production.

Total economic surplus in each year is calculated with the following formula:

$$TS = KPQ(1+.5KZ)$$

where:

$$Z = en/(e+n)$$

where e is supply elasticity and n is price demand elasticity.

The natural increase in demand every year is equal to

$$D = p + mg$$

where

p is growth rate of the population, m is income elasticity, g is GDP per capita growth rate. This is used, to shift the demand function each year. Adoption of technology will shift the supply function, and population and income growth rates will shift the demand function. These shifts take place until the adoption ceiling has been reached. Markets and policies that influence the output are identified. The market for mutton is closed at present, meaning that currently no exports or imports are taking place. There are policies in place affecting possibilities of export.

Data collection for this evaluation: Quantities and prices for a base year, the elasticities of the identified markets, and interviews with scientists to determine yield changes, cost changes, research success, adoption rate, and ceilings in adoption are necessary.[116]

Some of these statistics were collected in Indonesia. An important set of data were obtained

[116] An example of the questionnaires used in interviews appears in the appendix.

ɔm Dr. Philip Pardey at International Service for National Agricultural Research[117] (ISNAR), ɔo was at the time working with the government of Indonesia[118] on the ex-ante evaluation of ɛsearch in agriculture.

rice elasticities of supply, income, and price elasticities of demand are required for those ɔmmodity prices influenced by the research. Income and demand elasticities were obtained ·om various studies, and from a review done by Dr. Pardey's project[119]. The supply elasticity sed in the surplus model was estimated by Nu Nu San[120]. To determine shifts in demand, ɪojections of population and income growth are required. Population and Gross Domestic ᴾroduct per capita were obtained from International Financial Statistics (International Monetary ᴾund) and the Handbook of Economic Statistics (United States Central Intelligence Agency).

The discount rate used to determine the social opportunity cost of research funds should be a real rate of interest discounted for inflation. This should also reflect any restrictions placed on alternative uses of the funds (Norton, Pardey and Alston). World Bank and USAID rates will be considered. The ranges are between 8 and 15 percent for World Bank and 11 percent for USAID (Schwartz et al).

Research costs were collected from the research program Management Entity. Budgets from each institution in the U.S. from 1980 through 1990 were received to obtain information on the

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[117] Sjaiful Bahri, Wilhelmina Eveleens and Rita Nur Suhaeti. "An Economic and Technical Data Base for Priority Setting within AARD Indonesia". ACIAR Workshop on "Designing Information Systems to Support Research Priority Assessments in Agricultural Research: Concepts and Practices for International and National Level Institutions". Ming Court Hotel, Kuala Lumpur, Malaysia, 28-31 May 1991.

[118] Central Bureau of Statistics, and SUSENAS.

[119] Philip Pardey, Senior Officer. ISNAR. Regional Research Project Asia. "Priority Setting Mechanisms for National Agricultural Research: Indonesia Study", AARD-ISNAR.

[120] Graduate Research Assistant, Department of Agricultural Economics, University of Missouri Columbia, 1992.

level of the grants allocated to each country (Indonesia in this case), the one budgeted for the U.S. and the level of money spent in training graduate students from Indonesia and the U.S. between 1981 and 1990. The costs in the second cost column of table 5 are overestimated because all the U.S. funds were charged to Indonesia, while in reality U.S. scientists worked in more than one country. In the case where the component phase-out took place, and when projects started working in the hair sheep component in North Sumatra, percentages were calculated based on the opinions of the principal investigators. The costs are presented in the appendix. They include research funds, travel, training and U.S. portions of the budgets of each institution. The returns calculated with these costs would yield information on marginal returns to U.S. investments. New costs are calculated that include Indonesia research training costs, a fourth of the costs in the U.S, and the cost of four full time researchers paid by the Indonesian government.[121]

The amount of income generated by small ruminants in Indonesia are reported in several papers. Increase in productivity has an impact on both the amount sold and the amount consumed by the family. Small ruminants contribute between 15 and 25 percent to small farmer's incomes (Knipscheer, Sabrani, De Boer and Soedjana). Norton, Pardey and Alston suggest considering percent consumption of the commodities produced at home, when distributional issues are considered. At present this information is not available.

Expected per unit cost reduction or yield increase

Estimating and calculating what the cost reductions of a yield increase will be are done using two sources of information; the research already developed and estimates of cost changes gathered from the experience of researchers if no previous analysis has been done. In some cases it is possible to develop commodity enterprise budgets based upon old and new technologies. Proportionate cost reductions can be calculated with this information. If yield

[121]I thank John DeBoer for this suggestion. Infomration on costs of RIAP researchers was obtained from "Research Programming in the Central Research Institute for Animal Science, Agency for Agricultural Research and Development, Indonesia", by DeBoer, John, Winrock International Institute for Agricultural Development. Morrilton, AR. July-August, 1992.

changes can be computed, scientists should be asked if additional inputs are required to obtain this yield in order to net out the additional costs. If there are quality changes, different prices should be considered. In the case of Indonesia's Outreach Pilot Project calculations are made with the economist that participated in the project[122].

The probability of research success depends on a large array of factors including the characteristics of the commodity in its particular locations, the type of research envisioned, the quantity and quality of research workers available, level of support, etc. Scientists are the best source for this type of information. In the case of the OPP, the technology has been successfully tested. The probability of research success is one hundred percent. In the case of breeding research, controlling prolificacy to adjust to management requirements, identification is possible. The research is currently focusing on DNA testing to accelerate the selection process. Probability of success of this line of research is not yet 100 percent.

Level of adoption should consider geographical spread and the time rate of adoption to determine level and distribution of benefits. It is important to know site specificity and recommendation domain. The detail ex-ante evaluation being carried out by Pardey and Wood on research in Indonesia provides information of geographical regions where small ruminants can be introduced or where returns to investment in small ruminants is greater[123]. An initial calculation of the returns only considers impact in West Java with a peak adoption of 20 percent, using the SR-CRSP cost column of table 5. Researchers at RIAP were confident that the technologies developed and tested at the OPP could be adopted in other regions like Sumatra.

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[122] Atien Priyanti, Agricultural Economist RIAP, at the time (1991) completing her M.S. in Agricultural Economics at University of Arkansas.

[123] Philip Pardey and Stanley Wood. "Targeting Research by Agricultural Environments". Paper prepared for World Bank Conference on "Agricultural Technology: Current Policy Issues for the International Community and the World Bank", Airlie House, Virginia, 21-23 October, 1991.

Research lags were estimated by Pardey, Eveleens, Abdurachma, and Hermanto[124]. Research lag for management and nutrition for sheep is three years, for breeding and genetic improvement it is ten years from the time when research is successful, and for health research it is four years. Expenditures in research by RIAP (which includes donor funding) on breeding is almost 60 percent,in management and nutrition it is around 27 percent and is approximately 15 percent in health. Expenditures in post production research are approximately 15 percent of commodity research expenditure.

A second adoption pattern that includes other provinces of Indonesia is simulated. Pardey and Wood[125] developed a model for ex-ante evaluation that identifies spillovers of research across Indonesia. The final results have not been obtained, but they will be used in the future to determine the potential expansion of technologies developed in West Java to other provinces of Indonesia. The simulation considers spillover of the OPP results to Java and Sumatra. This is done by increasing ewes available by 19 percent over the amount West Java posseses.

Scientists and extension workers were asked to predict the ceiling of adoption, and what the likely pattern will be. This was a very difficult notion for researchers. This is why information on adoption from the OPP and the ex-post evaluation were used to give an estimate of adoption rate and pattern. Questionnaires to gather the latter information were prepared. This preliminary analysis considered two scenarios. The first one was an adoption peak of twenty percent which is reached in 12 years, and a second scenario where the peak is reached in 10 years. Information on research costs, budgets, and investments was collected to determine if the national research institutes are willing and able to take over the research when the SR-CRSP

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[124] Draft of "Public Investment in Indonesian Agricultural Research and Extension", provided by Philip Pardey. The research and development lags reported coincided with information obtained from researchers at RIAP.

[125] Philip Pardey and Stanley Wood "Targeting Research by Agricultural Environments" prepared for "Agricultural Technology: Current Policy Issues for International Community and the World Bank" Airlie House, Virginia 21-23 October, 1991.

phases out[126].

Additional costs per sheep on a yearly basis[127] included drenching, barn separations, salt, and a water bucket. Additional costs per sheep were 270 Rp. per head per year. Initial barn construction with a five year depreciation for ten sheep was 125,000 Rp. A depreciation per year per ten sheep was 25,000 Rp. We assumed that no other purchased inputs were used. With the management and nutrition techpack the costs were 27,700 Rp. per year for ten animals. At the original level of production, costs per sheep were 8,300 Rp. With the new technology, at previos level of production the cost is 6,155 Rp. per sheep. This calculation also assumed a yield increase of 50 percent and a mortality rate of 11 percent. The per unit cost change (K) is 25 percent. These estimates affect the assumption of a unit cost reduction, i.e. a vertical shift.

Adoption rate peak was predicted to be 20 percent for the farmers in West Java, assuming that ewes available were 39.14 percent of the animals. This was based on the records kept by the OPP. Inventoried animals estimated for 1989 were used as the base. The price used was a weighted average price of rams and ewes reported by Soedjana and Priyanti for 1989. The report stated that 66 percent of the animals sold were male and 34 percent were female. The price for a male ram was 78,400 Rp. and 72,250 Rp. for a ewe. These represented 66 percent of the sales. Younger animals were sold at an average price of 46,150 Rp. (34 percent of the animals sold). This was used to calculate a weighted average price of 65,500 Rp. An exchange rate of 2,265 Rp./dollar was used. This determined a price of 28.91 dollars per sheep, which was used as the base price.

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[126] Key questions asked:

- What is the probability that the research will be successful?
- If the research is successful, how soon will the results be available, how widely applicable will the results be, and how long will they be used?
- Once adopted, how much will the results of research contribute to changes in productivity and output?
- What are the costs of research and how are they distributed over time?

[127] Atien Priyanti, OPP/Economics Researcher, RIAP.

The supply elasticity employed was 0.3 (Nu Nu San)[128], the demand elasticity was -1.03 (uncompensated demand elasticity for meats, by Johnson et al. 1987).[129] The income elasticity was 1.6 (Sarma).[130] Population growth rate was 1.8 (1990) and GDP growth rate was 0.1 percent (1990). The sources of information can be seen in the references. The SR-CRSP budgets and production and consumption statistics are also included. Costs budgeted for the SR-CRSP in Indonesia and these attributed to West Java are presented in table 5. These costs include training, research travel, and U.S. research expenses for the four U.S. institutions. The total costs for West Java include SR-CRSP and RIAP research costs and training.

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[128]Nu Nu estimated a supply function for sheet and goats in Indonesia using data between 1970 and 1989 using a seemingly unrelated regression approach.

[129]Johnson, S., W. Meyers, H. Jenson, T. Tekle, and M. Wardhani, "Evaluating Food Policy in Indonesia Using Full Demand Systems", Final Report. Ames IA, Center for Agricultural and Rural Development, Iowa State University. 1987.

[130]Sarma, J.S., "Cereal Feed Use in the Third World: Past Trends and Projection to 2000", IFPRI Research Report 57. Washington, D.C. December, 1986.

Table 5

Budgeted costs of SR-CRSP in Indonesia between 1981 and 1990

Year	Total Indonesia[131]	Total SR-CRSP West Java[132]	Total West Java[133]
1981-1982	131,522	131,552	147,758
1982-1983	130,111	130,111	171,138
1983-1984	407,827	407,827	344,448
1984-1985	392,122	392,122	358,142
1985-1986	399,347	399,347	360,356
1986-1987	380,399	380,399	362,749
1987-1988	470,496	252,757	333,011
1988-1989	505,513	100,000	234,243
1989-1990	660,633	100,000	74,878
1990-1991	575,268	65,000	83,040

Source: Prepared with Annual Workplans and Budgets. See appendix.

The adoption pattern assumes a 10 percent adoption reached in 1997 and a 20 percent adoption in 1999, ten years after the technology was developed. This is a conservative pattern given that researchers in Indonesia mentioned in the discussions that the technology can be applied to fifty percent of the farmers in West Java, and that lags of three years are expected according to Pardey and Wood.

A lotus spreadsheet for a closed economy model with demand shift was used.[134] Costs and benefits between 1981 and 2005 were considered. Results using the animals of 1989 for West

[131]All the costs of SR-CRSP research and training in Indonesia: West Java and North Sumatra and U.S.

[132]All the costs of SR-CRSP research and training imputed to West Java and U.S.

[133]All the costs of SR-CRSP research for West Java, the costs of RIAP and training in the U.S. and Indonesia.

[134]The original spreadsheet was provided by George Norton and modified for the Indonesia case.

Java, and the costs and adoption patterns mentioned above, yielded an internal rate of return of 19.2 percent. The net present value was 2,925,652 dollars. If spillovers of research in management, reproduction, and nutrition are assumed to spread to other provinces, in this specific case of North Sumatra and Aceh,[135] the rate of return is 19.7 percent. If a lower animal base is considered in the analysis, 948,486 ewes (based on animal inventories of 1987) the rate of return is 17.4 percent. The net present value was $2,137,306 when the internal rate of return is 10 percent. If the inventories of sheep for West Java in 1987, 1988, and 1989 are added and an adoption pattern with a peak of 20 percent reached in 10 years is considered, an internal rate of return of 22.9 percent is obtained. If research spillover of 19 percent over the West Java ewe base is considered with the adoption peak and lags, the internal rate of return is 24.8 percent and the net present value (with a discount rate of 10 percent) is $5,013,874. When the cost information used includes the researcher costs paid by the Indonesian government, the rate of return is 19.3 percent for the last scenario. Consumer, producer and total surplus are presented in table 6.

Table 6

Consumer, Producer and Total Surplus of Indonesian Technological Package in Dollars

Year	Consumer Surplus	Producer Surplus	Total Surplus
1988	15,844	54,396	70,239
1989	16,148	55,442	71,591
1990	16,459	56,509	72,969
1991	84,171	288,987	373,158
1992	85,795	294,565	380,361
1993	175,664	603,113	778,777
1994	179,065	614,791	793,856
1995	368,235	1,264,276	1,632,512
1996	375,392	1,288,847	1,664,239
1997	382,687	1,313,895	1,696,583
1998	390,125	1,339,425	1,729,555
1999	397,707	1,365,460	1,763,167
2000	405,436	1,391,997	1,797,433
2001	413,316	1,446,628	1,867,976

[135]Small ruminants are being introduced. Roughly 150,000 sheep currently exist in both provinces.

Given the market conditions and supply and demand coefficients stated above, shifts in technology benefit producers more than consumers. This can be seen in the measures of producer surplus and consumer surplus calculated between 1988 and 2001. In the first year a 0.001 percent adoption rate was assumed. Consumer and producer surplus measures were used to determine the distribution of the gains of research. We wanted to determine this because the main target audience for the program was the producers of Indonesia. An elastic demand for meats, which is typical of this commodity in developing countries, with high income elasticity, yields positive returns to producers.

The marketing channels seem to be efficient. Producers tend to rely on marketing agents, rather than doing it themselves, basically to avoid the risk of returning home without having sold their animals. With agribusiness and fattening producers coming into the scene, it becomes necessary to understand the behavior of the processing industry in West Java and the type of derived demand behavior it will have. Under the present market conditions and assumptions made, and until regulations and facilites do not change to facilitate exports, gains from technological change will favor producers more.

Training in the Indonesia SR-CRSP

Graduate degree training was supported by the SR-CRSP[136]. Indonesian scientists involved with the SR-CRSP received 23 graduate degrees. Of these, 19 were directly funded and others are currently being funded; eleven at the masters level and an equal number at the Ph.D. level. Most of this training was done at universities in the United States between 1981 and 1990. Ten people received their masters degree training, and six researchers were trained at the Ph.D. level. Three of these degrees were in rural sociology, six were in animal nutrition, four were in animal science and breeding, and three degrees were in economics. The people trained until 1990 can be seen in Table 7.

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[136]Dolores Fernandez collected training information, which was later revised in Indonesia by the author.

There are currently two Ph.D. students being trained in the U.S., one in rural sociology and one in nutrition. A masters student in agricultural economics was supported by the SR-CRSP in Arkansas. Three students are being supported for their Ph.D. degrees.

Table 7

Degree Training of Indonesian Scientists in the SR-CRSP by Discipline

Discipline	M.S.	Ph.D.	Total
Rural Sociology	3	2	5
Agricultural Economics	2	2	4
Nutrition	4	4	8
Breeding	3	3	6
TOTAL	12	11	23

Source: Original data collected by Dolores Fernandez, and information collected in 1991 Indonesia.

Four of the five trained in rural sociology, and the four in agricultural economics were trained outside of Indonesia. Rural Sociology as well as economics are disciplines that are in short supply. Scientists returning with those degrees are in high demand in RIAP and AARD. The SR-CRSP also funded six bachelor degrees.

Dr. Argono and Dr. Sabrani (RIAP, Ciawi) provided valuable information about human research resources at RIAP. Only 9.9 percent of the researchers were from the socio-economic disciplines. There were 37 percent involved in breeding and 48.1 percent involved in nutrition. Reproduction research accounted for 17.3 percent and production for 21 percent. A current preoccupation at RIAP is the age distribution of their researchers. Currently 35.8 percent of the researchers have Ph.D. training, 39.5 percent have M.S. training, and 24.7 percent have a B.S. degree. Most of the Ph.D. researchers are close to retirement age. This is why RIAP considers training through the SR-CRSP very valuable to their institution, and to their ability to sustain

and improve their research.

Training and Contributions to the U.S.

A valuable contribution of the SR-CRSP to the U.S. is the training of the faculty and graduate studenty by having the opportunity to do research in other parts of the world. U.S. graduate students from all disciplines have been able to do their graduate research in Indonesia. The U.S. institutions involved in the High Prolific Sheep Component trained a total of ten doctoral students and fourteen masters students. In some cases the funding was provided for their graduate research. Other students that do not belong to other SR-CRSP host countries but do come from the developing world, were also trained; a total of four Ph.D. students and one M.S. student in the case of the University of California-Davis. Faculty from these institutions have had the opportunity to face and solve problems that would not have been thought of in the U.S, hence broadening their skills. Six faculty involved in graduate and undergraduate teaching have been involved in the Indonesia SR-CRSP at the University of Missouri at different times in the last ten years. Given the process of globalization and the role played by the United States, this knowledge is crucial today. The SR-CRSP contributes to the internationalization efforts in the universities that participate.

At North Carolina State the understanding of the biology and potential for sheep production in the Southern United States has increased. Many of the hair breeds and crosses appear to have adapted to the climatic conditions of the Southeast (Annual Report, NCS). Seven producers have purchased directly from North Carolina State approximately 250 hair sheep in the last two hears. These are being used primarily as seed stock for breeding year round, and for their resistance to internal parasites.

V. Institutions and Persons Involved, Acknowledgements

The SR-CRSP is a joint effort of the Republic of Indonesia and the United States Agency for International Development (USAID). The first nine years of the program concentrated in West Java. This collaborative effort on the U.S. side was carried out by four institutions involved in research and institutional development in four disciplines. The University of California, Davis (USD genetics and breeding), North Carolina State (NCS nutrition), Winrock International Institute for Agricultural Development (WI economics), and the University of Missouri-Columbia (UMC rural sociology) were the U.S. institutions involved in research and training. The counterpart institution is the Research Institute for Animal Production, RIAP (Balai Penelitian Ternak (BPT)) of the Central Research Institute for Animal Sciencs (CRIAS), Agency for Agricultural Research and Development (AARD) of the Ministry of Agriculture. The management entity is the University of California, Davis.

This research project, "The Small Ruminant Collaborative Research Support Program in West Java, Indonesia: Small Farmer Technologies and Economic Returns to Investments in Research-Final Report" was carried out by Corinne Valdivia, Research Assistant Professor a the University of Missouri-Columbia (UMC) with the support of Nu Nu San, graduate research assistant in the Department of Agricultural Economics at UMC. Principal Investigators that supported this project were Michael F. Nolan from UMC and Enrique Ospina from Winrock International (WI). Kevin Pond, Principal Investigator, NCS, and Eric Bradford, Principal Investigator, UCD, provided information about their research programs and training. Henk Knipscheer, Principal Investigator, WI, provided information, publications, and valuabel comments. John DeBoer, former principal investigator for economics (WI), reviewed the original draft and provided valuable and extensive comments.

George Norton from Virginia Polytechnic Intstitute and State University, Philip Pardey from ISNAR, and Stanley Wood, researcher in Indonesia, collaborated by providing information, sharing their data, and discussing the methodology and software used for the evaluation of the OPP and the SR-CRSP in West Java. In the U.S., Sri Wening Handayani and Atien Priyanti

laborated with the project.

e management entity, through Jim Scott and Mary Keane, provided the budgets from 1980 ough 1990 used in this evaluation. Joyce Turk, R&D at USAID was instrumental in arranging vel for author to Indonesia. Part of the information used in the training section was collected Dolores Fernandez at the University of Missouri-Columbia.

eppy Soedjana collaborated as the economics counterpart for the SR-CRSP in Indonesia. He ovided data collected by the economics projects to do an evaluation of the OPP in 1990. In donesia interviews were carried out with Sri Wahyuni, Subandriyo, T. Soedjana, M. Sabrani, rgono, Sri Wahyuni, B. Setiadi, A. Djajanegara, B. Haryanto, Kedi Suradisastra, I. Inounu, .. Prabowo, H. Prasetyo, K. Sutama, W. Mathius, M. Martawidjaja, S. Silitonga, and B. uparianto. Dr. Sabrani and Dr. Argono provided valuable information about research at RIAP. ri Wahyuni also participated in the interview of extension officers. Yanti and Pak Ocim were n important support for the field research in Bogor.

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VI. Other Resources

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Collaborating Scientists

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Dr. Michael Nolan, Principal Investigator, Rural Sociology, University of Missouri-Columbia
Dr. Henk Knipscheer, Principal Investigator, Agricultural Economics, Winrock International
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Dr. Argono, RIAP Ciawi
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Mr. Abdul Adjid, Animal Health OPP, Balitvet
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Ir. Teti, Program Planner Dinas Peternakan (extension), Bogor
Ir. Dahmit, Extension Dinas Peternakan, worked with OPP

erviews for economic surplus assessment of SR-CRSP technologies in Indonesia:

le of the Project:

erson Interviewed:

pecialty:

. Briefly describe the innovations developed through your research (if more than one line of research, please use on questionnaire per innovation)

2. How many scientists were working in this project (list names and field)

3. How do you measure the output and yield increase in your research (specify units, for example weight gain per animal)

4. Although the SR-CRSP has faced out from West Java, has the research been completed? Yes [ ] No [ ]

5. Was this research tested on-farm? Yes [ ] No [ ]

If the research was finalized, answer 6, if not answer 7

6. What is the yield, specify units of measure [ ].

   a. on research station _____
   b. on-farm _____ where _____
   c. before the innovation _____ where _____

   Do you have an estimate of the reduction in cost (per unit of production) [ ]

Sources for this questionnaire are Chapter Six "Implementing the Economic Surplus Approach" in Theory and Practice for Agricultural Research Evaluation and Priority Setting by George W. Norton, Philip G. Pardey and Julian M. Alston (forthcoming), and discussions with George Norton.

What is the extra offtake _____
What is the extra cost _____

7. Is the research being continued? Yes [ ] No [ ]

What is the expected increase in yield (per head) over the next five years if your research is successful (assume that current man power and resources will stay the same)

a. on research station _____
b. on-farm _____
c. before the innovation _____
d. when do you estimate the research will be completed _____

8. What is your estimate of increase in cost to the farmer (if any) of achieving the yield stated in 6 or 7

a. Does it require purchased inputs

b. Does it require additional labor or different timing of labor

9. If the research has been tested on farm, what type of farmers are using the innovation (describe the recommendation domain and how site specific the innovation is in terms of resources required [type of crops, number of animals, family size] and the farm system: low land, upland, etc.) In other words describe the main characteristics of the farmers that have adopted the practices developed.

10. When will the key research results be available to farmers _____
(Years [ ] Months [ ])

11. Will the quality of the animal change Yes [ ] No [ ]

How:

12. Who is in charge of extension

If you have an idea about the adoption process from your experience please answer these questions:

13. If you know, please state what is the percentage of participating farmers that have adopted the breeding practices _____; of neighbors _____; where _____

14. If farmers have been exposed and have not adopted why do you think this has happened (what are the constraints to adoption of the innovation developed)

15. Question about the adoption process:

    a. When will adoption start _____
    b. What do you expect the maximum adoption to be _____
    c. In what year do you expect to see the maximum adoption _____
    d. Try to define the pattern of adoption

Year 1	_____	Year 2	_____
Year 3	_____	Year 4	_____
Year 5	_____	Year 6	_____
Year 7	_____	Year 8	_____
Year 9	_____	Year 10	_____

16. Do you expect the technology to degenerate or become less effective over time? (planting sesbania, breeding, etc.)

    Yes [ ] No [ ]

    a. If yes, how many years after the release _____

17. Do you expect an increase in intensification (reduction of lambing cycle, increase of weaning rate, or total weight per ewe [which ever you consider]) over the next five years? If yes, **what is the target output and what type of farmers** (see definition of recommendation domain in 9) _____

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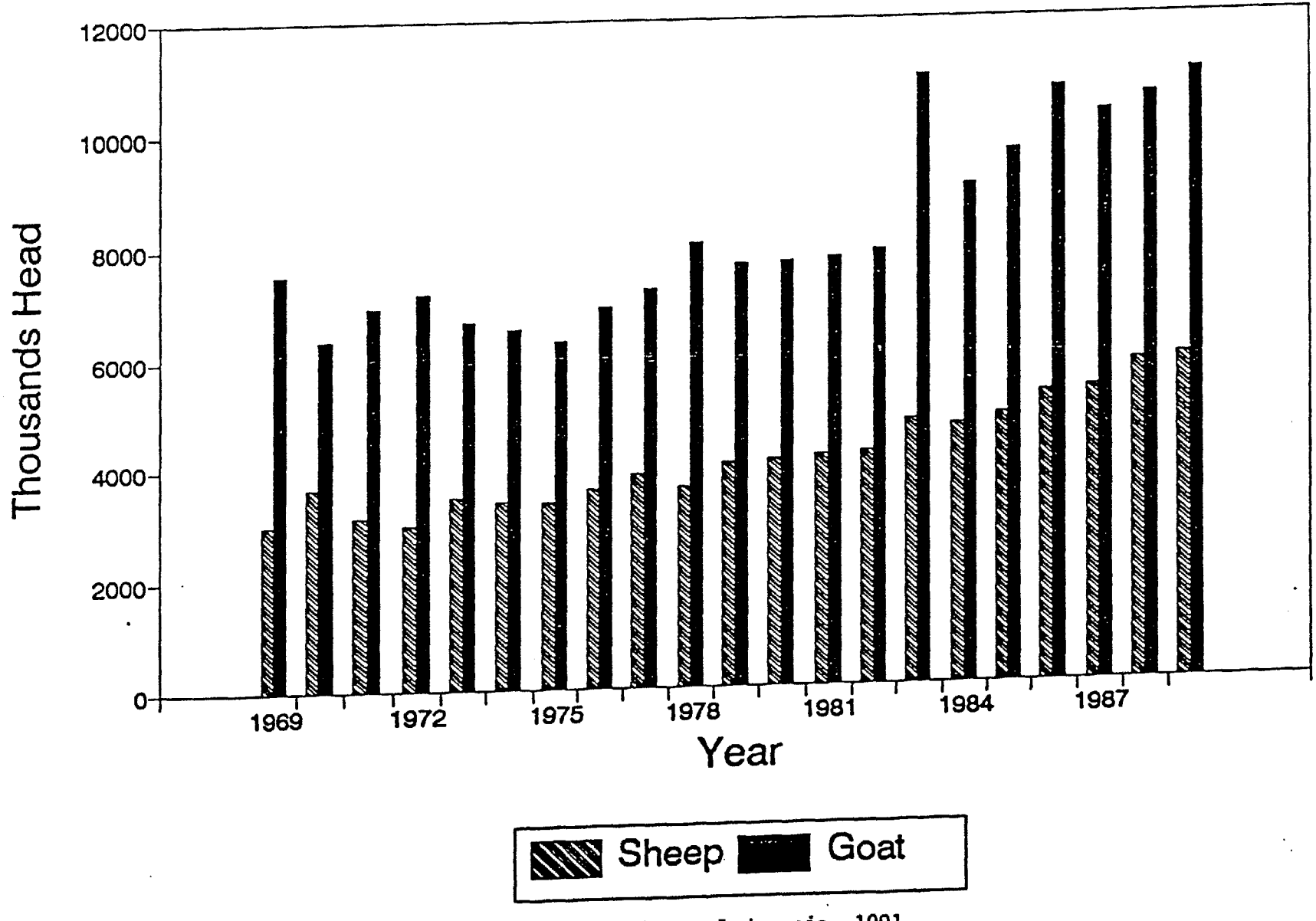
IX. Appendix

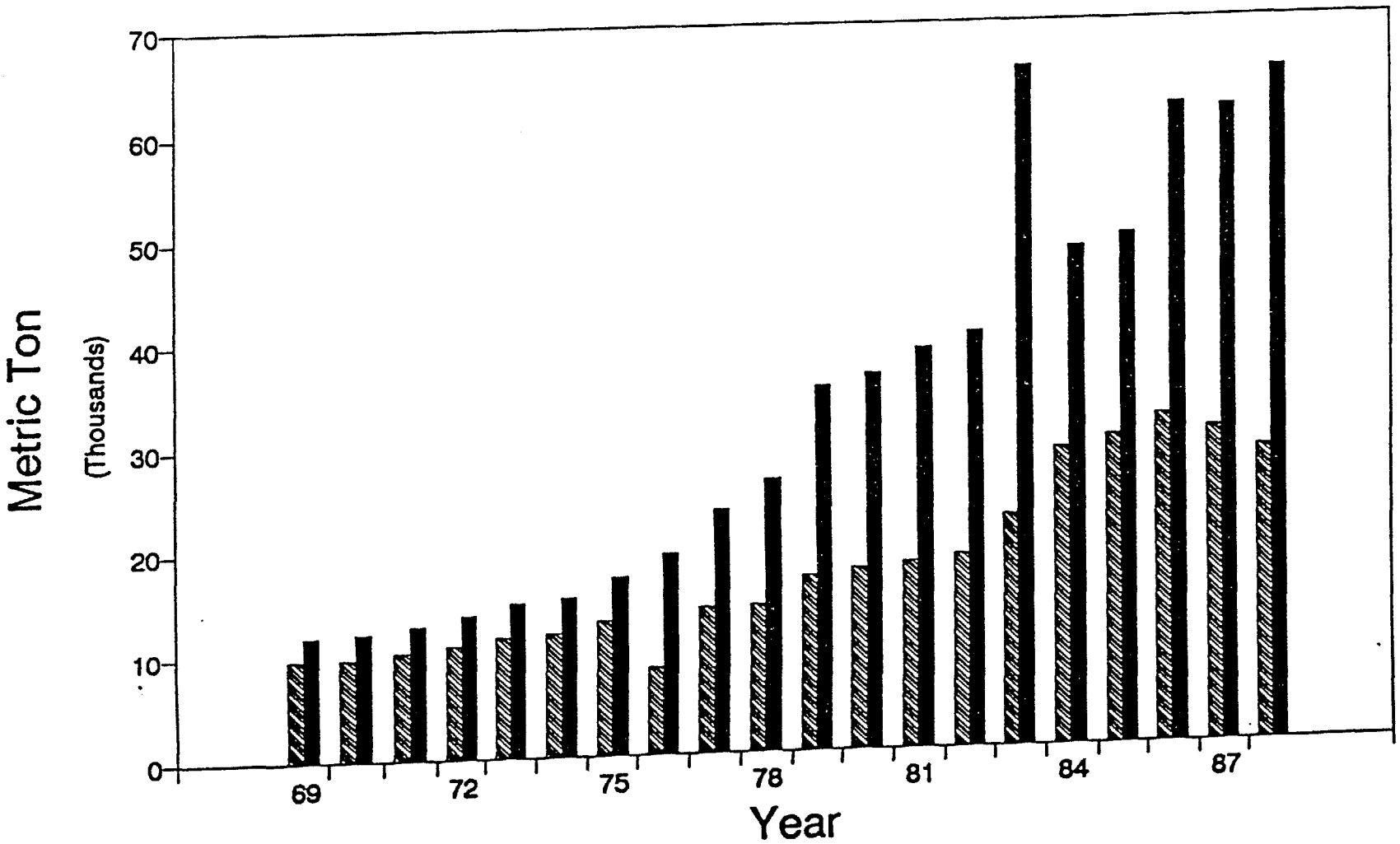
1. Graph: Indonesia Sheep and Goat Population from 1969 to 1989
2. Graph: Indonesia Mutton and Goat Meat Production 1969 to 1988
3. Graph: Retail Prices for Sheep and Goat Meat from 1970 to 1989
4. Indonesia, domestic animal production.
5. Indonesia, Consumer Prices of Goat and Sheep Meat.
6. Trade Value and Quantities: livestock products.
7. Indonesia macro variables
8. Indonesia Budget: SRCRSP 1981-1990
9. Training of Indonesian Scientists

Indonesia Mutton & Goat Population
From 1969 to 1989 (000 Head)



Source: Center Bureau of Statistics, Jakata, Indonesia, 1991.

Indonesia Mutton & Goat Meat
Production 1969 to 1988 (000 MT)



Indonesia, 1991

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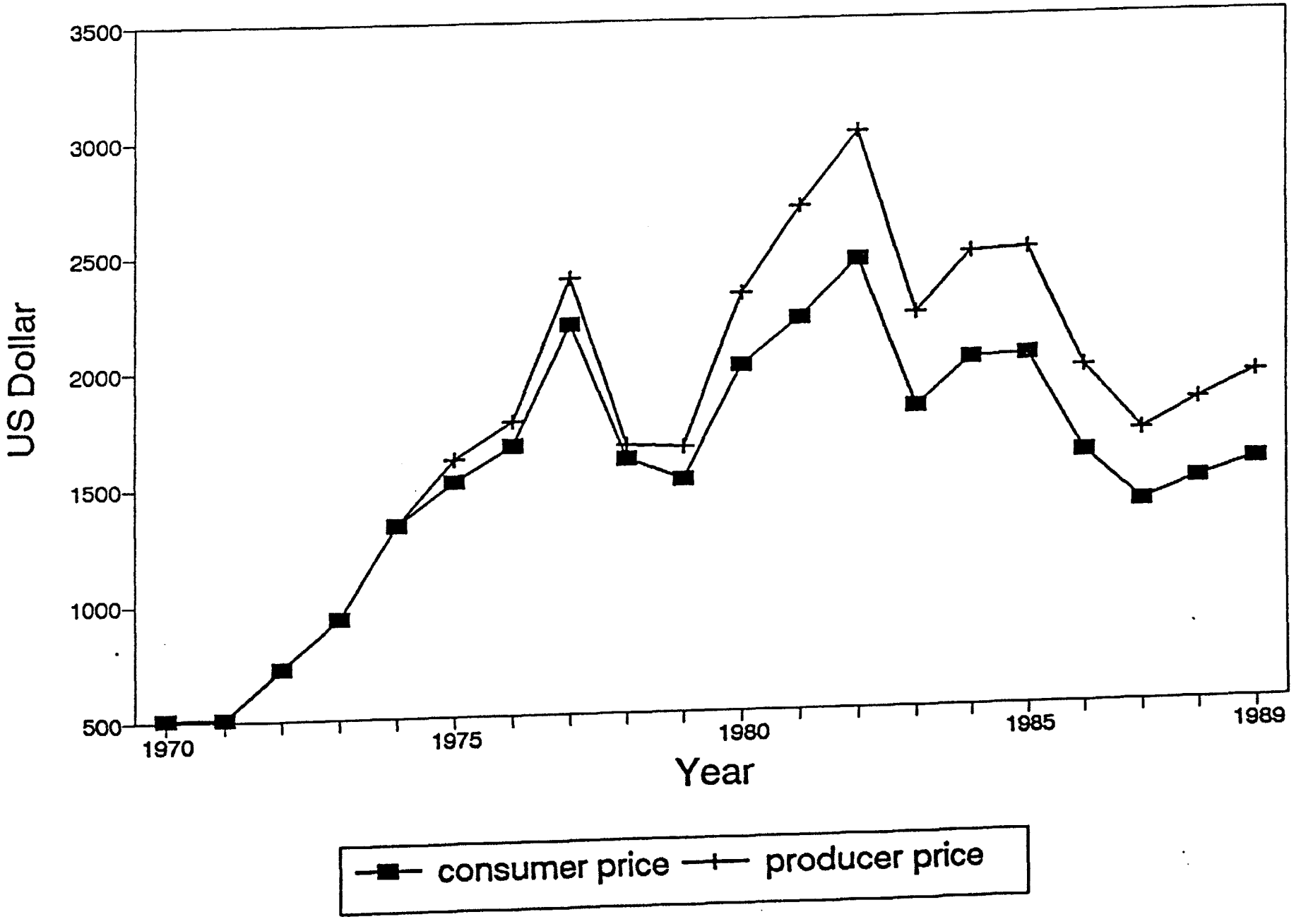
Retail Prices for Sheep & Goat Meat
From 1970 to 1989 (US $ per Metricton)



Source: United Nation Aries Data Base,1992

Indonesia Domestic Production
(Thousand Ton)

Year	Animal Produce				Crop				
	Cattle	Poultry #	Goat	Sheep	Milk	Soybean	Cassava	Corn	Rice*
1969	165	39	12	10	40	389	10917	2293	16
1970	167	39	12	10	52	498	10478	2825	17
1971	177	42	13	10	32	516	10690	2606	18
1972	196	49	14	11	48	518	10385	2254	17
1973	203	49	15	12	40	541	11186	3690	29
1974	219	55	15	12	65	589	13031	3011	20
1975	225	66	17	13	50	590	12546	2903	20
1976	225	78	19	8	72	522	12191	2572	16
1977	225	92	24	14	75	523	12488	3143	16
1978	225	95	26	14	71	616	12902	4029	18
1979	214	100	35	17	75	680	13751	3606	20
1980	221	172	36	18	79	653	13774	3994	22
1981	228	183	39	18	86	704	13301	4509	23
1982	236	201	40	19	117	521	12988	3235	24
1983	204	253	66	22	143	536	12102	5087	26
1984	216	280	48	29	179	769	14167	5288	27
1985	227	318	50	30	192	870	14057	4330	27
1986	228	343	62	32	205	1227	13312	5920	27
1987	235	383	62	31	235	1161	14356	5156	28
1988	245	403	65	28	262	1270	15471	6652	30
1989						1301		6336	

* Million Ton
\# Sum of Production of Broiler, duck, layer and chicken
Source: *Central Bureau of Statistics, Jakata, Indonesia*

Indonesia
Consumer Prices
US $ per Ton

Year	Goat	Sheep
1970	507	507
1971	509	509
1972	722	722
1973	930	930
1974	1327	1327
1975	1509	1604
1976	1659	1763
1977	2182	2381
1978	1597	1658
1979	1506	1646
1980	1993	2303
1981	2195	2681
1982	2445	3006
1983	1795	2206
1984	2005	2464
1985	2015	2477
1986	1588	1952
1987	1362	1652
1988	1458	1674
1989	1542	1801
1990		1910

Source: *United Nations Aries Data Base, 1992*

Trade, Value and Quantity, for Indonesia

	Chicken*		Sheep & Goat*		Milk*		Rice**		Corn**	
Year	Value US $ 000	Ton	Value US $ 000	Ton	Value US $ 000	Ton	Value US $ 000	Ton	Value US $ 000	Ton
1982										
1983										
1984										
1985							67423	381096		
1986	243	58	281	116	37331	38982	29187	205864	733	443
1987	176	62	296	122	37673	38088	10979	50346	664	4680
1988	92	45	310	110	47148	35238			3532	29970
1989										
1990										

* Import
** Export
Source: Central Bureau of Statistics, Indonesia

Indonesia Macro Variables

Year	GDP Bil Rp	CPI 1985=100	Exc Rt.* Mkt Rt	Population Growth	Real GDP Growth	Per Capita GDP US $	Per Capita GDP Growth
1981	58127	70.60	745				
1982	62476	77.30	730				
1983	77623	86.40	972				
1984	89885	95.50	1052				
1985	96997	100.00	1128				
1986	102683	105.90	1505				
1987	124817	115.60	2126	2.00	3.70	430	
1988	142020	124.90	2265	2.00	4.20	390	-0.4
1989	166330	133.00	2267	1.90	6.20	480	0.9
1990		142.90	2500	1.80	6.00	490	0.1

*Rupiah per SDR: period average

Source: International Financial Statistics Year Book-1991
Handbook of Economic Statistics 1988-1991
Directorate of Intelligence

INDONESIA BUDGET

1990-91				
ea	Institution	Trav + WF	Training	US Portion
eeding	UC Davis	119,577	3,000	31,547
ciology	MU	36,700	16,600	61,500
itrition	NC State	117,638	3,200	50,306
onomics	Winrock	86,800	19,800	28,600

1989-90				
rea	Institution	Trav + WF	Training	US Portion
eeding	UC Davis	113,950	14,000	47,066
ciology	MU	61,316	10,000	92,613
utrition	NC State	103,718	0	38970
conomics	Winrock	137,900	25,400	15,700

1988-89				
rea	Institution	Trav + WF	Training	US Portion
reeding	UC Davis	67,062	2,000	52,693
ociology	MU	51,500	39,500	63,000
Jutrition	NC State	90,558	0	35,000
Economics	Winrock	69,700	11,500	23,000

1987-88				
Area	Institution	Trav + WF	Training	US Portion
Breeding	UC Davis	85,225	13,000	46,354
Sociology	MU	20,250	8,500	60,000
Nutrition	NC State	85,800	0	51,367
Economics	Winrock	73,500	11,500	15,000

1986-87				
Area	Institution	Trav + WF	Training	US Portion
Breeding	UC Davis	86,680	0	44,726
Sociology	MU	44,675	0	46,275
Nutrition	NC State	48,140	4,000	66,385
Economics	Winrock	21,100	16,100	2,008
System	Texas A&M	0	310	

Source: Yearly Workplans of SR-CRSP from 1981 to 1991

1985-86				
Area	**Institution**	**Trav + WF**	**Training**	**US Portion**
Genetics	UC Davis	59,635	0	58,337
Sociology	MU	62,891	1,000	42,000
Nutrition	NC State	44,010	5,000	78,440
Economics	Winrock	10,486	0	31,976
1984-85				
Area	**Institution**	**Trav + WF**	**Training**	**US Portion**
Breeding	UC Davis	39,250	0	44,238
Sociology	MU	68,910	0	35,090
Nutrition	NC State	38,340	2,000	92,984
Economics	Winrock	44,810	3,500	23,000
1983-84				
Area	**Institution**	**Trav + WF**	**Training**	**US Portion**
Breeding	UC Davis	16,500	12,000	102,822
Sociology	MU	13,988	2,700	44,174
Nutrition	NC State	49,959	8,850	82,769
Economics	Winrock	43,490	1,000	29,575
1982-83				
Area	**Institution**	**Trav + WF**	**Training**	**US Portion**
Breeding	UC Davis	14,372	1,350	15,464
Sociology	MU	14,687	5,850	1,950
Nutrition	NC State	16,479	800	6,359
Economics	Winrock	48,565	0	4,235
1981-82				
Area	**Institution**	**Trav + WF**	**Training**	**US Portion**
Breeding	UC Davis	13,428	1,500	26,558
Sociology	MU	15,606	8,100	5,305
Nutrition	NC State	8,259	2,500	33,557
Economics	Winrock	4,026	1,056	11,627
Source: Yearly Workplans of SR-CRSP from 1981 to 1991				

Trainees from Indonesia

	Name	Degree	Area	Date
1	Handayani	MS	Rural Sociology	6/88-12/91
2	Suradiastra	MS	Rural Sociology	1/81-1/83
3	Suradisastra	PhD	Rural Sociology	2/83-12/87
4	Ginting	MS	Animal Nutrition	1/88-9/90
5	Haryanto	MS	Animal Nutrition	1/81-5/84
6	Haryanto	PhD	Animal Nutrition	6/84-5/88
7	Prabowo	MS	Animal Nutrition	10/86-9/89
8	Prabowo	PhD	Animal Nutrition	1/84-9/86
9	Silitonga	MS	Animal Nutrition	4/81-12/82
10	Inounu	MS	Animal Science	1/87-9/89
11	Tiesnamutri	MS	Animal Science	1/85-12/87
12	Muljadi	MS	Production Eco	5/81-7/83
13	Muljadi	PhD	Production Eco	9/87-9/90
14	Soedjana	PhD	Ag Economics	8/84-8/87
15	Subandriyo	MS	Animal Breeding	3/82-6/84
16	Subandriyo	PhD	Animal Breeding	8/87-8/91