AN ECONOMIC EVALUATION OF A LIVESTOCK PRODUCTION PROJECT OF BALI, INDONESIA

by

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ABSTRACT

This research was undertaken to determine the profitability of investing research funds into the Three Strata Forage System (TSFS) project, a cattle production project funded by the International Development Research Centre (IDRC) and carried out in the village of Pecatu, Bali. The purpose of the project was to increase the production of cattle and productivity of the traitional farming system by introducing different grass, ground ground legumes, fodder shrubs and trees, and changing the pattern of land allocated to these forages.

A TSFS plot foregoes 0.09 hectares of crop production to produce 0.09 hectares of grass and ground legumes (strata 1), 2000 shrubs (strata 2) and 42 fodder trees (strata 3) on the perimeter of a 0.25 hectare crop field. Cattle are fed exclusively with forages obtained from the plot, in contrast to the traditional system where cattle are tethered on marginal land and fed with feed obtained from other locations on the farm. The TSFS researchers have claimed that the TSFS will "not only increase the quantity and quality of the forages, but it could also increase the stocking rate [of cattle] and carrying capacity of the land, increase the soil fertility, reduce the soil erosion, increase the firewood supply, increase the farm income, induce other on-farm activities, and induce better ecological balance of the environment" (Nitis et al, 1989).

In this study, the claims made by TSFS project researchers have been evaluated using financial analyses. Using data collected from farms in Pecatu, Bali, the values of TSFS production inputs are estimated from local market prices and regressions estimating farm production relationships. The results of the financial analyses were then used to

infer the social welfare effects of the TSFS.

The results of the analyses show that the TSFS plot incurs negative returns, relative to a traditional crop field. Elements of the TSFS system, such as improvements to the local ecosystem, are believed to have a minimal effect on the final estimates of the profitability of the plot and are excluded from the analysis. The large negative returns of the plot indicate that there are resource allocation costs associated with the transfer of high value crop land to the low value forage production advocated by the TSFS.

The grasses and ground legumes introduced by the TSFS project were not familiar to farmers in Pecatu. However, the farmers were willing to experiment with the new varieties, with varying degrees of risk averseness and success in adoption (in accordance to the findings of Antle and Crissman (1990)). The tree and shrub forages of the TSFS were already known to farmers in Pecatu; the introduction of the TSFS did not appear to affect the use of tree fodder resources but may have increased the use of forage shrubs. The results of financial analysis of individual project forages indicate farmers have preferences for specific forage species. While farmers agreed to participate in the TSFS project due to financial incentives, they found they could reduce the costs of the TSFS by adopting profitable aspects of the TSFS, using a more flexible approach to land allocations and choice of forage species.

As the shrubs, grasses and ground legumes are well-known throughout Asia, it appears that the only new management techniques introduced by the TSFS are the planting arrangement and feeding system - and these aspects have resulted in negative returns. Therefore, any positive welfare effects associated with the project are due to an

increase in the rate of adoption of the forages included in the TSFS - although these effects are not large enough to offset the losses imposed by an inefficient allocation of land and labour resources to forage production.

Reviewing all resource allocation effects of the TSFS, and given the size of the payments needed to obtain farmer participation it is clear that the net welfare effects are negative. Notwithstanding the optimistic claims of the project literature, the forages produced by the TSFS regime are not valuable enough to match the profitable crop activities they are supplanting.

There is evidence to suggest that TSFS researchers have been prone to misjudge the true costs and benefits associated with the TSFS plot. This arises not only as a result of overly optimistic claims of project benefits and understated project costs, but a pervasive disregard for the rationality of traditional farmers.

For future research projects, it is recommended that the funding agency, IDRC, require *ex ante* economic analyses, to determine the true social costs and benefits of a proposed technology. In this way, projects of net negative social value can be identified and improved before research resources have been allocated to the generate an inefficient technology.

Table of contents

List of tables

List of Figures

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Chapter 1 Introduction

It is generally accepted that the approach to improving the productivity of resource-poor farmers is by introducing new agricultural methods (new resources, new skills or new techniques) that are more productive than the existing technologies. However, there is no such consensus about what particular kinds of new technology are required or even desirable, or how this new technology is to be extended to the farmer. For this reason, an assessment of new technologies is required in order to determine which production methods to develop and promote, and how to direct and manage future agricultural research.

The purpose of this thesis is to carry out an economic evaluation of the Three Strata Forage System (TSFS), a cattle feeding system developed and researched in Bali, Indonesia. The TSFS is designed to increase farm incomes in dryland regions by increasing the production of cattle. This goal is to be achieved by improving the production and management of grass, shrub and fodder tree species to ensure an adequate year-round supply of high quality green feeds for ruminant livestock raised in these regions.

1.1 Background: The Three Strata Forage System

1.1.1 Traditional cattle production practices

Under traditional management, cattle in dry land regions of Bali are fed from feed resources on the farm, although in times of feed shortages, usually at the end of the dry season, farmers may travel up to 20 km to obtain feed for their animals (Nitis et al (1986)). Cattle are tethered to graze on native grass growing on marginal land or land fallowed

from crop production. Marginal land (often on rocky land, along the border of the farm or the edges of fields) is also allocated for the production of fodder trees and shrubs, which are cut and carried to supplement the diets of the cattle. Tree fodders (particularly feed from the Ficus tree[1]) are often the sole sources of feed on the farm at the end of the dry season (Nurbudhi, 1968). Crop residue is fed to the cattle during the year as it becomes available (Nurbudhi, 1968; Nitis et al 1980). Depending on the supplies available, farmers prefer to give fresh, green feeds to their cattle (Nurbudhi (1968)), possibly because of the high water content of green feeds (water is scarce and is a constraint to livestock production in dryland regions).

The Balinese provincial government has initiated several programs to encourage increased cattle production. Programs involving the dispersal of improved genetic cattle stock and improved animal production technology (government sponsored veterinary services, introduction of improved forages (grasses, shrubs and ground legumes) and livestock feeding practices) have been carried out. In regions believed to be not very productive for cash crop production (because of low annual rainfall), semi-intensive beef production is encouraged; included in these dry regions is the site of the Three Strata Forage System project, the village Pecatu on the Bukit peninsula of Bali. Nitis et al (1990) maintain that despite the efforts of the government, the low quality of feed and shortages of feed have limited increases in cattle production. The Three Strata Forage System has been offered as a solution to these problems; it is believed that by adopting the TSFS, farmers will be able to increase the production of cattle.

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[1]The Ficus tree has been included in the Three Strata Forage System.

1.1.2 The Three Strata Forage System

A TSFS plot[2] consists of grasses, ground legumes, shrubs and trees planted on the perimeter of a 0.25 hectare crop field. Each plot consists of 42 trees, 2000 shrubs and 0.09 hectares of introduced grasses and ground legumes. The core of the plot (0.16 hectares) is planted with crops. Figure 1.1 illustrates the layout of the TSFS plot. The layout of the TSFS plot is important to the TSFS concept since the TSFS project claims that the presence of the grass, shrubs and trees on the perimeter of the plot will decrease soil erosion.

The shrubs and trees of the TSFS plot are plants that farmers have been using for many years to feed their cattle[3]; however, the project has defined, on a per animal basis, the number of shrubs and trees that should be planted. The grasses and ground legumes used in the project plots are introduced varieties, which have been previously tested and promoted to some extent in Bali[4], but not widely adopted by farmers. These grasses and ground legumes are also defined as to how much should be grown per animal.

The TSFS differs from the traditional cattle rearing system in that cattle are kept in stalls full time, rather than being tethered on grass during the day as practised under the

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[2] One hectare of TSFS plots may support 3.2 animal units (each animal unit is 375kg) (Nitis et al, 1990).

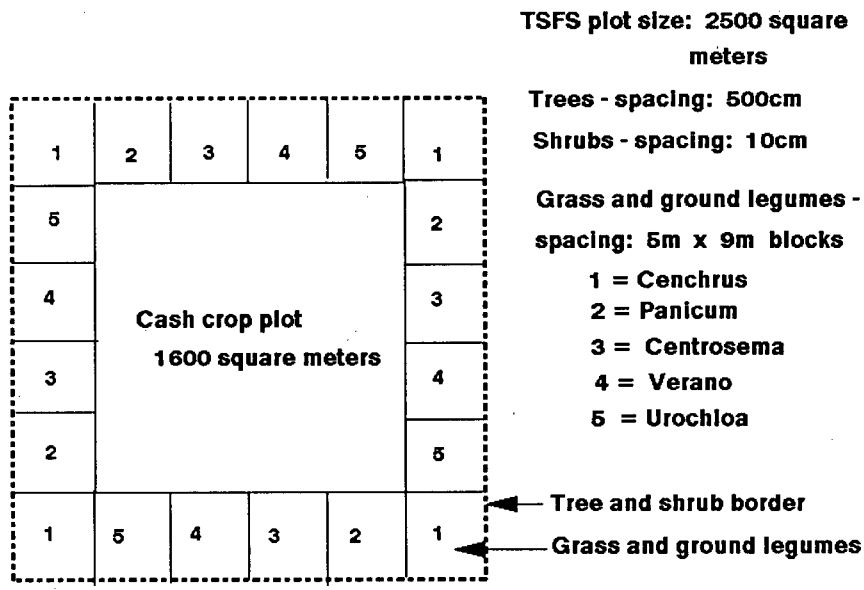
[3] The trees have been growing in the Bukit region for the past 100 years. The Leucaena shrub was introduced in the 1950's and the shrub Gliricidia was introduced in the 1970's (Nitis et al, 1985). The shrub Acasia villosia is an exception, and was recently introduced into the project in 1986/87 - however, this shrub has also been promoted independently of the project, by the provincial government of Bali.

[4] The exception is the drought tolerant grass, Urochloa mosambisensis, introduced to the project (and presumably for the first time in Bali) in 1987. Past research, carried out in the Bukit peninsula, on locations with 10km of the Three Strata Forage System project, on forage grasses has been reported by Nitis and Nurbudhi (1975); Rika and Whiteman (1976); and Mastika et al (1977).

traditional system, and are fed exclusively from forages and crop residues obtained from the TSFS plot.

The TSFS has devised a feeding regime to improve management of feed resources (shown in Table 1.1). As can be seen from the table, the quality of the TSFS diet is different from the traditional diet in that native grasses and other sources of feed, such as crop residues, have been excluded - being replaced by introduced varieties of grasses and ground legumes - with the requisite quantities of each category of feed (grasses, shrubs, trees) clearly defined for the seasons.

Figure 1.1: TSFS plot



Adapted from Nitis et al (1989), Figure 3.6; and Nitis et al, (1990), Figure 1.

Differences between the TSFS and traditional feeding practices will depend upon how far a farmer deviates from this system.

Table 1.1: TSFS feeding regime (based on the requirements of an animal of 375kg requiring 50kg of feed per day). (Adapted from Petunjuk Praktis - Tata Laksana Sistem Tiga Strata, Nitis et al (1988), pg. 26).

	Wet season	Early dry season	Late dry season
grasses and ground legumes	35kg (70%)[a]	5kg (10%)	5kg (10%)
shrubs	10kg (20%)	35kg (70%)[b]	10kg (20%)
trees	5kg (10%)	10kg (20%)	35kg (70%)[c]

a. the 35kg of grass and ground legumes should consist of 7kg (14%) each of the grasses Cenchrus ciliaris, Panicum maximum, and Urochloa mosambisensis, and the ground legumes Stylosanthes guyanensis and Centrosema pubescence **or** any combination of these plants which results in a total amount of 35kg.

b. the 35 kg of shrubs should consist of 17.5kg (35%) each of Gliricidia sepium and Leucaena leucocephala **or** any combination of these plants which results in a total amount of 35kg.

c. the 35 kg of tree fodder should consist of 12kg of Ficus Poocellie, 12kg of Lannea corromandilica, and 11kg of Hibiscus tilliaceus **or** any combination of these plants which results in a total amount of 35kg.

The TSFS project claims many benefits of the TSFS plot over the traditional farming practices. First, the cattle will reach market weight more quickly as they are given a diet of high quality feeds throughout the year. The project has claimed that farmers adopting the TSF system will allocate less labour to cattle production and improve the productivity of their land by keeping more cattle per unit of land. By keeping the cattle in stalls full-time, the TSFS researchers believe that: 1) greater amounts of manure may be collected and spread on crop fields, increasing soil fertility; 2) erosion caused by grazing cattle is reduced; 3) the cattle are less exposed to disease and parasites than are other cattle.

TSFS literature claims that the management of land resources will be improved.

By arranging plants in a specified manner around the edge of the crop field, soil erosion will be reduced and by introducing nitrogen-fixing plants, soil fertility will be increased. As a result of increased soil fertility and improved erosion control, it is expected that crop yields in the TSFS plots will be greater than yields obtained in traditional fields.

The project has also noted that as the woody branches cut from the shrubs and trees are not eaten by the cattle, firewood is an additional by-product of the plot.

After five years of research and development, researchers associated with the project have noticed benefits related to the TSFS technology which were not anticipated at the beginning of the project:

- the presence of shrubs and grass around the perimeter of the plot deters roaming livestock (cattle, swine or goats that have broken free from their stalls or tethers) from entering the plot and eating the food crops

- poultry and snail production may be enhanced as snails and free roaming chickens find a source of feed and protection among the forage plants in the plot

- if the forage plants are allowed to reach a flowering stage, the plot can provide a source of nectar for honey bees, introducing an opportunity for honey production

- due to the canopy of shrubs and trees, light intensity and wind is reduced, resulting in reduced water evaporation from the soil in the plot

(Nitis et al, 1989).

These additional benefits of the TSFS plot have <u>not</u> been studied or quantified[5], and as a result, are difficult to incorporate into an economic analysis.

The 1989 TSFS Report summarizes the attributes of the plot as follows:

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[4] Research related to honey production has recently been carried out, but data related to input and output structures is not currently available.

> "With the TSFS, farmers are not spending extra money to hire a truck to cart the feed cut from other sources; the extra time saved from caring for the cattle and getting firewood can be used to get extra money from off-farm and other on-farm works; more money is received from rearing more cattle; and less money is spent to buy feed supplement for the 'Kampung' chickens. The overall result is higher farm income for the TSFS farmer. TSFS farmers feel secure since they have more money to buy other requirements, have more spare time to do social activities, and own an established field to produce appropriate farm produces." (Nitis et al, 1990, pg. 228).

Costs incurred by the TSFS result from the layout of the plot. Since the grasses and ground legumes of the TSFS plot are grown on land previously used for crops and the shrubs and forage trees may replace productive trees not used for cattle feed, a farmer who adopts the TSFS technology will reduce the area devoted to field crops by 36% (0.09 hectares out of 0.25 hectares) and may grow fewer fruit trees (or trees planted for other purposes) than a farmer following the traditional farming practices. The TSFS has claimed that the costs of such a system are small because 1) the value, to the farmer, of land close to the edge of the field is very low (native grass is often left on the edges of fields); 2) fields are typically surrounded by low value trees or shrubs - with cactus a predominant species; 3) grazing land is scarce (and therefore costly) due to a land-use pattern dominated by crop production (Nitis et al, 1990; IDRC, 1984). Labour costs, costs of materials for the construction of a stable and the costs of seeds associated with the plot have not been estimated by the TSFS project, but should be included into an economic analysis.

The project claims that overall, the TSFS plot is more efficient and increases farm incomes by 31 to 35% over the traditional system (Nitis et al, 1988; Nitis et al, 1990). Constraints to adoption of the TSFS are believed to be "the subsistence behaviour of the

farmers, high exploitation cost of TSFS development, low technical know how of feed conservation and feed rationing among farmers" (Nitis et al, 1990).

1.1.3 The Three Strata Forage System project

The purpose of the Three Strata Forage System (TSFS or TSS) project was to evaluate the biological and economic feasibility of increasing production and improving the management of forage from trees, and herbaceous pasture species planted on field borders. The TSFS project was carried out for five and one-half years in the village Pecatu, on the Bukit peninsula of southern Bali. During the length of the project, the yields of forages and crops produced from the plot were estimated and the growth, feed intake, and carcass quality of Bali cattle raised on these feeds were evaluated. All labour for the establishment and daily maintenance of the plots was contributed by farmers leasing land to the project; these farmers were compensated for their participation in the project with various incentives.

Information about the establishment and maintenance of the TSFS plot has been publicized by researchers associated with the project, through articles in local and national newspapers, provincial radio and television broadcasts, and special workshops for farmers. Articles related to the TSF system have been presented at livestock and forage conferences in Indonesia, Asia, South America and Europe; there have been numerous articles published in professional journals and local publications.

In addition to claims of its attributes as a production unit, the TSFS plot has been promoted as an extension tool, to teach farmers how to better manage land and labour resources to increase crop and livestock production. Demonstration plots have been set

up on farmers' land[6] in various locations in dry land regions of Bali (the government of Bali has sponsored the establishment of 30 units of TSFS; the Foster Parents Plan has sponsored 30 units; and a local non-government organization has sponsored an additional 67 units). The demonstration plots are expected to become a source of cuttings of trees, shrubs and grasses, as well as a teaching aid, for farmers in the vicinity of the plot.

1.2 Problem statement

The purpose of this thesis is to determine whether the TSFS is a good investment for farmers adopting the system. Using the results of analyses estimating the private benefits of the TSFS, it may be determined if the TSFS project itself is a good investment for agencies funding the research. Previous work carried out by the TSFS team has indicated that it is a good investment, based on physical criteria (e.g. total quantities of forage, crop, cattle and firewood production). Economic studies reported in several TSFS documents report positive income effects of the TSFS plot, although these studies are inconclusive since they do not include <u>all</u> the costs of the plot (such as the labour for cattle husbandry, or the revenues foregone from crop production) nor are the costs and benefits of the plot discounted over time. The purpose of this study is to use economic principles to estimate the net returns of the discounted costs and benefits of the TSFS plot.

Using cross-sectional data obtained from surveys carried out in the village of Pecatu, the site of the TSFS project in Bali, this study will determine 1) which aspects of

[6] Generally, these farmers receive economic incentives for establishing a demonstration plot similar to the incentive received by farmers participating in the TSFS project in Pecatu.

the TSFS plot constitute a new technology; 2) whether there has been an increase in cattle or crop production as a result of the TSF system; and 3) whether this increase in production has been achieved profitably. In the process of determining the success of attempts on the part of the TSFS project to improve the management of traditional production systems, the production efficiency of traditional cattle and crop production is investigated.

1.3 Thesis Objectives

The objectives of this study are as follows:

1) to determine the effects of the TSFS on farm production

2) to collect data to validate these effects and to incorporate them into an economic project evaluation, using benefit-cost analysis

3) to present the lessons or conclusions to be obtained from investment into such a project

To facilitate this work, sub-objectives of this thesis are as follows:

1) to review economic theory and economic literature related to the production practices of resource-poor farmers in developing countries.

2) to collect data and information concerning the production of crops and livestock, the allocation of labour between farm and off farm tasks, the costs and returns to factors of farm production on farms in the village Pecatu and farms participating in the TSFS project

3) determine whether these farmers are efficiently allocating land and labour resources for the traditional production of crops and cattle

4) determine whether the Three Strata System (TSFS) will improve the profitability of the crop-livestock production system by comparing the profitability of the TSF system to the traditional system.

5) determine which aspects of TSFS technology are being adopted by farmers and explain why certain aspects of the TSFS might be more favourable for adoption.

6) to use the results of the above analyses above to infer the social welfare costs of the TSFS.

1.4 Research procedure and thesis guide

In chapter 2 economic theory concerning agricultural production in developing countries will be discussed. Theory relevant to the generation and analysis of agricultural production is presented.

Chapter 3 describes traditional farming practices, the site of the TSFS project and the results of project experiments.

In Chapter 4 the accuracy of the data and the possible differences between sample groups in farm output and farm resource use are investigated using simple statistical methods.

In chapter 5, regressions used to estimate the marginal returns to factors of production will be described. The budget sheets for the financial analysis of the TSFS plot and the traditional production system, for participation in the TSFS project and for individual forage species will be outlined.

Chapter 6 presents the results obtained from the estimation of the regression equations and the cost-benefit analyses, and the implications of these results. The total welfare effects of the TSFS plots are discussed.

In chapter 7 , the results obtained from the analysis in chapter 4 and 6 are reviewed. The implications of results concerning the wider adoption of the TSFS are presented. General lessons for project choice by IDRC are suggested. Recommendations for further research are offered.

Chapter 2 Theoretical Considerations

The purpose of this chapter is to present the economic theory relevant to evaluating the costs and returns of investing resources into the TSFS project. Section 2.1 will present economic theory related to the economic evaluation of the investments such as the Three Strata Forage System project. Section 2.2 reviews development theory relevant to interpreting the production behaviour of resource poor farmers in developing countries. Section 2.3 applies the theory described in section 2.2 to predict the behaviour of farmers who may adopt the TSFS, and more specifically, the behaviour of farmers participating in the TSFS project. Section 2.4 introduces aspects of the Hayami-Ruttan induced innovation hypothesis which are relevant to the study of the TSFS.

2.1 The benefit-cost analysis of alternative investments

Heady (1952) describes the effects of a technological change as follows: With the introduction of a technical change, there is a shift in the production function such that a greater output of product occurs from a given total input of resources. In order for the technical change to be an improvement upon the old technique, there must also be a simultaneous increase in the discounted profits (or a decrease of the losses) of the firm. A firm will adopt an innovation only if 1) output is increased from a given set of resources or 2) an input is decreased for a given output (in other words, the firm's cost curve must be lowered). The only exception to these conditions is the case where the innovation increases *ex ante* profit expectations through a decrease in the uncertainty or risk associated with production - although in this case there is also a long-run increase in output. In this thesis, the TSFS will be analyzed using cost-benefit analysis to determine

if any of these conditions have been achieved to increase the profitability of traditional farm production in dry land regions of Bali.

Benefit-cost analysis is a method of evaluating the relative merits of alternative production plans in order to achieve an efficient allocation of resources[7]. It concerns choices between alternative courses of action, where the value of one course can be determined only relative to that of some alternative course (Sugden and Williams, 1978).

In this thesis, the TSFS is analyzed using financial analysis, a type of cost-benefit analysis which analyzes the profitability of the plot from the point of view of the farmer - the user of the new system. This type of analysis is believed to be the most appropriate, since the ultimate goal of the project is to develop a system which improves the income of the farmer. Using the results of the financial analysis, the welfare effects of the TSFS on society may be inferred.

In many instances, market values may be used to determine the costs and returns of the inputs and products of the TSFS. However, there are some factors of production and some farm outputs which are not often traded on local markets. Economic theory will be used for guidance in estimating the most likely value, to the farmer, of these items. Because the TSFS project is concerned with designing a package to educate farmers about the correct use of land to grow crops and forage for livestock, it is assumed that farmers are currently not achieving economic efficiency and that this inability to achieve economic efficiency is due to a lack of knowledge concerning the use of both modern and traditional production inputs. Economic theory will better enable us to predict the

[7] A description of the cost-benefit analysis tools used in this thesis may be found in Roemer and Stern (1975).

success of efforts on the part of the TSFS to improve the management of these farm resources. In the following section, theory chosen for these purposes will be outlined.

2.2 Production behaviour of resource-poor farmers

The most widely accepted hypothesis describing the production behaviour of resource-poor farmers was put forth by Schultz (1964). This hypothesis predicts that resource-poor farmers will endeavour to maximize profits, and allocate farm resources efficiently, within the constraints imposed by risk and uncertainty, current knowledge and understanding of production inputs, institutional or market factors, and scarce capital resources.

The Schultz hypothesis suggests that the production processes of resource-poor farmers in traditional[8] agriculture are economically (technically and allocatively) efficient[9]. These farmers are responsive to economic incentives and will adjust production to take advantage of changes in output and factor input prices. Under traditional agriculture, production inputs are allocated optimally; inputs cannot be reallocated to efficiently increase farm production. Also implied is that if farmers have sufficient understanding of a profitable new technology, they will endeavour to incorporate this technology into farm production activities in order to increase their profits.

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[8] Stevens and Jabara (1988) define traditional agriculture as follows: "Traditional agriculture can be defined as farming in which the technology used has been developed by keen observation of nature by people who lack knowledge of and access to science and industrial technology... Traditional farming practices (technologies) have been developed without access either to knowledge of the sciences of biology, chemistry, and physics, or to industrially produced inputs. Traditional agricultural technology is the art of agriculture, which has been passed on verbally and by demonstration from one generation to the next, based on much observation and experience in local farming areas over the years" (Stevens and Jabara, 1988:60).

[9] A thorough description of conditions defining allocative and technical efficiency is found in Yotopoulos and Lau (1976).

Evidence to support the hypothesis concerning the allocative efficiency of farmers in traditional agriculture has been documented in studies by Hopper(1965); Chennareddy(1962); Yotopoulos(1968); Khan and Maki(1979)). Evidence of efficient farm labour resource allocation has been found in a study by Larson and Hu (1977). Evidence of efficient allocation of resources in traditional environments has been found for the production of cattle (DeBoer and Welsch (1977)) and for crops under risky production conditions (Norman (1977)). Barbier (1990) has demonstrated that profit-maximizing behaviour can explain farmers' attitudes towards the adoption of soil conservation practices.

Generally, in the earlier studies of farm production efficiency, the evidence of allocatively efficient production practices was obtained by the estimation of Cobb-Douglas production functions and the derivation of average estimated marginal productivities from these functions. The marginal value products (marginal productivities transformed to money units by multiplying by the price of output ($MP_{input} * P_{output}$)) are compared with relevant marginal factor costs (the observed unit costs of factor inputs, assumed to be constant over the sample)(Shapiro, 1983). Under profit maximizing conditions, the ratio of marginal value product to marginal factor cost is equal to one.

Researchers re-examining the results of early studies testing for allocative efficiency found that quite often the marginal value products of inputs estimated from statistically significant coefficients sometimes differed from the input factor costs by as much as 40% (Shapiro,(1983); Bliss and Stern (1982)), suggesting that an allocation of inputs required for profit maximization was not always achieved. However, in some cases, these results

are obtained because the local input and output prices (including the local rate of interest - the rate used to discount the returns to inputs or production outputs) actually seen by the farmer were not used to estimate the marginal value product or marginal factor cost. Some authors have suggested that models which do not incorporate the effects of risk and uncertainty of farm production on farm management decisions will also lead to inaccurate estimates of the expected value, to the farmer, of production inputs (Dillon and Anderson (1971); Lipton (1968); Bliss and Stern (1982); Roumasset et al (1976)).

In the context of the conditions found in Pecatu, Nitis et al (1989) state that some crops (corn) often fail[10] and that for this reason, cattle production is promoted in the region. It may be possible that TSFS reduces the risk and uncertainty of farm production, through modifying the allocation of resources between crop and cattle production, thus increasing farm profits over the long run. However, without a knowledge of the probability distributions of expected crop returns or returns to livestock production, it is difficult to estimate the effects of the TSFS on the risk and uncertainty of farm production, therefore possible underestimating the value of the increased livestock production of the TSFS plot.

It has been pointed out that studies using statistical techniques such as ordinary least squares, to evaluate the allocative efficiency of production, have presupposed that on average technical efficiency is achieved (Timmer, 1970). By assuming technical efficiency, researchers have ignored the possibility that some farmers can achieve higher outputs than their neighbours using the same input combinations. In research

[10] The validity of this statement cannot be challenged here, although as farmers continue to allocate resources to the production of crops, one might suspect that crops are more often profitable than not.

investigating the production behaviour of resource-poor farmers, researchers (Bliss and Stern (1982), Ray (1985) and Shapiro (1983)) have found evidence of technical inefficiency; Shapiro (1983) argues that if some farmers are more technically efficient than their neighbours, there may be scope for increasing output through increased efforts in areas such as extension and education, which are aimed at improving the allocation and use of available resources, without major investments into new inputs and new technologies. In this context, it is possible that farmers will benefit from the lessons offered by the TSFS concerning the improved management of traditional and modern farm production inputs.

However, except in cases where there are institutional constraints[11] preventing the proper use of production inputs, technical inefficiency appears to derive from a lack of knowledge or understanding of the use of modern inputs - rather than an inability to manage traditional factors of production (Ali and Chaudhry, (1990)). Supporting evidence is found in studies which demonstrate that the effects of extension and education (or human capital) on productivity were more likely to be positive in a modernizing environment than a traditional environment (Lockheed et al, 1980). Feder et al (1985) cite studies which have related human capital or education to the successful adoption of new technologies. These results suggest that while traditional inputs are understood and efficiently incorporated into farm production, the use of modern inputs requires an ability

[11] As it is now recognized that institutional constraints may affect the efficiency of resource use, it is possible to include their effects into models of production behaviour.

to understand and adapt these new inputs to the particular circumstances found on the farmer's own land[12].

Observing the results of previous work relating technical efficiency, risk averse behaviour, and the value of education (or human capital) in environments where new technologies are being introduced and adopted[13], Antle and Crissman (1990) have tested the hypothesis that farmers are risk averse in adopting a new technology because they are unfamiliar with it. These farmers will experiment with a new technology, often making mistakes in the adaption and application, until the correct use of the new technology is fully understood. During this period of time, the technical and allocative efficiency measures obtained from these farms would indicate some inefficiencies in farm production; inputs would be used to levels not optimal for the maximization of profits. Some farmers, because they are better farm managers, more willing to experiment, or quicker at understanding and adapting the new technology to their own circumstances, would obtain greater output per unit of input than their less able, more risk averse neighbours. The results obtained from the study support the idea that farmers are willing to undertake on-farm experimentation and, in relatively few years, are able to achieve technical proficiency in the use of a modern technology. These results are important when interpreting the production behaviour of farmers in Pecatu, Bali; there may be evidence of inefficient allocations of resources as farmers experiment with the new inputs and production practices introduced by the TSFS. There may also be evidence that some

[12] This hypothesis has been put forward by Schultz (1975).

[13] Feder, Just and Zilberman (1985) have done an extensive review of the adoption literature, which cites studies relating risk, institutional constraints, human capital, and resource endowments to the adoption of new technologies.

farmers are more willing to experiment aspects of the TSFS or more able to successfully incorporate aspects of the TSFS into farm production activities. Further, the educational benefits farmers derive from exposure to the TSFS plots should be considered when evaluating the TSFS project.

2.3 The allocation of farm resources for the TSFS

The following paragraphs describe the allocation of production inputs, assuming that the farmer is able to achieve economic efficiency - bearing in mind that there may be influences from the effects of risk averse behaviour, lack of technical knowledge, market inefficiencies and the high costs of capital. The values described are expected to be, on average, a close approximation to what is truly observed by the farmers.

The costs of the TSFS include land and labour costs, as well as the cost seed materials. The costs of materials are outlined below, followed by a description of land and then labour costs.

2.3.1 The allocation of forage seed resources

It has been claimed by the TSFS project leaders that the TSFS plot is meant to be a source of seeds and clones for establishing new plants. This system of dispersing seed is not costless, as using plant materials from the plot imposes costs in the form of revenues foregone when materials are taken from another use or when resources are committed to obtaining these planting materials.

The stakes for planting shrubs and trees are usually obtained on the farmer's own land or from a neighbour (in the spirit of 'gotong-royong', or mutual help, where the cost is a 'favour' expected in return). If the stakes are obtained on the farmers own land, the

cost of the shrub and tree stakes is the cost of the labour of finding and cutting the stake (usually done while collecting feed for the cattle) and not using the stake for firewood. It should be noted that stakes for gliricidia are easily obtained, while stakes for the trees, particularly Ficus, are more difficult to find (Nitis et al, 1986) and therefore more expensive. In this study, the price for tree and shrub stakes is also indicated by the price paid by the TSFS project for these materials.

The price of grass clones will be determined similar to the price of stakes for shrubs and trees; the opportunity cost of obtaining clones from an existing clump of grass is the loss of production of the clump of grass from cattle feed. However, as farmers in the project and some farmers' groups in Pecatu were able to obtain grass clones for free from the project or from government programs these costs may not be observed by the farmers at the present time.

2.3.2 The allocation of land resources

Land rent can be described as the theoretical earnings of and resources - the economic return that accrues, or should accrue to land for its use in production. It is the portion of the total value product or total returns that remains after payment is made for total factor costs or total costs, respectively. The rent (or returns) earned by a piece of land often indicate the market value of a piece of land in a particular locality. It is also a measure of the opportunity cost of the land. The following paragraphs describe the effects of the TSFS on the returns to land.

The TSFS advocate the transfer of 36% of crop land to forage production. As this transfer takes place, crop land will become more scarce - the effects of this transfer on

price are unknown until the profitability of the TSFS is estimated. As forage production is transferred to crop land, there should be a resulting decrease in the demand for grazing land. This land will now be free for other uses - the possibilities dependent upon the fertility and location of the land.

Alternatively, there may be a trend to chose aspects or combinations of the TSFS that provide the greatest amount of feed, with the least competition for the most costly land resources (such as crop land). As land for grass, tree and shrub production is in greater demand, there will be increased competition with other land uses, such as:

1) land for crop production
2) grazing land (land not used for crops)
3) land used to grow trees other than fodder trees

If the farmer is not able to buy or rent more land, he may give up one of the above listed land uses for increased forage production. There may be an increase in the price or rent of all land, as land for forage production becomes more scarce or desirable. The farmer will chose the land use pattern such that the marginal returns for each land use (crop, forage, etc) are equivalent.

2.3.3 The allocation of labour resources

In addition the costs of seed and land, the costs of grass, shrub and tree production are labour costs:

1) Grass
   - costs of tilling and preparing the soil
   - planting the seeds or clones
   - weeding
   - obtaining the grass seeds or clones
2) Shrubs and Trees
   - clearing away other shrubs, trees, cactus
   - preparing the soil
   - obtaining and planting the seed stakes

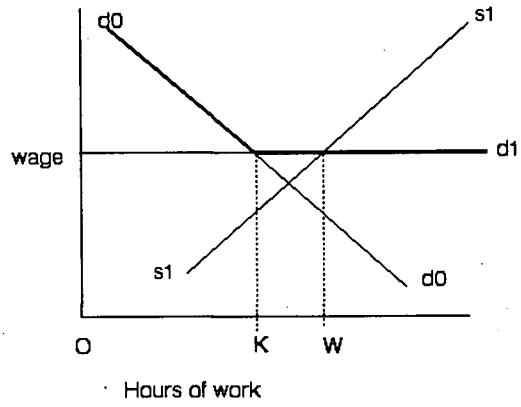
Therefore, in addition to competing for land resources, the TSFS also competes for the labour resources of the farmer. The farmer will allocate his labour between crop production, off-farm work, livestock production, and the planting of grass, shrubs and trees, such that the MVP of labour for each activity is equivalent.

If a farmer is free to allocate his time between off farm and farm employment, he will allocate the time such that the marginal revenue product of farm work is just equal to the net wage paid for nonagricultural labour. Figure 2.1, adapted from Robinson et al (1982) gives a graphical presentation of the equilibrium between on- and off-farm labour.

It is assumed that the farmer is free to devote as many hours as is desired at the available net off-farm wage rate, subject to institutional constraints. The wage that a farmer receives for off farm work will be a function of his human capital (education, experience, skills or abilities) and the cost of commuting to the work place. The demand for labour in farm work is a function of the price of labour in farm work; the price of farm output; the prices of all other farm inputs; and the stock fixed inputs (fixed factors of production). Assuming a concave production function, the demand for on-farm labour is downward sloping.

In Figure 2.1, the equilibrium quantity of time worked is given by the intersection of the farmers demand for labour curve (the kinked curve D_0-D_1) and the farmers' total labour supply curve S_1S_1'. The total quantity of time worked by the operator is OW. The farmer works OK hour on the farm - since the value marginal product of work on the farm exceeds the off-farm wage above the point K. KW hours are worked off the farm -

Figure 2.2: Allocation of labour between farm and off-farm employment



because the off farm wage rate exceeds the value marginal product of on farm work to the right of point K.

2.3.4 The rate of discount - the allocation of capital resources

The decision to undertake a particular activity, planting grass, shrubs, tree, crops or working off the farm will be affected by the expected rate of return to the investment of labour (or land). For efficient production, the present value of the MVP of labour (or land) equals the present value of the cost of labour (or land). The relative profitability of alternative actions is affected by the rate of discount chosen by the farmer.

The rate of discount measures the opportunity cost of postponement of receipt of any benefit (or cost) yielded by an investment - the returns foregone by not having the benefits of an investment available for immediate consumption or reinvestment (Baumol,1968). The rate of discount will vary among individuals depending upon their

preferences between present and future consumption. The riskiness of an investment may affect the rate of discount; incorporating a risk averseness factor into a discount rate results in rates that favour present consumption. For private investment, the market rate of interest provides a good estimation for the discount rate (Marglin, 1963).

2.3.5 Response to production incentives offered by the TSFS project

One aspect of the Schultz hypothesis studied extensively, is the response of farmers to economic incentives. In general, research has found that changes in the price of factor inputs and farm output will induce farmers to modify their production practices to take advantage of these changes in price (Krishna (in Stevens and Jabara,1988); Jegasothy et al,1990; Flinn et al,1982).

Assuming that inputs are allocated optimally, and that farmers are responsive to economic incentives related to the cost and returns of inputs and production outputs, it may be assumed that economic incentives offered to farmers participating in the TSFS project will influence the way they allocate farm resources between private and project activities. Therefore these incentives must be taken into account when analyzing the TSFS using data obtained from participating farms. Any economic incentives offered to farmers participating in the project may lead to an allocation of factor inputs (land, labour or capital), which would be inefficient under 'normal' farming conditions (Anderson, 1985)[14].

It may be argued that if farmers are rational, and have some information related to the constraints imposed by the project, they will adapt their production practices to

[14] Anderson, 1985, goes so far as to state that any financial incentives or compensation offered to participating farmers will render any economic data obtained from the project uninterpretable.

minimize the effects of the project constraints on the returns to farm resources. In the context of this study, farmers will not allocate labour to the project unless it is profitable to do so. It is assumed that when they accepted the project plot on their farm, they incorporated participation in the project into the optimizing process of farm resource allocation.

2.4 Hayami-Ruttan induced innovation hypothesis

The purpose of this section is to provide some theory related to generating agricultural technologies. Using the theory presented here as a guideline, it is possible to more fully assess the effects of the TSFS on the welfare of society as a whole.

Since the introduction of the Schultz high pay-off input model of research, greater efforts have been put toward the creation of new technology for resource-poor farmers. However, the Schultz high pay-off input model is criticized because, while it advocates agricultural research for the generation of new technology, it does not explain how to choose the direction of research.

In response to the limitation of the Schultz hypothesis (and the limitations of other development theories) to explain these processes of technical change, the Hayami-Ruttan induced innovation hypothesis was introduced. Hayami and Ruttan (1971) hypothesized that the optimal direction of research will be towards generating technology which saves on factors of production which are scarce or exhibit rising prices:

> "The market mechanism relies on the positive output response of producers to output prices and on the adjustment of input mixes in a cost-minimizing way in response to changes in factor prices. Induced innovation reinforces both these mechanisms by directing the innovative effort of firms to goods and factors of production that are scarce or exhibit rising prices" (Binswanger, 1978).

Evidence in support of this reasoning has been found by Hayami and Ruttan (1971), who studied the comparative history data for the United States and Japan; "it was demonstrated that factor prices appeared to reflect national factor scarcities...[and that] technology appropriate to those resource endowments was generated and used" (Biggs and Farrington, 1989).

The theory implies that output prices will also affect the direction of research - the total amount of research devoted to a particular commodity will rise with increases in the expected discounted output price. However, "the effect on the bias of technical change of a rise in the output price cannot be predicted and depends on research possibilities and factor costs" (Binswanger, 1978:108).

If input or output prices are distorted by market inefficiencies or domestic policy, the direction of research will not be optimal. Market inefficiencies distort perceptions of the relative scarcity of factor endowments; research efforts may be directed to saving the use of a factor which is in fact relatively abundant, while neglecting research which may save the more scarce inputs. Similarly, the direction of research is influenced by distorted output prices: "Those goods whose relative prices rise as a distortion will receive research resources in an amount that is disproportionate to their potential contribution to real national income" (Binswanger, 1978:125). The welfare losses of market inefficiencies are compounded by the misdirected research: "The additional "dynamic" welfare loss that results from the inducement of inefficient technical changes must be added to other, more dynamic components of welfare losses of monopoly and quantitative restrictions" (Binswanger, 1978:125). It is in the best interests of society to determine the true factor

costs and output prices of farm production, to induce the most optimal directions for agricultural research.

Relating this theory to the TSFS project, we find that the plot design replaces crops with forage production to increase the production of cattle. If descriptions related to the costs and returns of the TSFS plot are accurate, it may well be that the TSFS researchers have allocated research resources optimally to generate the TSFS. However, if researchers have under- or over-estimated the relative value, to farmers and to society, of production inputs and outputs of the TSFS, they may be induced to generate a technology inappropriate to the farming conditions found in dry land regions. Further, the net welfare effects to society of such mis-directed research may be negative.

2.5 Summary

This chapter has presented economic theory relevant the economic evaluation of the TSFS as a production system for resource-poor farmers. Financial analysis has been chosen as the analytical tool most appropriate for the evaluation of the TSFS.

Economic theory related to the production practices of resource-poor farmers has been presented. This theory will provide guidelines for estimating the value of inputs to the traditional farming system and the changes imposed upon this system by the TSFS.

The Hayami-Ruttan hypothesis for induced innovation was also presented. This theory implies that for efficient generation of new technology, research should be directed to finding methods of saving the most costly factor of production, where accurate estimates of the social value of factor inputs are used.

Chapter 3 The TSFS project site and results of TSFS project experiments

The purpose of this chapter is to describe TSFS technology. The chapter begins with a description the village Pecatu, the site of the TSFS project. This is followed by a description of the TSFS project and the results of crop, cattle and forage experiments. These descriptions are required to predict and interpret economic values associated with the changes, introduced by the TSFS, to the traditional production system.

3.1 The village Pecatu - the site of the TSFS project

The village is located in the Bukit peninsula, a dry region on the southern tip of Bali. The Bukit peninsula has traditionally been considered as one of the poorer agricultural regions of Bali because of the low fertility of its soil and dry climate (Raka, 1955), with average annual rainfall at 1000mm with 47 rainy days (Nitis et al 1989).

The village consists of 2674 Hectares, with a population in 1988 of 5437 people (or 2.03 people/hectare). The population density is very low[15] and is a reflection of the poor agricultural conditions of this region. Selected statistics concerning the village - livestock population, tree fruits, water resources and population densities are presented in Table 3.1. The cattle population has been increasing steadily since 1983 (from 2390 in 1983 to 3729 in 1988 - or 1.1 cattle/ha in 1983 to 1.4 cattle/ha in 1988). It is possible that the increase in numbers of cattle is due to the positive influence of the TSFS project. However, since the numbers of cattle began to increase since before the project began, it seems likely that other factors - for example, increases in cattle prices or government

[15] The average population densities of Bali and Indonesia are 476 people/km^2 and 85 people/km^2, respectively.

programs promoting the use of forage shrubs and improved varieties of grasses - may have had some influence on the decision to keep more cattle.

It can be seen that effort has been continually made to increase water storage reservoirs and decrease constraints due to scarce water resources. There is no indication, from the statistics presented in this table, that village poultry production has been directly affected or increased as a result of the introduction of the TSFS.

Table 3.1: Pecatu - village statistics*

Size of village: 2674 hectares					
Year	1984	1985	1986	1987	1988
Population	5238	5335	5378	5433	5437
No. head of family (#of families)	1109	1199	1193	1234	1307
person/hectare	2.0	2.0	2.0	2.0	2.0
village bank	-	-	-	-	1
water reservoirs	1021	1080	1116	1146	1171
cattle	2952	3474	3550	3474	3729
No. cattle/hectare	1.1	1.3	1.3	1.3	1.4
No. cattle/population	0.6	0.7	0.7	0.6	0.7
free roam chicken	39000	19443	19940	19443	17518
orange trees	85000	85572	99410	81513	-
other trees**	59415	73791	82817	93110	82571

* Source: Pecatu village statistics.
** other trees: coconut, mango, jackfruit, banana, papaya, soursop, cashew, kapok, teak, guava, sawo etcetera.

Table 3.2 shows village revenue generated from various activities in Pecatu in the 1984 crop year. The numbers presented in Table 3.2 indicate that field crops (or

'palawija' crops) and off-farm activities generate the greatest levels of revenue among the items included here (livestock statistics are not available). Orange production, ranked very high in the contribution to village revenue, ceased in 1988 when a virus epidemic destroyed the ability of the trees to bear fruit[16].

Table 3.2: Value of industrial and farm output - village Pecatu, Bali, Indonesia[1,2]

Item	Quantity 1984	Price 1984	Value ('000 rupiah) 1984
peanuts	80000	350	28000
mungbeans	50000	500	25000
soyabeans	90000	400	36000
cassava[a]	1100000	70	77000
corn	40000	150	6000
brick production[b]	18000	15000	270000
oranges	70000	4000	280000
tree products[c]	-	-	35600

Source: Tabulasi data potensi desa, Departemen dalam negeri, Direktorat Pembangunan Desa, Propinsi Bali, 1988 and 1984.
1. Quantities are in kilograms unless specified otherwise.
2. Prices are in rupiah/kilogram unless units are specified otherwise.
a. quantity units are in 'wet' kilograms
b. quantity units are in cubic meters
c. tree products include the fruit of kapok, jackfruit, banana, mango, papaya and coconut.

Results of a survey of farmers participating in the TSFS project show that crops contribute the largest on-farm revenues (38% for total crops; 25% for soyabeans alone);

[16] While orange production is no longer an important factor in village economic activity, the fact that it did take place indicates that there is land in Pecatu capable of supporting a highly valued perennial crop.

with sales of cattle the second largest at 26% and tree products the third highest contribution at 16% of total on-farm revenue (Arga, 1990). Off-farm income is approximately 24% of total farm earnings (Nitis et al, 1989). Average total farm revenue per year is estimated at Rp1,425,000 or Rp426,000/hectare ($US250/hectare)[17] (Arga, 1990).

The quality of farmland in Pecatu varies widely (Rika and Whitemen, (1976); Nugari and Winaya, (1977)). Land of sufficient fertility to grow crops is scarce - 81% of farmers surveyed in this study stated that the amount of land put into crop was limited by the total quantity of sufficiently fertile soil available on the farm (17% believed that labour was a constraint and 2% claimed that both labour and the amount of fertile soil were constraining factors). Because the quality of farm land varies so widely, the farmers practice a system where some land is cropped continuously, and some is cropped and then left fallow for a number of years[18]. The length of time a piece of land produces crops or is left fallow is determined by a number of factors: the inherent fertility of the soil, the slope of the land (or its susceptibility to erosion), the capital and labour required to cultivate the land, and the amount of cropland available.

Traditionally, to guard against erosion on sloping land, farmers build terraced fields and stone waterways. The farmers plant productive trees along the terraces to hold the soil and strengthen the terrace wall (Raka,1955). On average, the wall of each hectare of land in dryland regions contains 104 shrubs and 304 trees (Nitis et al, 1986).

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[17] July, 1989 Rp1700 = $US1.

[18] Surveys for this study reveal that approximately 60% of crop land is cropped continuously (never fallowed), and 40% of land in crop is rotated between crop and fallow.

Observations is Pecatu revealed that, contrary to the claims of the TSFS, the trees surrounding many fields are productive (see Table 3.2) - cactus appeared to be reserved for borders along public pathways.

Most families own the land they cultivate - average farm size is approximately 3 hectares[19]. Farmers tether their cattle on their own land. Trespassing onto a neighbour's land is subject to fines, as agreed upon by the village government organizations (Nurbudhi, 1968).

Crops are grown using a system of intercropping leguminous (soyabeans, peanuts, mungbeans) and non-leguminous (cassava, corn, sorghum) plants. Farmers also plant chilis, squash, green beans, sweet potato and other plant species in their fields. Turi (Sesbania grandiflora), an annual tree grown for food and livestock feed is intercropped with the other plants in many fields. Crops such as soyabeans and peanuts are sold as cash crops; corn, cassava and other crops are usually grown for home consumption.

Labour required to carry out tasks related to the production of crops or livestock is usually provided by family members, but on occasion hired labour may be used for work in the fields. The plowing of land in the month of October is often done by hired labour - especially when there is not a sufficient number of trained draft animals on the farm.

As shown in Table 3.2, off-farm employment is an important source of family income. The men most often work off the farm, particularly once the work in the fields has been completed. Work in limestone quarries is the most common type of off-farm

[19] This statistic was obtained from the farmers' group Kelompok tani Selonding, Pecatu, 1988. Sample size is 51 farms.

labour for men, as it requires no special training or skill. In this study, employment as government officials (including teacher), traders, hotel workers, and construction workers was also recorded. Women work off the farm less frequently than the men. Most often women obtain income by collecting and selling firewood and by weaving mats (made from the leaves of the Pandanus plant) for sale to local traders. Work as a small scale trader, and as a seamstress were also recorded. These activities suggest that on-farm wages are influenced by off-farm employment opportunities, as described in section 2.3.3.

3.2 The Three Strata Forage System project

The following paragraphs will describe the set up of the project plots[20] - the selection of farmers participating in the TSFS project, the establishment and maintenance of the project plots, and the economic incentives offered to farmers participating in the project.

3.2.1 Selection of participating farmers

The selection of farmers participating in the project was based on land ownership, cattle and water cachement ownership, willingness to participate in the TSS project and willingness to till their own lands, in addition to references from the head of the village (Nitis et al, 1990). Farmers participating in the project as TSFS or 'NTS' farms (described below) were required to own at least one hectare of land. Other participants were assigned to the 'traditional' group; these farmers did not donate any land to the project.

3.2.2 Economic incentives offered to participating farmers

[20] The set-up of project plots is explained in greater detail in Nitis et al (1989); Nitis et al (1985); and Nitis et al (1986). The description here contains the information relevant to this study.

Farmers participating in the TSFS project as NTS or TSFS farmers supplied the following items to the project:

- crop land for the project plots - in addition to a crop field, Non-strata (NTS) farmers donated a 0.25 hectare grazing plot from 1986 onwards.

- labour for the care of project cattle, the preparation of land for TSFS forages, planting the forages, maintenance of forage plants, and the production of crops on project plots

- farmers were expected to participate in the weighing of cattle once monthly, and to attend monthly TSFS project meetings.

The following items were supplied by the project, free of charge, to participating farmers:

- forage seed, fertilizer for the establishment of forage plants

- materials for the construction of a cattle stall

- a 122kg steer (with the understanding that at the end of the project the cattle would be sold; after the cost of the calf had been deducted from the gross sales value, the farmer would receive one-half of the net sales value)

- all veterinary care for project cattle as required (vaccinations, castration, medications, monthly spraying for flies)

- an educational session on cattle production, with special emphasis placed upon the care of cattle using the TSFS.

- according to project reports, farmers were reimbursed for feed supplies obtained from outside the plot in the fourth year of the project.

- farmers received rent for all crop land donated to the project, the revenues obtained from the sale of project cattle (described above) and produce from the plots (firewood, crops).

3.2.3 Establishment and management of project plots

The TSFS project was carried out from 1984, when the shrubs, trees and grass were planted to March of 1989 when the cattle were sold. Cattle were introduced into the experiment in December of 1985.

A TSFS plot consists of grasses, ground legumes, shrubs and trees; the specific species have been listed below Table 1.1 in Chapter 1[21]. The seeds and stakes used to establish the shrubs and trees of the TSFS plots were obtained from local farms. The seeds for the grasses and ground legumes used in the project were imported from Australia.

The cattle for the project were purchased from a livestock market in Bali. The project cattle were castrated[22] and medicated with antibiotics at the beginning of the experiment and were sprayed for flies (to prevent disease) each month throughout the duration of the project; cattle raised traditionally may not receive such veterinary treatment.

To prepare the experimental plots, the cactus, pandanus (used for weaving mats), and other plants not used as cattle feeds which were growing on the wall of the field were cleared. The shrubs, Gliricidia and Leucaena, were kept if they were growing in the proper sequence. The trees, Ficus, Lannea, and Hibiscus, were kept as they were found on the

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[21] Of the original ground legume species tested in the plots, one variety of ground legume was replaced and another variety resown with a companion plant to increase the total yields. The shrub Leucaena leucocephala (K8) was replaced by the shrub Acasia villosa in December, 1987 after a parasite destroyed the Leucaena plants. During the outbreak of the Leucaena pest, the project was forced to obtain feed from traditional feed supplies of the project farmers, as no feed was available in the plots. See Nitis et al (1986), Nitis et al (1987).

[22] Under the traditional system male cattle are often left as intact; farmers believe that the intact bulls have a higher rate of gain than steers, although there is conflicting scientific evidence concerning this matter (see Devendra et al (1973); Suardjaya (1976); Supardjata (1973); Supardjata and Djagra (1974)).

plot, and were counted as part of the trees to be planted. All other plants growing inside the wall of the field (except for the cash crop) were cleared or moved to another area (in a few cases valuable species, such as mature coconut trees, were not removed from the plots).

The types of crops grown on the plots, when they were to be planted, and when they were to be harvested was determined by a group decision reached by all farmers participating in the project. This was done in order to obtain comparable estimates of crop yields in the plots. However, the freedom of individual farmers to choose the variety of crop grown and the planting or harvesting dates most suitable to the farmer's own unique circumstances was forfeited.

This loss of freedom to choose the most optimal allocation of farm resources was also evident in the project policy concerning the treatment of sloping plots. After three years a decline in crop yield was observed in some of the sloping project plots. Farmers tending these plots desired to take them out of production, as usually done under traditional management. However, the project decided to keep these plots in crop production, attempting to prolong crop production with increased efforts to control soil erosion. Grass was planted to a width of 1m along the top (sloping region) of the terraces and gliricidia shrubs were planted at a distance of 1m apart along the top edge of each terrace; these actions also increased the supply of feed available in the project plots (Nitis et al, 1987). As some farmers complained about the very poor yields obtained from these plots in 1989, it is not certain that the efforts of the project to maintain profitable crop production were successful.

As a control for the TSFS plots, Non-three strata system (NTS) plots were set by the project. Many of the conclusions of the TSFS project reports concerning the attributes of the TSFS plots have been based upon the comparative performance of the NTS plots. It is important therefore, to understand why the NTS plots are not believed to be a legitimate representation of the traditional system. Also, since the NTS farms are included later in regression analyses of farm production, any regulations imposed upon NTS farms which may inhibit or influence the optimal allocation of farm resources should be described.

An NTS plot consists of ¼ hectares of crop with trees (Ficus or Lannea) the corners of the plot to mark the boundary of the plot. No grass or ground legumes or shrubs were planted in these plots at the beginning of the project. In addition to controls related to crop production (identical to the controls on the TSFS plots), the NTS plots were subject to controls on the feeding of NTS cattle. Increased controls on the care of NTS cattle lead from a system where feed was obtained from anywhere on the farm to a system where the feed resources were limited to a grazing plot (0.25 hectares) and the crop plots (0.25 hectares). By the end of the project, controls had also restricted the periods of time access to either the grazing plot or the crop plot would be permitted (Nitis et al, 1986; 1987; 1988). During the project NTS farmers began to plant shrubs and trees (gliricidia, leuceana, ficus, lannea) and panicum grass (at a distance of up to one meter from the edge of the field) on the edges of the cash crop plots (Nitis et al, 1987); the project has interpreted this activity as an indication of the acceptability of TSFS technology

to local farmers. In this study, the validity of this interpretation is challenged (in Section 6.3.2).

In addition to TSS and NTS plots, a group of farmers (Traditional farmers) were given project cattle to care for and were free to feed these cattle as they wished. The cattle were of the highest and lowest weights among all the cattle bought at the beginning of the experiment. Because the 'traditional' group of farmers were given the greatest amount of freedom during the project, the cattle raised by these farmers more accurately represents cattle raised under 'traditional' systems[23]. However, because the TSFS team did not collect data from the 'traditional' farms concerning crop yields or stocking rates and feed intake of traditionally raised cattle, there are no project estimates of these variables. Data concerning the rate of gain of the Traditional cattle has been collected, but has not been officially documented in TSFS reports.

3.2.4 TSFS project experimental results - cattle

Results of experiments carried out for cattle production are presented below. The project design consists of two planting systems (three strata (TSS) and nonstrata (NTS)), and two stocking rates (2 cattle per hectare and 4 cattle per hectare). To achieve the appropriate stocking rates, four cattle per hectare is equivalent to one animal per plot and two cattle per hectare is equivalent to one animal per two plots.

The performance of project cattle has been presented in Table 3.3. TSFS researchers have claimed that TSFS cattle grow 13% faster than NTS cattle, although the difference between the two groups was not statistically significant (Nitis et al, 1989:153).

[23] Although, there may be some special treatment of these cattle as well; farmers have incentive to feed the cattle enough to reach market weight by the end of the project.

Feed sources in both the TSS and NTS plots were usually depleted by the end of July or August each year, so that the diets of project cattle were supplemented each year with feed obtained outside the plots, very often from the farmers' own land. It is interesting to note that the Traditional cattle performed the best of all cattle groups - although data related to the performance of the traditionally raised cattle were not tested for statistical significance or documented in TSFS publications. Figure 3.1 shows the weight gain of all cattle over the course of the project.

TSFS research has shown that it is not possible to feed cattle year-round with fresh green feeds from the TSFS plot[24]. Therefore, stocking rates for the plot have been estimated which include excess feed produced in the wet season preserved (as hay silage[25]) for use in the dry season. The estimated stocking rates are shown in Table 3.4.

Table 3.3: Performance of TSFS project cattle (copied from Nitis et al (1989) pg 111 Table 5.8)

	Initial live weight (kg)	Final live weight (kg)	Live weight gain (kg/day)
TSS (2 cattle/ha)	122.05	332.73	0.18
TSS (4 cattle/ha)	122.10	339.20	0.18
NTS (2 cattle/ha)	122.82	334.09	0.18
NTS (4 cattle/ha)	122.15	292.56	0.14
Traditional*	129.0	372.1	NOT AVAILABLE

*estimated from raw data provided by the TSFS project.

[24] See Nitis et al (1989), page 136.

[25] A successful technology for preserving hay silage has not yet been discovered, however, research to develop this technology is under way.

Table 3.4: Stocking rates of TSFS plots (animal unit/hectare of TSFS plots) (one animal unit = one 375 kilogram animal).

Feeding system	Stocking rate
Forage + hay silage	2.8
Forage + hay silage + crop residue	3.2

The carcass quality of TSFS, NTS and traditionally raised cattle were compared at the end of the project. There were some differences in meat quality between the sample groups, but there is no indication that cattle traders or farmers will be financially rewarded for these differences when selling the live cattle. Therefore in this study a premium is not assigned to the price of TSFS cattle.

Observing the data provided by the TSFS project, it is difficult to determine whether there has been an increase in cattle output over traditional practices. The performance of traditional cattle may be superior but since there are no estimates of feed intake or stocking rates, this higher rate of gain may not indicate greater efficiency of feed resources. Therefore it is not possible to directly compare the TSFS cattle rearing system and the traditional cattle rearing system.

3.2.5 TSFS project experimental results - crops

The TSFS project claims that crop yields in the TSFS plot will improve as a result of an increase in soil fertility and a decrease in soil erosion. As a result of these effects the crop\fallow cycle of crop land is expected to improve, such that it is possible to keep a field in crop one year longer before it must be fallowed again (ie the rotation will be

changed from 3 years crop\3 years fallow to 4 years of crop - with not mention of the effects of this change on the fallow cycle[26]).

Evidence to support the claims of superior crop performance in TSFS plots is rather weak. Observing yields for sloping, flat\sloping and flat land, the researchers have concluded that the TSFS plots obtain higher yields over a longer period of time. Yet the data for the crop yields of the plots indicate that the NTS plots (on average, 1986 - 1989) have higher yields - for all types of land (with the exception of corn, which is higher for sloping TSFS plots) (see Table 3.5). TSFS project statistics indicate that soyabean yields have actually **increased** - possibly due to the use of fertilizer and new seed varieties - with a greater increase observed in the NTS plots than in the TSFS plots.

[26] Results of the survey for this study found crop\fallow rotations ranging from three years crop\15 years fallow to 10 years crop\5 years fallow - suggesting that the assumption of three years crop\three years fallow itself may be unrealistic.

Table 3.5: Production of the cash crop (gDW/m²) for all land and sloping land - average of 4 years (1986-1989) with percentage change in crop yields 1986 to 1989.

	TSFS - all land	TSFS - sloping land	% change in crop yield - TSFS	NTFS - all land	NTFS - sloping land	% change in crop yield - NTFS
corn[1]	131.48	89.33	-27.4	135.11	69.35	-41.5
soyabeans	98.90	100.24	8.3	109.00	102.52	9.7
cassava tuber	169.08	86.74	-36.0	196.03	86.74	-59.4

1. average of 2 years.

Table 3.6: Discrepancy of the relative yield to the actual yield of cassava tuber. (pg 172, Nitis et al, 1986; pg 40. Nitis et al, 1989.

	Number of plots observed	Yield - cassava tuber(kgDM/plot)		Discrepancy of R over A (%)
		actual (A)[1]	relative (R)[2]	
TSFS - Flat	11	362.77	425.22	17
TSFS - Sloping	9	261.32	301.41	15
TSFS - Flat/sloping	9	278.88	300.46	8
NTS - Flat	5	440.01	827.75	88
NTS - Sloping	9	383.39	Not available	56
NTS - Flat/sloping	Not available	415.10	719.23	73

1. total yield (DM) per plot.
2. measured per m² and multiplied by the respective area of the plot.

As the 4 year average yields of the NTS plots appear to be similar or higher[27] than the TSFS, there is little physical evidence to suggest that the TSFS can consistently produce higher yields than the other crop production system (NTS). Furthermore, errors

[27] When monetary values are applied to the yield estimates, NTS shows higher average gross returns - see Appendix E.

in the measurement of crop yields (Table 3.6) indicate that any scientific evidence for crop yields may be unreliable, particularly for the NTS plots[28].

Based upon the physical yield data presented here it is difficult to make any generalizations concerning the comparative performance of TSFS and NTS plots. Possibly, by estimating the monetary value of the yields, the attributes of the TSFS plot will become more obvious.

3.2.6 TSFS project experimental results - forages

The dry matter yields of forages and firewood produced from the plot have been listed in Table C.6 and are illustrated in Figures 3.2 and 3.3. It can be seen that only native grass produces forage in the first year. Gliricidia is the only forage plant which produces firewood during the first five years. Farmers will take the yields of these forages into consideration when selecting varieties for use on their own farms. As farmers face greater constraints to forage production in the dry season, plants which are productive during this time (ie the Ficus tree) are also very attractive investments.

As the yields estimated by the TSFS were obtained on the higher quality land in Pecatu (land otherwise used for crop production), farmers may not obtain these yields when they attempt to produce the TSFS forages on lower quality marginal land.

[28] There is some evidence that the yield estimates obtained by the TSFS project are higher than what would be expected for Pecatu. The crop yields obtained by the project were compared to yields estimates of Indonesia, Bali, and other regions of Indonesia with agronomic conditions similar to Pecatu. The comparison of yields shows that yields estimated by the TSFS team are higher than those estimated by economic studies in other regions. The soyabean yield estimates of the TSFS project are comparable to the yield averages of Indonesia, which seems a little unreasonable if Pecatu is truly representative of one of the poorest regions of Bali or Indonesia.

Figure 3.1 Weight gain of project cattle

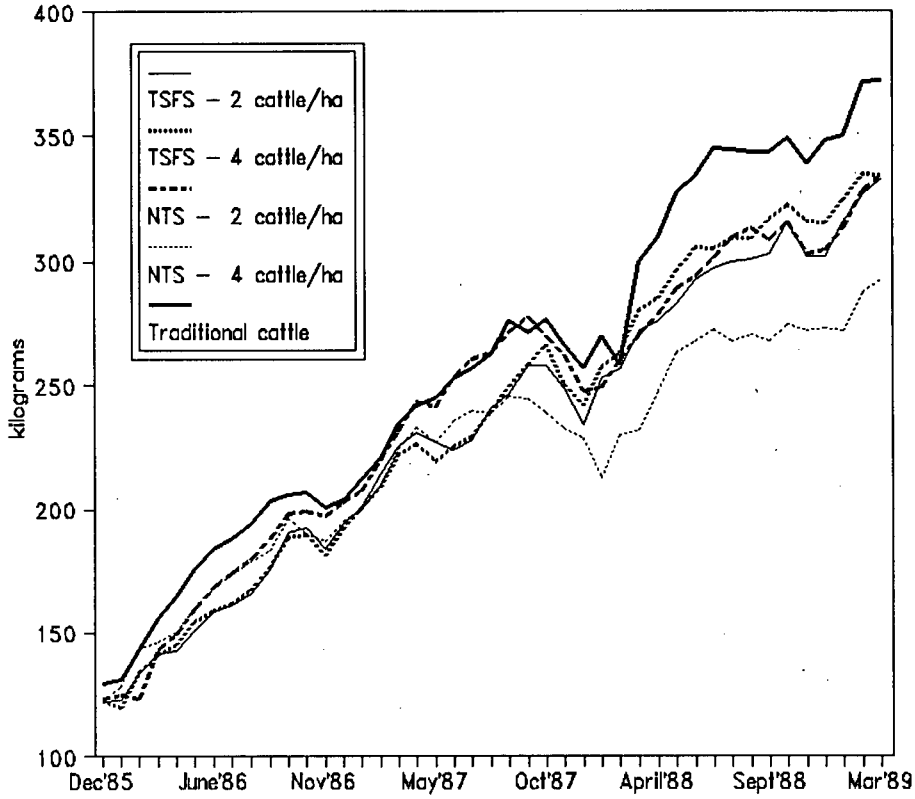
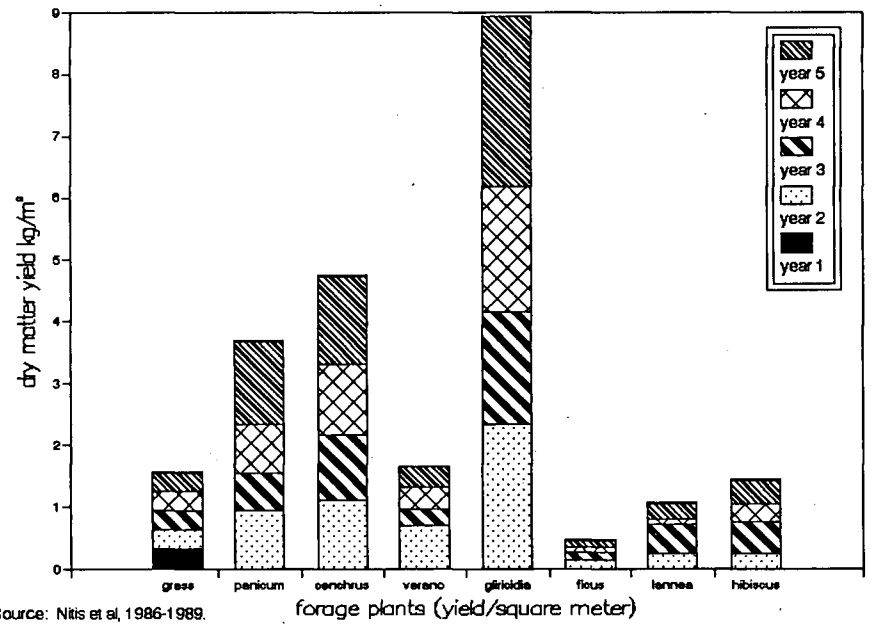
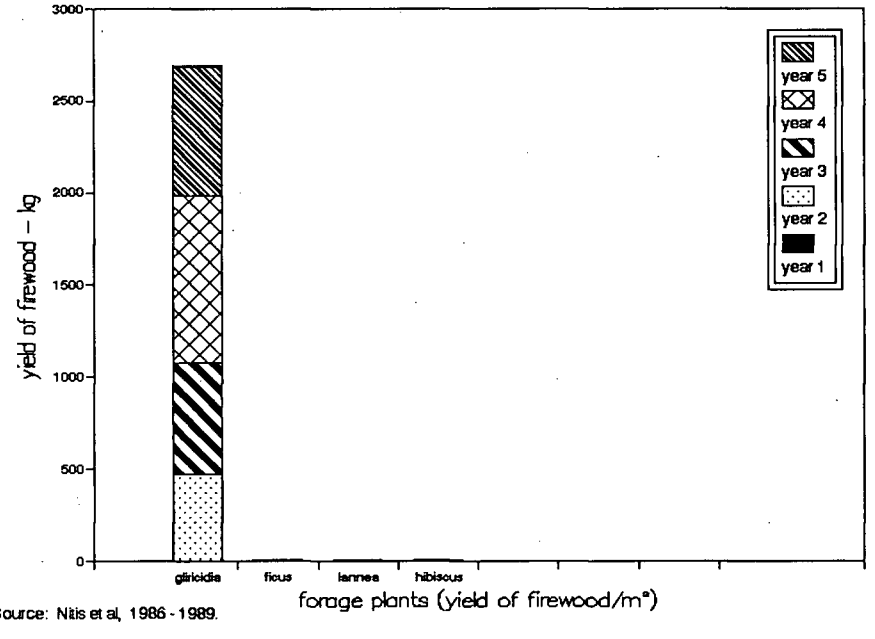


Figure 3.2 Dry matter yield of various forages over a five year period



Source: Nitis et al, 1986-1989.

Figure 3.5 Yield of firewood (shrubs-yield/sq.m trees-yield/2sq.m)



Source: Nitis et al, 1986 - 1989.

Chapter 4 Description of data

The following chapter describes the data for this study using simple statistical analysis.

4.1 Statistical description of data

The purpose of the statistical analysis is to determine if there are differences in production resources and farm output between sample groups of the TSFS project - any differences in resources must be taken into account when the effects of the TSFS on farm production are estimated. The tests conducted here may also lead to insight about the effects of the TSFS project on production practices is obtained.

Throughout this study, statistical analysis is hindered by incomplete samples - any modification of the data to correct for missing data may bias the results and the interpretation of the data analysis[29]. For example, the crop revenues were adjusted to reflect the values believed to best reflect the conditions found in Pecatu. The standard deviations for many of the variables tested here is quite large - in many cases equal to, or greater than, the means. However, economic data is seldom as complete nor as accurate as we would like to see; this is particularly true of data relating resource use and output on small farms (Anderson and Hardaker, 1979).

The following definitions were used in determining farm resources and farm revenues:

Family labour resources:

The mean family size includes all members of a family currently living in the same household or housing compound. It also includes children attending school in Denpasar (and therefore boarding away from home) but still dependent upon their

[29] See Appendix 4.2

parents for support. In the statistical analysis of farm labour resources, the mean numbers of men, women, elderly people or children on the farm include all members (including children) who are available to participate in farm production activities (ie the family members who do not have year round off-farm employment and are not students boarding away from home).

Value of cattle on farm:

The mean value of cattle on the farm includes all animals present on the farm; it does not include animals which are owned by the farmer but which are raised on another farm (under the 'ngadas' system of sharing cattle).

Forage resources:

The numbers of trees[30] included only the varieties used in the project, as these are the major sources of tree forages in the area. The land area devoted to improved varieties of grasses includes varieties promoted by the Balinese government, in addition to varieties introduced by the project. The land area includes the areas planted to grass for which the farmer could give an estimate in 0.01ha units.

Tables describing the mean and standard deviation of variables tested, and the results of F-tests and tests of correlation applied to these variables are described below.

The mean values of farm labour and land resources are shown in Tables 4.1 and 4.2. The statistics here indicate that the TSFS group has greater land and labour resources than the Traditional farms. NTS and Nonproject farms had significantly smaller farms than the TSFS group, but did not show a significant difference from the TSFS group for labour resources.

[30] The numbers of forage shrubs were not estimated because of the large numbers of shrubs on the farms, the differences in age and productivity of these shrubs and the wide variety of planting arrangements, which made it difficult to come up with an accurate and consistent method of counting them. The number of shrubs on a farm ranges from 2000 to 10,000 (outside project plots).

Table 4.1: Mean family size (standard deviation in brackets)

	Total family members	Men on farm	Women on farm	Elderly family members	School age children	Children under 6 years
Total sample	8.3 (4.0)	1.8 (1.1)	2.2 (1.4)	0.4 (0.7)	1.1 (1.2)	0.6 (0.9)
TSFS	10.8[a1] (4.69)	2.4[a2] (1.55)	2.4 (1.32)	0.4 (0.76)	1.8 (1.59)	0.3 (0.62)
NTS	7.9 (2.33)	2.1[b2] (0.77)	1.9 (1.00)	0.5 (0.66)	0.8 (1.08)	1.0 (1.00)
TRADITIONAL	6.3[c1] (3.14)	1.2[c2] (0.42)	2.3 (1.41)	0.4 (0.68)	1.1 (1.10)	0.4 (0.96)
NON-PROJECT	8.0 (4.01)	1.6[d2] (0.81)	2.2 (1.55)	0.4 (0.61)	0.8 (0.77)	0.6 (0.89)

Note: the following statistics are significantly different at 5%: a1 and c1; a2 and c2; b2 and c2; d2 and c2.

Table 4.2: Mean farm size[31] and land use (0.01 hectare units)

	Land farmed	Land owned	Crop area	Area not used for crops
Total sample	374.7 (205.0)	361.2 (215.2)	95.8 (38.6)	274.0 (193.6)
TSFS	555.0[a1] (172.85)	553.5[a2] (169.97)	109.1 (37.25)	439.4[a4] (190.60)
NTS	373.2[b1] (213.49)	375.3[b2] (219.60)	99.6 (38.16)	279.8[b4] (203.34)
TRADITIONAL	262.1[c1] (124.76)	251.0[c2] (138.65)	81.3 (31.59)	180.8[c4] (104.34)
NON-PROJECT	293.9[d1] (154.33)	255.3[d2] (161.62)	90.4 (40.02)	198.9[d4] (139.33)

Note - the following are significantly different at 5%:a1 and b1; a1 and c1; a1 and d1; a2 and b2; a2 and c2; a2 and d2; a4 and b4; a4 and c4; a4 and d4.

The area of land devoted to crop production is statistically equivalent between sample groups. It may also be observed from data concerning land use that approximately 26% of total land in the survey is used for crops, while 74% is used for

[31] By estimating the total population of the sample and the total land area in the sample, the population density of the sample was very close to the population density of the village - suggesting that data concerning farm size and family size are reasonably accurate.

grazing cattle or other purposes. These numbers do not support the supposition that farmers in Pecatu do not devote areas of land to forage production due to a land use pattern predominated by crop production (as described in TSFS literature - Nitis et al (1990b); IDRC (1984)). These statistics suggest that there are factors other than a shortage of total land area which have discouraged the production of the forage materials favoured by the TSFS project.

A trend to higher crop revenue from the TSFS farms was evident to some extent. Total crop revenues (Table 4.3) and crop revenue/0.01 hectares were not significantly different between farm groups, although the TSFS group had the highest crop revenues and the traditional group had the lowest. When average net returns to land (or fixed factors of production) are estimated, the TSFS and NTS sample groups unexpectedly showed the lowest returns - indicating that higher costs were incurred while achieving higher crop revenues.

Tests carried out to determine whether differences in resource use were responsible for differences in farm output between farm groups yielded

Table 4.3: Crop revenue

	Crop revenue (Rupiah/0.01ha)	total crop revenue	net returns to land* (Rp/0.01ha)
Total sample	4502	435928 (235918)	899 (1835)
TSFS	5297	557876 (259804)	1007 (2423)
TRADITIONAL	4110	355605 (232827)	1195 (1980)
NTS	4333	375478 (158941)	218 (1080)
NON-PROJECT	4070	422000 (213675)	1183 (1562)

At 5%, all numbers are statistically equivalent.

* net returns to land = total crop revenues minus variable input costs (seeds, plow, labour). Net returns to land has not been tested for statistical significance between sample groups. To obtain labour costs, total days of men's labour is multiplied by Rp1500/day; women's labour is multiplied by Rp1000/day; children's labour is multiplied by Rp600/day; and team-days (for plowing) are multiplied by Rp10000/day.

interesting results. Table 4.4 shows the mean resource use (per 0.01ha of crop land) for the production of crops for each sample group. The results indicate that Rupiah of seed and team-days of plowing are not statistically different between groups. However, there are significant differences in labour use between project (TSFS and NTS) and non-project (here non-project includes traditional and non-project farms) farms. Both TSFS and NTS farms reported significantly more men's labour, and TSFS significantly more women's labour, per 0.01ha of crop land than Traditional and Non-project farms.

When crop production activities were grouped into three separate categories, planting, weeding, and harvesting, statistical analysis between farm groups showed that the number of days spent weeding was the main source of the differences in labour per unit area of crop (shown in Table 4.5 - 4.7).

The TSFS groups spent significantly more days weeding than the Traditional and Nonproject groups; the NTS farms spent significantly more days weeding than the Traditional group. It is not clear whether the increased amount of labour the TSFS and NTS farms devote to weeding the crop is directly a result of TSFS project influences or whether it is due to the greater labour resources on TSFS and NTS farms. It is also not clear that the increased labour for weeding has resulted in larger crop revenues, although it seems reasonable to suspect a positive relationship.

Table 4.4: Mean input use, crop production (unit/0.01hectare)

MEAN	Seeds (Rupiah)	plowing (team-days)	men's labour (days)	women's labour (days)
TOTAL	394.0	0.07	1.0	1.1
TSFS	472.7	0.07	1.2^{a4}	1.4^{a5}
TRADITIONAL	333.8	0.06	0.7^{b4}	0.9^{b5}
NTS	394.1	0.09	1.1^{c4}	1.1
NONPROJECT	353.9	0.05	0.8^{d4}	0.8^{d5}

Note: the following are significantly different at 5%: a4 and b4; a4 and c4; c4 and d4; c4 and b4; a5 and b5; a5 and d5.

Table 4.5: Total harvest labour (days/0.01 ha)

	men	women	total family
TSFS	0.18^{a1}	0.34	0.55^{a3}
TRADITIONAL	0.14^{b1}	0.22	0.36
NTS	0.20^{c1}	0.26	0.51
NON-PROJECT	0.15^{d1}	0.20	0.34^{d3}

Note: at 5%, a1 and d1; b1 and c1; a3 and d3 are statistically different.

Table 4.6: Total weeding labour (days/0.01ha)

	men	women	total family
TSFS	0.74[a1]	0.82[a2]	1.57[a3]
TRADITIONAL	0.34[b1]	0.41[b2]	0.75[b3]
NTS	0.65[c1]	0.62	1.27[c3]
NON-PROJECT	0.44[d1]	0.44[d2]	0.87[d3]

At 5%, a1 and b1; a1 and d1; c1 and b1; a2 and b2; a2 and d2; a3 and b3; a3 and d3; b3 and c3 are significantly different.

Table 4.7: Total planting labour (days/0.01ha)

	men	women	total family
TSFS	0.19	0.23	0.45
TRADITIONAL	0.16[b1]	0.22	0.41[b3]
NTS	0.29[c1]	0.27	0.59[c3]
NON-PROJECT	0.22	0.23	0.47

At 5%, b1 and c1; b3 and c3 are significantly different.

F-test statistics indicate that TSFS farms had a significantly greater value of cattle on the farm than Traditional farms; less predictable (because of the expected positive influence from the project plots on the TSFS farms) was the result that the mean values of cattle on the farm for TSFS, NTS and Nonproject groups were statistically equivalent. The average stocking rates[32] (for July-August, 1989) were calculated using the following formula:

(average total value of cattle on farm/price of cattle per kilogram)/(375kg)/average total land farmed)

[32] One animal stocking unit = one 375kg animal. It is recognized here that any tests to determine differences in stocking rates or value of cattle on the farm do not take into account the value of cattle sold from the farm. However, the numbers presented here can be a close approximation, on average, to differences in cattle production on the farms.

Table 4.8: Mean value of cattle on farm (Rupiah)

	July-August, 1989	January, 1989	Average* stocking rates (cattle/ha)
Total sample	2670111 (1257293)	-	1.3 (0.66)
TSFS	3516250[a1] (1270400)	2940833[a2] (939924)	1.1[a3] (0.25)
TRADITIONAL	1685555[b1] (944535)	1827777[b2] (572330)	1.1[b3] (0.46)
NTS	2642500 (1108258)	2664500 (1214805)	1.4 (0.75)
NON-PROJECT	2597500[d1] (1002129)	-	1.7[d3] (0.73)

Note - the following are statistically different at 5%: a1 and b1; b1 and d1; a2 and b2; a3 and d3; b3 and d3.

It was surprising to discover that the Non-project farms have a higher stocking rate of cattle than project farms. No explanation for this result is offered - errors in data collection are not ruled out as the source of the differences.

Results of the f-tests showed no differences between sample groups of total numbers of forage trees per 375 kg animal units on the farm. In general, the numbers of trees per animal unit are less than the numbers of trees recommended by the TSFS project (52.5). There were no statistically significant differences in total grass forage resources. The total supply of introduced grasses per animal unit much less than the amount recommended by the TSFS (11.25 - 0.01 hectare units). Observing the average values for each group, there is a trend for farm groups more closely related to the project to grow more grass. This may indicate that either 1) farmers closer to the project have

greater knowledge of the grasses and therefore are more willing to invest farm resources in producing grass; or 2) farmers more closely associated to the project have better access to grass seed. Seventeen farmers groups in Pecatu requested seed from the TSFS project, which may indicate that there is some difficulty in obtaining seed stocks from other sources.

Table 4.9: Average number of forage trees, average area sown with forage grasses.

	grass (.01ha units)	trees/ animal unit[1]	grass/animal unit[2]
Total sample	13.9 (13.2)	24.7 (19.2)	3.0 (3.8)
TSFS	19.0 (17.6)	24.0 (12.8)	3.0[a7] (4.5)
NTS	14.9 (12.2)	30.0 (25.8)	2.64 (3.1)
TRADITIONAL	11.6 (9.6)	23.1 (23.0)	4.7 (6.9)
NON-PROJECT	9.0 (6.4)	21.6 (14.3)	1.5[d7] (1.3)

Note - the following pairs are statistically different at 5%: a7 and d7.
1. one animal unit=375kg 2. one animal unit=375kg - grass is estimated in 0.01hectare units.

Some results obtained from the data collected for this study were contradicted when economic data collected by the TSFS project team was tested. The tests were done on the data according to the classification of sample groups as described by the TSFS project[33]. These tests showed no differences in land resources, and few significant differences in farm revenues (means for crop and cattle revenue were not significantly different between sample groups) although Arga (1990) reports statistics which indicate that TSFS farms have higher crop and cattle revenues and greater land resources than NTS and Traditional farms.

[33] Problems associated with constructing sample groups are discussed in Appendix B.

Tests of correlation (shown in Table 4.10) indicated that crop revenues were positively and significantly correlated to the number of men on the farm, the farm size, the area of crop land, the value of cattle on the farm in August[34], and the area devoted to improved grass production. There was no significant correlation between the area of cropland devoted to the project plots and crop revenue. There was some indication that the value of cattle on the farm in August was positively and significantly related to family size, farm size, area of crop land and crop revenues, number of forage trees on the farm, improved grass production, and size of grazing land. There was no significant correlation between the area of land devoted to a project plot and the value of cattle on the farm in August. Possibly, farmers who are better managers are more likely to obtain higher crop revenues, higher cattle production, and are more likely to own larger farms and adopt new technologies such as improved grasses.

It does not seem unreasonable at this point to suggest that farmers who are better managers are also more likely to be chosen for participation in the TSFS project. It has become evident that there is a bias in the data such that TSFS farms appear to have more resource endowments and possible, greater farm output because of these endowments. It was discovered, upon observing the data, that among the participants for TSFS and NTS farms, were included a local school teacher, two local traders (one of whom takes the largest share of village business) and a village leader. These people are among the most influential in the village, and are certainly not representative of the local population.

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[34] In the tests of correlation, cattle production was represented by the total value of cattle on the farm in August, 1989. This value allows the inclusion of non-project farms into the sample.

Table 4.10: Correlation between selected variables n=39

	Total value of cattle on farm in August	Total crop revenue	Total area devoted to project plot
total family size	0.579 *	0.323	0.088
total men on farm	0.448 *	0.462 *	0.307
total women on farm	0.395	0.219	-0.040
total elderly (+65 years) on farm	0.356	0.222	-0.134
total school age children on farm	0.096	-0.10	0.053
total children under 6 years on farm	-0.02	0.029	-0.131
total farm size	0.678 *	0.430 *	0.344
total crop land	0.574 *	0.616 *	0.230
total area of land devoted to project	0.316	0.307	1.000
total crop revenue	0.584 *	1.000	0.307
value of cattle on farm in August	1.000	0.583 *	0.316
total number of Lannea trees on farm	0.766 *	0.509 *	0.119
total number of Ficus trees on farm	0.324	0.154	0.024
total number of Hibiscus trees on farm	0.428 *	0.092	0.390 *
total number of forage trees on farm	0.619 *	0.352	0.098
total area devoted to improved grass	0.518 *	0.505 *	0.091
total cattle grazing area on farm	0.578 *	0.296	0.310

*correlation is significant from zero at 1%

Because of the effects of differences in resource endowments, it is difficult, on the basis of tests conducted here, to determine the effects of the TSFS technology on total farm output. The analysis of data using F-test and tests of correlation provide some indication of patterns in resource use and farm output, but do not put an economic value on these patterns. Therefore it is desirable to use a different type of data analysis (regression analysis) to determine the effects of the TSFS plot on farm revenues.

4.2 Summary

The analyses carried out here indicate that the TSFS farms have greater land and labour resources than other farms in the sample. There is some indication that TSFS and NTS farms obtain higher crop revenues per unit of land, but this may be a result of more care and nurturing of the crop during the crop season. A trend to greater livestock production on TSFS farms was not evident. It appears as though farmers closely associated with the project have benefitted from experience with new grass and ground legume varieties, and are more likely to devote farm resources to the production of these plants than other farms.

Appendix 4.1 Estimation of labour for crop production

In this study, the costs for cultivating crops on a one hectare section of land have been calculated as the average costs of materials (seeds) and labour derived from the sample of project and nonproject farms. The labour required to cultivate crops was obtained from interviews with farmers. In some cases, the questions concerning labour requirements were asked twice. In these cases, the first answer was finally assumed to be the most accurate. The final estimate included the costs of plowing, seed, planting, two weedings, and the harvest of corn, soyabeans and peanuts. The harvest for cassava was not included as it is believed that labour estimates for the cassava harvest were extremely overestimated. A number of other tasks were left out: thrashing soyabeans, the third and fourth weedings, and a number of other unspecified tasks. This was done because the inclusion of these tasks into the total costs led to negative returns on the farms. The value that is used (Rp419842 for one hectare) resulted in low average returns to land (Rp871/0.01hectares) after labour and materials costs. Nitis et al (1990) have estimated gross returns to crop production (and crop yields - Table 4.13) to be approximately Rp8814/0.01hectares - quite a bit higher than the estimates obtained here.

The labour requirements for dry land crops in other regions (shown in Table 4.14 - estimates have been obtained from Timmer, 1987) are higher than the labour requirements used in this study. When the labour estimates for other regions are so high, there is some inclination to believe that final labour estimates used here have been seriously under-estimated. However, an estimation of labour costs reported in Nitis et al

(1989:158) shows similar labour costs to those described in this study. This issue cannot be resolved without detailed research related to farm labour allocations and crop production.

Table 4.11: Yields (00kg/ha) of crops, various provinces.

	Bali[1] and Nusa Tenggara	TSFS[2]	TSFS[3]	TSFS[4]	Indonesia[5]
corn	14.1	14.3	2.8	13.1	20.8
soyabean	9.97	10.8	9.9	9.89	11.0
cassava[a]	99	55.2	9.3	50.7	-

1. Yields are for 1986. Source: BPS, Indonesia, 1987.
2. Yields reported for TSFS plot by Arga in TSFS Final Report, Nitis et al, 1989, page 157.
3. Yields reported by farmers for this study, 1989.
4. Yields are averaged over 4 years (except for corn, which is averaged over two years). Values have been converted from grams of Dry weight/meter^2. TSFS Final Report, Nitis et al, 1989, page 40.
5. Yields are for 1988. Source: ERS, United States Department of Agriculture, 1990.

a. Yields are in wet root equivalents.

Table 4.12: Costs and returns of crop production in dryland fields.

	Pecatu		Gunung Kidul			Kediri
Inputs and outputs per hectare	cassava, corn legumes - TSFS project	cassava, corn, legumes - survey	cassava, corn	cassava, corn and legumes	cassava, corn, upland rice, and legumes	cassava and corn
soil type	varies	varies	hill-side, no terrace	hill-side terrace	level vale soils	hill-side terrace
labour use per season (days):						
male	~200	94.7	188.8	223.6	305.2	292.1
female		99.7	157.0	138.7	246.4	22.3
Percent labour hired:						
	-	0%	0%	5.8%	14.8%	38.5%
bullock power (pair days):						
	12	6.4	0	0	28.2	4.5
Fertilizer (kg):						
urea	12	?	0	0.9	201.3	386.0
TSP	-	?	0	0	40.2	0
manure	?	?	0	174.0	3520.0	8630.0
non-labour cash costs (000Rp):						
	33.0	35.9	1.6	3.5	59.2	33.7
Yields (00kg) (yields considered normal by farmers in brackets):						
cassava	50.7	9.31	26.4	22.7	69.0	120.0
corn	13.1	2.8	2.0 (4.3)	1.1 (2.7)	3.5 (4.7)	6.1 (6.1)
legumes[a]	9.89	9.9	-	2.0 (2.7)	5.8 (8.3)	-
Total output value[2] (000Rp):						
	1416.1	665.9	258.0	338.3	1014.0	1083.0

2. Values are determined using the following prices: corn - Rp300/kg, soyabeans - Rp650/kg, cassava - Rp75/kg.

a. For TSFS project calculations and economic sample calculations, legumes includes soyabeans only. For Gunung Kidul and Kediri, legumes includes peanuts, mungbeans and other field legumes in addition to soyabeans.

Source: TSFS project reports; Timmer (1987).

Appendix 4.2 Estimation of crop revenues

In many cases, revenue obtained from cassava production was not available at the time the surveys were carried out. In cases where 1989 data was available, revenues from the TSFS 1988 data were used. Often enough (most often for the Non-project sample group), there was no data for either 1988 or 1989. To deal with these cases, the average cassava yield per kilogram of seed was calculated (using the available 1989 data) for the entire sample group. This average was then used to approximate the yields obtained on individual farms, which would otherwise have no other estimate. The kilograms of cassava seed used to plant the crop was multiplied by the average yield/kg seed to obtain a yield estimate for the cassava crop.

Another area of concern was the information collected on corn and mungbean revenues. Mungbean revenues are believed to have been greatly exaggerated - revenues were often up to a five hundred times the reported expenditures of mungbean seed and were quite often much larger than what had been reported to the TSFS team in the previous year. So I divided all the mungbean revenues by ten to obtain estimates believed to be more accurate.

Reported revenues for corn varied between interviews. It appears that the reported revenues would become larger every time the farmer was questioned (again) about corn revenues. The only possible choice is to take the first answer. In some cases there was no first answer.

Chapter 5 Description of budget analyses

This chapter describes the budget sheets used for cost benefit analysis of the TSFS plot. In order to carry out cost-benefit analysis, the shadow prices of costs and benefits of production must be estimated. Therefore, this chapter will consist of two parts. Section 5.1 describes the methods used to obtain the shadow prices which will be used in financial analysis of the TSFS technology. In section 5.2, the budget sheets, designed to compare the profitability of the TSFS and traditional production systems are described. Section 5.3 describes in detail the costs and returns of land, labour, and materials used in the analyses described in section 5.2.

5.1 Derivation of shadow prices for the TSFS plot

The purpose of this section is to determine the monetary value of costs and benefits of production in the TSFS and traditional production systems. The value of cropland must be determined in order to know the opportunity cost of growing forage on this land. The returns of land and labour to crop production are estimated using data collected in Pecatu and by estimating regression equations to determine the marginal value of these inputs to farm production. (The market values of land, labour, and the discount rate, used in the cost benefit analysis, have been described in Appendix A). A second purpose of the regression equations is to determine the effects that the presence of project plots on farms have had on farm production of crops[35].

[35] Regressions were also estimated for cattle production. These regressions gave poor results, for a number of reasons. A small sample size hindered the estimation of coefficients in addition to the fact that the period of time covered by the regression (8 months) is only a fraction of the actual period of time required for cattle production (approximately five years).

5.1.1 Effects of the TSFS plot on crop yields - monetary yields

A budget sheet was set up to determine the effects of the changes in yields of soyabean, corn and cassava yields on the total crop revenue of project plots. The budget sheet measures the effects of a decrease in yield from year 1 (1986) to year 4 (1989) using data from TSFS reports. The monetary value of the crops was derived using market prices obtained in Pecatu. Sensitivity analysis was carried out to determine the effects of changes in crop prices on total crop revenues. The results are used to determine the benefits accruing to TSFS plots in the form of increased crop revenues.

5.1.2 Regression equations for crop production

The purpose of the regression equations for crops is to determine a shadow price for crop land, taking into account the share of returns to labour, draft power and seed to crop production.

The problems of estimating production functions has been well documented in Upton (1979), Yotopoulos (1970) and Yotopoulos and Lau (1976). The linear form is used for all equations. Although the linear functional form yields satisfactory results, it imposes constant marginal product of inputs on the model of the crop production process and the elasticity of production of an input approaches one as the input level increases. If diminishing marginal returns of a factor input is believed to better represent the production process, the linear model can be regarded as only a local approximation to the true production process (Esparon and Sturgess, 1989).

The sales production function is used to estimate the marginal value of factor inputs of cattle and crop production. The dependent variable is the total value of crops

produced on the farm. By estimating a sales function, rather than an engineering production function, it is possible to aggregate output across different products allowing for the comparison of farms with different inter-cropping patterns.

Crop revenue is believed to be a function of land, labour, seed and draft power (hired labour), and project plots.

Total crop revenue = f(crop land, labour, plowing (hired labour) seed, cattle manure or chemical fertilizer, project plots)

The coefficients of this function are a measure of the marginal value of each input to total crop revenue, such that:

$$\frac{\partial p \cdot q}{\partial x} = p \cdot \frac{\partial q}{\partial x} + q \cdot \frac{\partial p}{\partial x} \quad where, \ \frac{\partial p}{\partial x} = 0$$

Data related to the use of cattle manure was extremely difficult to obtain and therefore is not included in these regressions. Data related to the use of fertilizers is not complete, and therefore is also omitted from the regressions[36].

The presence of the plot on the farm has been measured in two ways. The first method estimates the area of cropland included in the plots and includes this area as a separate variable in the equation. In this first method, the coefficient of the project plots indicate the returns to this land when project land is assumed to be an input distinguishable from ordinary crop land.

The second method includes all crop land in a single variable and accounts for the effects of a project plot on the farm through the use of dummy variables. The dummy

[36] Data related to the use of fertilizer indicates that it is not used on all farms, nor is it used in large quantities.

variable has been included in two different forms; in the first form, the coefficient of the dummy variable is an estimate of the shift in the sales function as a result of TSFS (or NTS) technology. The second form measures the effect of the TSFS on the slope of the sales function. It has been assumed that the change in the slope will be reflected in changes to the returns to land; returns to other factors of production (including labour) are not affected by TSFS technology.

The coefficients of the dummy variables represent the effects of the project plots (TSFS and NTS) on farm revenues (similar to the effects of education on farm production, as outlined in Welch (1970)). If farmers have learned superior farming practices by direct experience with TSFS technology, the dummy coefficients represent the increase in crop revenue when the farmer has learned to apply the technology to his farm, and is better able to manage farm resources for crop production. The dummy variables for the NTS plot may be a bit more difficult to interpret. They imply (following the same logic) that having any kind of NTS plot on the farm also leads to a change in crop revenues due to a different allocation of farm resources or better use of farmer resources. Since NTS farmers are also expected to learn about better farming techniques, if only about what <u>not</u> to do, this coefficient is also expected to be positive.

The crop production equations have also been estimated without taking accounting for the presence of the project plots on the farms. If the project plots have no production or educational features that differentiate them from private crop land, then the coefficients of these equations may best describe the returns to production of the relevant farm inputs.

The definition of the dependent variable, crop revenue, and the independent variables, are given below.

Cropinc = dependent variable - total revenue obtained from crops - soyabeans, corn, cassava and peanuts. The value of crop residues and other food (sweet potato) or feed crops (sorghum) has not been included.

MTcost = labour input of men for planting, two weedings, harvest of corn, soyabean, peanuts measured in days of work. The coefficient value should represent the MVP of labour for men, or the local wage rate for men.

WTcost = labour input of women for planting, two weedings, harvest of corn, soyabeans, peanuts measured in days of work. The coefficient value should represent the MVP of labour for women (the local wage rate for women).

CTcost = labour input of children for planting, two weedings, harvest of corn, soyabeans, peanuts measured in days of work. The coefficient value should represent the MVP of labour for children.

CRland = total amount of land used to grow crops (including project crop land), the coefficient value should equal the returns to land obtained from previous estimates - the local rental rate for land.

Ncrland = amount of land used to grow crops but does not include project crop land. The coefficient value should equal the returns to land obtained from previous estimates - the local rental rate for land (without any influence from the project plots).

Tantss = amount of land used to grow crops, included in the TSFS project plots. The coefficient value should equal the returns to cropland under the TSFS system of cropping.

Nts = amount of land used to grow crops, included in the NTS project plots. The coefficient value should equal the returns to cropland under the NTS cropping system.

Dumts = dummy variable for presence of a TSFS plot on the farm. The coefficient of this variable is a measure of the shift in the production function due to the TSFS technology. Dumts=0 if no TSFS plot on the farm, 1 if there is a TSFS plot on the farm.

Dumns = dummy variable for presence of NTS plot on the farm. The coefficient of this variable is a measure of the shift in the production function due to the NTS technology. Dumns=0 if no NTS plot on the farm, 1 if there is an NTS plot on the farm.

Slts = A dummy variable measuring the change in the slope of the sales function. The variable is of the form D*(Crland) where D takes on the value of 1 if a TSFS plot is on the farm, and 0 if there are no TSFS plots on the farm.

Slns = A dummy variable measuring the change in the slope of the sales function. The variable is of the form described for SLTS, but for this variable, takes on the value of 1 if an NTS plot is on the farm, and 0 if there are no NTS plots on the farm.

Seeds = seed inputs - an aggregate value of all seeds, measured in Rupiah - the coefficient is expected to measure the marginal value of seed to total crop revenue.

Plow = the number of team-days[37] spent plowing to prepare the soil measured in days of work. The coefficient is expected to reflect the MVP of plowing the soil - the rental rate for one day of plowing.

5.2 Benefit-cost analysis of the TSFS

There are three different budget analyses used to analyze the TSFS. The first is an analysis of the TSFS plot. The TSFS project claims that the sale of cattle raised under the TSF system will compensate for the foregone revenues from crop production (crop revenues foregone because forages were grown on crop land). The purpose of the first

[37] One team-day represents the work completed in one day by a team of cattle and one man. In one day, a team usually works for no longer than 5-6 hours.

budget sheet is to determine whether this claim is supported by the results of financial analysis.

The second budget estimates the returns to farmers who participate in the TSFS project. The benefits accruing to a 0.25 hectare TSFS project plot will be compared to the benefits accruing to a traditional crop field of similar size. An analysis of a 0.25 hectare NTS plot is also presented.

The third budget will determine the profitability of individual forage species used in the TSFS plots, relative to the yields of native grass. The values of these forages will be compared to the value of native pasture grass. The purpose of this analysis is to determine if the preferences of farmers for particular forage species can be explained by the economic value of these forage species.

Each of these analyses is presented in greater detail below.

5.2.1 The profitability of the TSFS plot

The budget records the costs and benefits of the plot over a period of 5 years. Year 0, the costs of all materials, labour and land required for planting forages are paid. At the end of year 1, the costs of the young cattle, the materials for stalls to house the cattle, and the labour required to care for the cattle are paid. From year 2 to year 4, the farm receives revenue from firewood sales and pays for labour required to care for the cattle. In year 5, the farm receives the revenue from the sale of the cattle.

The budget sheet for the traditional farm includes returns to 0.09 hectares of cropland from years 1 to 5 - with returns received at the end of each year. In this analysis, the two systems (TSFS field and traditional crop field) were compared using the

net present value. The net present value of the plot is determined by calculating the present value of (returns-costs) of the plot. The costs incurred in year 0 were not discounted.

The internal rate of return to the TSFS was derived by graphing the net returns against various discount rates and determining the discount rate at which the NPV is equivalent to zero.

5.2.2 Profitability of participation in the TSFS project

The budget sheet for participation in the TSFS project includes costs similar to those presented for a TSFS plot. The differences between the costs and revenues incurred by participating in the project, and the costs and revenues of private investment in a TSFS plot are described below.

Economic incentives offered to farmers participating in the TSFS project have been described in Chapter 3. Also included in the budget was the supply of feed obtained from outside the project plot for the second and third year of the project (when sources of feed from the project were exhausted). According to project reports, farmers were reimbursed for feed supplies obtained from outside the plot in the fourth year of the project.

The costs and returns of the NTS plot are very similar to the costs and returns of the TSFS plot. The NTS plot does not incur costs for forage production in the crop field, but requires 0.25 hectares of grazing land in addition to the 0.25 hectare crop field. TSFS financial reports indicate that NTS farmers did not receive rent for this grazing land. For the financial analysis done here, the value of the 0.25 hectare grazing plot was determined to be Rp1000 per 0.01 hectares.

5.2.3 Comparative profitability of TSFS forages

In this analysis, the net present value of the production of each type of TSFS forage over a five year period is estimated relative to native grass. The costs of the forages over a five year period included the opportunity cost of native grass land, the labour to plant the forages, and the seeds for the forages.

The costs are determined for one square meter of grass (or ground legume), one square meter of shrubs and two square meters of tree. The unit of measurement, square meters, was chosen because it is the easiest to manipulate to include all three varieties of plants. The return to grazing land (or pasture) is determined to be the opportunity cost of growing TSFS forages on this land. The value of grazing land incorporates the value of native grass, in addition to all costs of producing this grass.

Shrubs (most commonly, Gliricidia) are grown along fence lines, at the edges of fields and at various locations scattered over the farm. The distance between each shrub and other plants will vary, depending on the type of land, the species of other plants, and of course, the farmers own personal preferences for planting arrangements. Forage trees are found in similar locations but because of their larger size take up more room. The TSFS project planted shrubs 10 cm apart with a tree planted every 5 meters. For the cost benefit analysis, shrub density was therefore estimated to be 10 shrubs per meter squared. The density for trees was estimated at one tree per two square meters (different from the project spacing), as observations in Pecatu showed that this was a fairly common measure (although, it would not be hard to find an exception to this rule).

The yields for both grasses and firewood were calculated from project estimates. The forage yield estimates of the project may or may not reflect the yields obtained by farmers, since farmers may have different harvesting schedules or managing techniques than the system practised in the project plots.

The prices for forages and firewood were calculated from price estimates obtained from Pecatu; although trade between farmers for forage is not common, there are cattle traders in the village who buy feed for cattle temporarily in their care. The derivation of forage prices has been described in detail in Appendix D.

The discount rate for the forages was determined to be approximately 28%.

5.3 Description of costs and returns of the TSFS

The costs of establishing and maintaining production in a TSFS plot include the labour, land, forage seed and fertilizer required to set up a TSFS plot; the cost of young cattle and the labour and veterinary care required for the care of these cattle; the cost of a stable for the TSFS cattle; and the cost of opening up new crop land every three years to replace worn-out land taken out of crop production. These costs and returns have been further described below.

5.3.1 Cattle

The TSFS reports suggest that one hectare of TSFS plots can support 3.2 animal units (each animal unit = 375 kg) per hectare, assuming that crop residues and preserved forages from the plots are used to feed cattle through the later parts of the year. The analysis will be carried out as if technology for preserving feed already

exists[38] (labour and other costs of preserving feed are unknown and therefore cannot be included in the budget).

For the analysis, it was assumed that the farmers would buy young cattle at a stocking rate of 3.2 cattle per hectare of TSFS plots (each animal weighing 122 kg - the starting weights of cattle in the TSFS project) and raise these cattle until they reached 375kg at the end of four years. In this first analysis, the value of only 0.25 hectares (one TSFS plot) is estimated. Therefore the stocking rate is estimated as:

3.2 cattle/hectare of TSFS plots*0.25 hectares.

The cost of the young cattle and the selling price for the market weight cattle was assumed to be Rp1600/kg. This price was obtained from observations in Pecatu and from a livestock market in Bali. It has been observed that this price will vary with the age and weight of the animal, but in this study, Rp1600/kg gives a reasonable estimate for all cattle.

5.3.2 Labour required for the care of TSFS cattle

Labour for feeding and caring for the TSFS cattle based on direct observations of these activities in February, 1989 and from May to August, 1989. According to these observations, the care of project cattle takes from 40 minutes to one hour each day per animal plus five or ten minutes per day to clean the project stalls. The lower bound values were used in the analyses carried out here. The value of labour for the care of the cattle has been described in detail in Appendix A.2.

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[38] It is evident later on that the use of this stocking rate does not affect the interpretation of results concerning the profitability of the plot.

5.3.3 Cattle stall

Costs of the materials to build a stall were included in the analysis. No labour estimates were obtained for the building a stable for the cattle; discussions with farmers revealed that the labour required ranged from one day to one week. The numbers of stalls required were determined by the stocking rate of cattle.

5.3.4 Cost of materials and the establishment of TSFS forages

The cost of forage materials includes the cost of grass and legume seeds, shrub stakes, and tree stakes. The numbers of shrubs and trees planted and the amount of grass and ground legume seed required are estimated according to the description of the TSFS technology. The cost of grass and legume seeds and fertilizer applied to the grass were calculated from TSFS project financial reports (1989). The cost of grass seed may not perfectly reflect the value of grass clones, which the farmers are using, but since both materials result in the same output, the difference in value may be minimal. The price of shrubs and tree stakes were obtained from interviews with farmers and from TSFS financial reports.

The labour costs of planting the forages were calculated from estimates obtained from interviews with farmers. Labour estimates for planting forages will vary, depending upon how much labour is required to clear the land of other plant species and cultivate the soil, and how much time and effort is spent obtaining seeds and shrub stakes. Grass and ground legumes require 1.5 man-days per 0.01 hectares; trees and shrubs require 0.007 man-days per shrub or tree planted (or seven days per 1000 shrubs or seven days per 100 meters of shrubs, each shrub planted 10cm apart).

5.3.5 Cost of land for the TSFS forages (returns to crop land)

While collecting data for this study, many traditional fields were examined for native grass growing on the edges. Most often, it was discovered that the field has been cultivated to the edge, with no areas untouched where fertile soil was available, and with very little amounts of native grass found - contrary to the description offered in TSFS publications. Since the TSFS forages were likely established where field crops would otherwise be grown (most certainly, if the forages extended five meters out from the edge of the field), the opportunity cost of using this land is the returns to crops.

The returns to crop land (estimated from market values of land in Pecatu, and from regression equations) are used in the place of the variable costs and gross revenues of crop production. The value of land and labour in Pecatu have been estimated from market values - these derivations are described in Appendix A.1 and A.2.

5.3.7 Firewood and other tree products

Revenue earned from firewood was determined by using estimates of firewood production from the TSFS plot (in kilograms), dividing this estimate into 12kg bundles (the unit used for the sale of firewood) and multiplying the number of bundles by the market price of one bundle of firewood (Rp300/bundle) in Pecatu, 1989. Firewood yields reported by the project do not take into account the quality of wood harvested - which may affect the price received for the wood (this may be relevant, as farmers do not usually sell firewood from gliricidia shrubs, but reported using this wood for home use and selling the wood of other tree species).

It has been shown that the TSFS trees and shrubs may compete for land used to grow other types of productive trees. However, it is very difficult to incorporate the cost of replacing other productive trees, due to the wide variety of planting arrangements, species, production cycle and management of these other plants. Therefore, the opportunity cost of replacing these trees with TSFS fodder trees and shrubs has not been included into the budget sheets - possible underestimating the costs of the TSFS.

5.3.8 Water

Water is a scarce resource and may be a limiting constraint to livestock production. However, efforts to collect data with respect to water resources did not yield consistent results due to misunderstandings, on the part of the researcher, concerning the system of allocating water between household and livestock use, as well as allocating public water resources between households. Therefore, the cost of water is not included into the budget analyses.

5.3.9 Environmental effects

The TSFS project has listed benefits associated to the project, related to improved management of the local ecosystem (ie reduced soil erosion as a result of decreased tethered grazing of cattle, increased soil moisture due to the presence of trees on the edge of the field). Factors affecting soil fertility on crop land will be reflected in crop revenues. However, other factors cannot be assigned a monetary value as there is insufficient information regarding the effects of these items on farm revenues. Therefore the financial analysis may be biased slightly downward from the true returns to the TSFS.

Chapter 6 Results

This chapter presents results obtained from the regressions and financial analyses described in chapter 5.

6.1 Soil Erosion: effects of TSFS plot on crop revenues

To determine if there are differences between the monetary value of crop yields obtained from TSFS and NTS plots over a 4 year period, budget sheets were set up to determine the effects of the changes in soyabean, corn and cassava yields on crop revenue. The yield values used are the four year averages for flat, flat-sloping, sloping and all TSFS and NTS plots. Also estimated were the values of revenues obtained using the project estimated percentage decline in yield from 1986 to 1989.

Table 6.1: Effect of TSFS on crop revenues - estimated revenues

	Average crop value - four year average revenue (1986-1989) (Rupiah)	Estimated revenue - derived from percentage decline in yield (1986 to 1989)
TSFS - all land	14897	9933
NTS - all land	16305	10225
TSFS - flat	20196	-
NTS - flat	20319	-
TSFS- flat\sloping	13152	7903
NTS - flat\sloping	15220	8159
TSFS - sloping	11716	8800
NTS - sloping	13388	6599

The results of these analyses show that NTS farms obtain a slightly higher total crop revenue for all alternative measures, with the exception when the percentage decline

in yield from 1986 was used to estimate 1989 values for sloping land. The conclusions reached from these analyses are similar to those reached in section 3.2.5. There is no evidence to suggest that TSFS plots have obtained consistently higher crop revenues over NTS plots. Furthermore, when the effects of prolonging the crop cycle on the period of time required for the fallow cycle are unknown, it is difficult to fully evaluate the effects of the TSFS on crop yields.

However, crop yields may have declined to the point where it is insignificant whether or not TSFS plots exhibit losses more or less than NTS plots. Farmers base their decisions to keep a field in production based on the expected profits of one more year. Several farmers with TSFS project plots maintained that if they had been given a choice, they would not have put in a crop during the final year - suggesting that yields in some plots had dropped to a level less than desirable for the farmer.

6.2 Results of regressions

Table 6.2 lists the results of regressions carried out to determine the effects of the TSFS plot on crop revenues. The coefficients obtained from these regressions will be compared to the market value of inputs shown in Table 6.3.

The adjusted R-squared values and the low t-statistics for the regression coefficients suggest that crop revenue is not entirely explained by the model. The ability of the model to explain the economic behaviour of farmers producing crops will be affected by the accuracy of the variables in the equation; errors in variables and missing variables are suspected to influence the results obtained from the regressions. All variables are affected by errors, since the crop revenue data and the labour input data

Table 6.2: Results of crop regressions (n=41)

	Regression:							
	1	2	3	4	5	6	7	8
MTCOST	963.81 (1.03)	-	792.1 (0.89)	-	957.94 (1.12)	-	986.83 (1.04)	-
WTCOST	-	436.92 (0.72)	-	364.51 (0.62)	-	543.40 (0.95)	-	478.19 (0.80)
CRLAND	1641.1 (1.89)	1964.6 (2.51)	-	-	1664.5 (2.02)	1938.4 (2.55)	1601.1 (1.90)	1886.8 (2.43)
NCRLAND	-	-	1703.3 (2.03)	1958.0 (2.56)	-	-	-	-
DUMTS	44143 (0.65)	49208 (0.72)	-	-	-	-	-	-
DUMNS	-32238 (-0.49)	-14943 (-0.24)	-	-	-	-	-	-
TANTSS	-	-	3224.2 (1.85)	3603.6 (2.19)	-	-	-	-
NTS	-	-	920.4 (0.62)	1324.7 (0.95)	-	-	-	-
SLTS	-	-	-	-	-	-	381.2 (0.64)	444.8 (0.76)
SLNS	-	-	-	-	-	-	-352.6 (-0.52)	-168.3 (-0.26)
SEEDS	2.08 (1.10)	2.56 (1.44)	2.04 (1.12)	2.42 (1.40)	2.6 (1.48)	2.9 (1.76)	2.03 (1.06)	2.50 (1.39)
PLOW	11368 (1.56)	13519 (1.99)	12704 (1.70)	14370 (2.03)	11248 (1.57)	13459 (2.05)	11179 (1.53)	13227 (1.94)
CONSTANT	34516 (0.44)	13268 (0.17)	34143 (0.46)	19713 (0.26)	18255 (0.25)	1816 (0.03)	39761 (0.51)	20845 (0.27)
adj.R^2	0.48	0.47	0.50	0.49	0.50	0.49	0.48	0.49
f-statistic	43.88	43.14	45.58	44.99	63.27	62.6	43.8	45.1

(t-statistics in brackets below estimate of coefficient)
(for f-statistic - test is for all coefficients significantly different from zero)

Table 6.3: Estimated market value of farm production inputs.

	Men's labour	Women's labour	Child's labour	crop land*	plowing
value (Rupiah)	1500-2000/day	1000-1800/day	1000-1800/day	1000/0.01ha	10000/team day

* minimum estimated value.

had to be constructed from sometimes insufficient data sources. As a result of these manipulations, the regression coefficients obtained may be biased and inconsistent (as a result of errors in the explanatory variables) or will show a large variance (as a result of errors in the revenue data).

Linear relationships are suspected to exist between the explanatory variables; tests indicated that the presence of multicollinearity may result in some inconsistency of coefficient estimates. Labour data is believed to be most strongly correlated; coefficients for labour showed very poor results when all variables were included into the model. Ctcost was dropped from the equations after showing very large negative and statistically insignificant coefficients. Mtcost and Wtcost were both estimated separately for the various regression models and pooled estimates of the labour variables were obtained.

The coefficients for all of the labour variables were statistically insignificant in all equations[39]. All labour coefficients were much smaller than expected, suggesting that labour has been over-supplied to the crop production process. The fact that the coefficient for labour is very small (relative to the market value of labour) and insignificant may be due to a number of factors; 1) errors in the measurement of the dependent or explanatory variables have resulted in inaccurate coefficient values; or 2) the farmers are not able to allocate resources efficiently - possibly the presence of the project plots has lead to an inefficient allocation of resources due to constraints imposed by the project. Statistical analysis of the data revealed that TSFS farms and NTS farms allocated more

[39] The labour coefficients of equations 5 and 6 were tested for statistical equivalence to Rp1000/day. In each equation, the t-statistic was very small (-.05 for equation 5 and -.80 for equation 6), indicating equivalence to Rp1000/day. However, the 95% confidence intervals were quite wide: ranging from -766 to 2682 for equation 5, and -609 to 1695 for equation 6.

labour to crop production than Traditional or Non-project plots. Alternatively, adverse weather conditions[40] or to some other factor unknown to the farmer when he/she was allocating resources to crop production may have reduced crop revenues, resulting in returns to labour much lower than expected.

The coefficient for days of plowing performed reasonably well, although there was a tendency in all equations for the coefficient to be higher than the reported daily wage for plowing[41]. The coefficient for seeds was not significant. This coefficient reflects the increase in crop revenue for each rupiah spent on seed. Since the coefficient is greater than one, it suggests that farmers could increase farm revenues by using more seed or higher quality seed (since the coefficient may represent either quantity or quality characteristics). Both the plowing and seed inputs may be used to less than optimal levels due to the effects of risk averse behaviour or capital limitations preventing greater expenditure on these inputs.

The coefficient for private crop land was reasonably consistent across all regression equations and reflects a value within the predicted range (according to estimates of local market values) for the marginal value of land.

The following paragraphs report the coefficient values of the project crop land, and the dummy coefficients representing the presence of the project plots on farms. It should be noted beforehand, that while the coefficients are interpreted as reflecting the effects

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[40] In the year the data was collected, the quality (and the price) of soyabeans were reduced on some farms because of heavy rains during the harvest caused some deterioration in the quality and price of soyabeans.

[41] The coefficient for plowing was tested for statistical equivalence to the market rate of Rp10000/day. In equations 5 and 6, the plow coefficient was statistically equivalent to the market rate, however, the 95% confidence interval of the coefficient was quite wide, ranging from -3274 to 25769 in equation 5 and -199 to 26719 in equation 6.

of the plots, there is the possibility that the plots themselves are not responsible for differences in production or crop revenues. Differences in resources between project sample groups suggest that production technologies are inherently different without the influence of project plots, confounding any interpretations of the coefficients obtained for TSFS and NTS plots located on these farms.

In all equations, for all forms tested, the TSFS coefficients indicated that the presence of a TSFS plot on the farm was related to returns to crop production greater than the returns of 'non-project' land - although the coefficients were statistically insignificant in most equations (the significant coefficient in equation 4 is the exception). Similarly, the coefficients of the NTS plot indicated a negative relation between the presence of an NTS plot on the farm and total crop revenues. The negative effects of the NTS plot are surprising, but if farmers have had their entire farm system upset (ie labour and land cannot be allocated efficiently outside the project plots because of the commitment of these resources to the project) then it is possible that the mere presence of an NTS plot on the farm is detrimental to farm production - and that any knowledge of better farming practices is useless since it cannot be applied. However, if this is the case, I wonder why NTS farmers have not learned to allocate farm resources efficiently around the project - at the time of data collection, the project was in its fifth year[42].

The results obtained concerning the effects of the TSFS plot on farm revenues are not surprising if they are evaluated in the context of the widely publicized claims of the

[42] There is some evidence that TSFS and NTS farms have devoted relatively less land to crop production per unit of farm size and family size than Traditional farms - which suggested that with so much labour devoted to the project, they had less labour available to put in more private crop land. Several families complained that they had no time for activities (off-farm work for example) because of commitments to the project, supporting this observation (see Section 6.4.2 for other complaints related to the project).

TSFS project; the TSFS project has claimed that the TSFS will increase soil fertility such that crop yields are greater than yields obtained under the traditional system.

However, the results obtained from the previous section (6.1) contradict the information obtained in the regression analysis of increased crop revenues on TSFS farms - and the indications of reduced crop revenues on NTS farms. TSFS project data concerning crop yields indicated that TSFS and NTS plots were obtaining the crop revenues - with the NTS revenues slightly higher. Given this information, it is difficult to explain why the coefficients for NTS farms consistently show negative effects of the NTS plots.

The second point of difficulty concerns the comparison in returns to TSFS crop land and privately owned crop land. It is difficult to explain why the data used in this study indicates returns to TSFS crop land greater than returns to private crop land, implying that local farmers are not imitating obviously superior production practices, after observing the TSFS plot for five years. Statistics obtained in Chapter 4 indicate that when labour is valued at the market price, returns to fixed factors of production for TSFS farms are not higher than on traditional fields. Possibly, the TSFS has achieved high returns to land only through a more costly application of labour to cropland.

In summary, while the results obtained from the crop regressions are interesting, they are not easily explained in light of crop yield estimates of the TSFS project or observations of crop production activities of farmers in Pecatu. Errors in the data and a small sample size have limited the estimation and interpretation of regression coefficients.

Confidence intervals (shown in Table 6.4) have been determined for the coefficient of crop land; these intervals may be used in the sensitivity analysis of the project budget sheets. An equation where the effects of the plots are left out has been chosen for two reasons: 1) returns to crop land (Crland and Ncrland) appear to be fairly consistent across all equations, regardless of model specification and; 2) the coefficients for project influences are often insignificant and any evidence of positive returns to the plot cannot be explained in light of observations of crop yields obtained by TSFS researchers, or from the monetary value of the yields (estimated in section 6.1). Choosing between equation 5 and 6, equation 6 is preferred because it yields a higher lower-bound estimate for returns to crop land.

Table 6.4: Confidence intervals (95%) for crop land coefficient.

Equation number	Lower value	Coefficient	Upper value	Standard Error
5	-0.04	1664.5	3329.0	823.6
6	401.7	1938.4	3475.1	760.4

6.3 Results of cost-benefit analyses

6.3.1 The profitability of the TSFS

In this analysis, the two systems (a TSFS plot and a traditional crop field) were compared using the net present value of returns. The base values (the values determined to be most representative of prices observed in Pecatu) for wages, crop land and live cattle are Rp1500/day, Rp1900/0.01 hectares and Rp1600/kg, respectively. These

values were varied in a sensitivity analysis. The results of the analysis for base values and alternative values under sensitivity analysis are summarized in Table 6.6.

The results of the budget sheets indicate that for all three discount rates (20%, 28%, 36%), the TSFS cattle rearing system yields a large negative return; at a discount rate of 28%, the net present value is -Rp141875.

Figure 6.1 illustrates the net present value of the plot under varying discount rates; the internal rate of return to the plot is obtained where the graph crosses zero. This internal rate of return is obtained for returns to crop land=Rp1900/0.01ha, wages=Rp1500/day, and a cattle price of Rp1600/kg. The rate of return to the plot is quite low at approximately 8% - as the rate of internal interest seen by farmers is believed to be at least 20%, real, 8% is too low to be considered profitable.

The values of return to crop land, wage rate, and price of cattle modified in a sensitivity analysis. All other variables in the budget sheet (cost of forages, cost of stable) remain fixed.

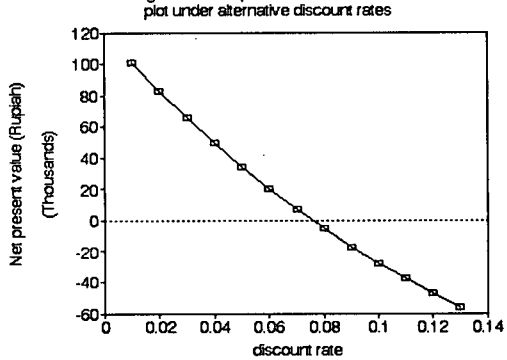
The results of the sensitivity analysis are shown in the bottom rows of Table 6.5. In the regressions to determine the returns to crop land, confidence intervals for the marginal value of land indicated that returns to land would vary from approximately Rp400/0.01 hectares to Rp3500/0.01 hectares. This wide range in returns to crop land seems reasonable, given the widely varying soil conditions of Pecatu; and it is on the poorer, less productive soils that the TSFS project has claimed the TSFS will be most profitable. A wide range of values for the returns to crop land have been used, ranging from Rp400/0.01ha to Rp3000/0.01ha (as described by confidence intervals obtained in

the previous section). The lower bound estimates are very low in comparison to what is believed to be commonly found. Previous estimation (Appendix A) has determined that the minimum **expected** return to crop land is around Rp1000/0.01ha.

It can be seen from the table that under varying returns to crop land, wage rates and prices for live cattle, the net present value of the TSFS plot is negative, and becomes more negative as returns to crop land increases[43]. The net present value of the TSFS plot also becomes more negative with an increase in the wage rate and a decrease in the price of cattle. Within the bounds of the sensitivity analysis carried out here a decrease in the wage rate are not sufficient to result in a positive net present value to the TSFS plot.

As a comparison to the TSFS plot, the returns to a 0.09 hectare traditional crop field and the sensitivity analysis for alternative wage rates are presented in Table 6.6. These results are reasonably accurate for what has been estimated for the upper and lower bounds on production. The returns to crop land shown in these tables give some idea of the magnitude of losses incurred by the TSFS plot. The TSFS plot is approximately 3.5 times less profitable than a traditional crop field.

Figure 6.1 Net present value of TSFS plot under alternative discount rates



[43] Similar results were obtained when the differences between the TSFS and traditional crop fields for the crop-fallow rotation. Gains from this claimed benefit of the TSFS are not sufficient to offset the losses incurred.

Table 6.5: Results of benefit/cost analysis - net present value of TSFS plot.

Selected variables under alternative values			NPV under alternative discount rates (Rupiah)		
crop land Rp/0.01ha	cattle Rp/kg	labour Rp/day	20%	28%	36%
1900	1600	1500	-106166	-141875	-163509
400	1600	1500	-60322	-100133	-125049
3000	1600	1500	-139784	-172485	-191713
1900	1600	1000	-68690	-107717	-131907
1900	1600	2000	-143641	-176032	-195111
1900	800	1500	-137549	-150724	-140932

It will be shown in section 6.3.2 that the land rent and other financial incentives offered to farmers participating in the TSFS project were sufficient to obtain the cooperation of these farmers, despite the negative (or low) net returns incurred by the TSFS plot.

Table 6.6: Results of benefit/cost analysis - net present value of 0.09 hectares of traditional crop field.

Selected variables under alternative values			**NPV under alternative discount rates (Rupiah)**		
crop land Rp/0.01ha	**cattle price Rp/kg**	**labour Rp/day**	**20%**	**28%**	**36%**
1900	**1600**	**1500**	**51139**	**43297**	**37291**
400	**1600**	**1500**	**10766**	**9115**	**7851**
3000	**1600**	**1500**	**80747**	**68364**	**58880**

6.3.2 The profitability of participation in the TSFS project

The purpose of this section is to compare the profitability of participating in the TSFS project to producing crops in a privately owned crop field.

The results of the comparison between the profitability of participating in the TSFS project are shown in Tables 6.7 (TSFS) and 6.8 (NTS plot). The results presented in this analysis indicate that participation in the TSFS project, whether as a TSFS or an NTS farmer is a profitable investment under the base case and alternative values for grass (provided by farmers to supplement the diets of project cattle) and wage rates. The net present value (relative to investment in a traditional crop field) of participation with a TSFS plot is the equivalent of Rp2355/0.01hectares and of the NTS plot is Rp1870/0.01hectares paid at the beginning of each year of the project.

Table 6.7: Results of benefit/cost analysis - net present value of participation in the TSFS project - TSFS plot.

Selected variables under alternative values			NPV under alternative discount rates (Rupiah)		
crop land Rp/0.01ha	grass Rp/kg	labour Rp/day	20%	28%	36%
1900	20	1500	214530	210275	209273
3000	20	1500	179001	178190	179912
400	20	1500	271665	261362	255589
1900	20	1000	271769	256294	251526
1900	20	2000	163751	164256	167020
1900	10	1500	223217	217619	215551

Table 6.8: Results of benefit/cost analysis - net present value of participation in TSFS project - NTS plot.

Selected variables under alternative values			NPV under alternative discount rates (Rupiah)		
crop land Rp/0.01ha	grass Rp/kg	labour Rp/day	20%	25%	30%
all values	20	1500	149732	166979	182274
all values	20	1000	200913	211285	221139
all values	20	2000	98550	122673	143408
all values	10	1500	161250	132493	151868

The results of these analyses have several implications. First, there will be some doubt concerning the validity of using farmers' response to the project as an indication of the acceptability of the TSFS. There will be some incentive for farmers to co-operate with the project team by following the directions given to them concerning the care and maintenance of the project cattle and the project plot and by reacting positively to the project (reacting in a negative manner to the TSFS project may insult the members of the project team, leaving them angry and in the market for more co-operative 'employees'). In the case of NTS farmers, attempting to please the members of project team by modifying the NTS plots to more closely resemble the TSFS plots is not an unreasonable thing to do; because the project team imposed increased restrictions on the sources of feed available to NTS cattle, farmers may have modified their plots in order to have a reasonably adequate source of feed for the cattle they were responsible for. Since all farmers had been educated through various media concerning the layout and content of a 'good' TSFS plot, it would not be difficult to figure out what the project team would like to see.

Second, the results here support the results of section 6.4.1. If the TSFS plot is not profitable, farmers participating in the project must be compensated for the losses incurred by the plot. The magnitude of the economic incentives for participation in the project supports the results of the previous section which indicate large losses associated with the TSFS.

Farmers participating in the project were paid Rp344933/plot, or Rp13797/0.01 hectares at the beginning of the project. This amount is equivalent to Rp4250/0.01 hectares paid at the beginning of each year for five years **or** it is the equivalent of an annuity of Rp3863/0.01 hectares (0.28 (the real rate of interest) * Rp13797). Since this value is greater than the average yearly expected returns to cropping the land (Rp1900/0.01ha), the rental rates paid by the project are more than enough to purchase lower quality land in Pecatu and are sufficiently high to attract agents selling the highest quality land[44]. Further, despite the magnitude of the rewards to participation in the project, there is evidence that allocative ineffiencies due to constraints and regulations imposed by the project have resulted in losses such that the farmers did not receive the entire value of the incentives initially offered.

Despite receiving rent for land of Rp344933/plot at the beginning of the project, in addition to revenues from crops and one-half the net returns from the sale of project cattle, the net present value of the TSFS was Rp210275/plot and the NTS was Rp166979/plot (at base values for inputs and a 28% discount rate), indicating that the

[44] There is some evidence indicating that the sale price of farm land in Pecatu was as high as Rp9000/0.01 hectares.

value of participation in the project was diminished, by more than half for NTS plots, during the course of the project.

There is evidence that the farmers themselves were aware of the diminishing returns to participation in the project and attempted to minimize them. During the data collection for this study, there were a number of farmers who, despite their desire to maintain good relations with the project, expressed some dissatisfaction with the losses imposed by the project plots. Some farmers complained that the diminishing yields obtained from their plots no longer made it worthwhile planting and tending a crop - these farmers argued that the land should be left fallow. Several families complained that the project regulations concerning the care of crops in the plots did not allow them time to pursue other activities. Many farmers complained that taking care of project cattle required too much of their time - NTS farmers were especially prone to make this type of complaint. During several monthly meetings with the project team, individuals were chastised for shirking their duties (taking short-cuts to save time) in the care of project cattle. NTS farmers faced increasing regulations over the course of the project on where and how much feed they could give their project cattle - a member of the project team explained that the controls were originally put in place to stop the farmers from 'over-feeding' the cattle. Farmers had originally believed that they would be paid a higher price for heavier cattle at the end of the project, so there was some incentive to cheat during the experiment. In 1989, the entire group of farmers participating in the project asked a visiting official from IDRC (in a speech made by the head of the group) how much longer they would have to follow the regulations of the project - they wanted to be free to make

their own decisions. Finally, some farmers complained about not being allowed to sell their project cattle privately at the end of the project; these farmers felt they would have been able to get a higher price than the price obtained where all cattle were sold as a group and all farmers received identical sums of money for their cattle.

The fact that farmers had complained in this way indicates that they were attempting to reduce the losses associated with the project - either through a change in the project regulations, by cheating and attempting to disregard the regulations, or by soliciting compensation for the perceived losses.

The regulations and constraints which have reduced the economic incentives of payments for project participation are social losses. These losses may be small in comparison to the total cost of the project (land rental is 13% of the total project budget) yet they are important because they are welfare losses to society incurred as a result of an inefficient allocation of research resources.

6.3.3 The relative profitability of TSFS forages

In this section, the relative profitability of planting and growing each different type of forage on the farm will be determined. The results of the analysis (the net present value and sensitivity analysis) are shown in Table 6.9. The results of the financial analysis using a native grass land value of Rp1000/0.01hectares, the price of labour at Rp1500/day and a price of forage of Rp20/kg show that the shrub gliricidia, native grass and the grasses panicum and cenchrus show positive returns after a 5 year period. The ground legume verano, and the trees showed negative returns. Sensitivity analysis shows that the net present value of the TSFS forages are sensitive to changes in the discount

rate, the market value of the forages, the opportunity cost of land, and the labour costs of establishing the forages.

Table 6.9: Net present value of forages under alternative prices of land, forage and labour.

Selected variables under alternative values:				NET PRESENT VALUE PER SQUARE METER:							
				Forage varieties*:							
value of land Rp per 0.01ha	price of forage Rp/kg	labour wages Rp per day	rate of discount	1[a]	2	3	4	5	6	7	8
1000	10	1500	0.28	25	3	24	-28	149	-90	-96	-93
1000	20	1500	0.28	25	64	106	2	261	-83	-94	-88
1000	10	1500	0.36	22	-5	12	-30	90	-86	-92	-89
1000	10	1500	0.20	30	14	40	-25	228	-94	-102	-99
1000	5	1500	0.28	25	-28	-17	-43	93	-93	-98	-96
1000	10	2000	0.28	25	-5	17	-36	114	-93	-100	-97
1500	10	1000	0.28	38	-13	8	-44	133	-129	-126	-122

* forage varieties are listed in columns 1 - 8 as follows: 1 - native grass 2 - Panicum 3 - Cenchrus 4 - Verano 5 - Gliricidia 6 - Hibiscus 7 - Ficus 8 - Lannea

a. The net present value of native grass is determined by the net present value of land - valued at Rp1000/0.01hectares and Rp500/0.01hectares.

The results of the budget analysis are supported with observations of the activities of farmers in Pecatu. When farmers were asked about which plant varieties they preferred, they consistently replied that the gliricidia, the forage plant with the highest net present value relative to native grass, was the favourite forage plant because of its high yields and ease of establishment. Although the shrubs have been used by farmers for a number years before the arrival of the project, there is some evidence to suggest that the farmers have increased the numbers of shrubs planted and increased the amount fed

to cattle since the project began. Observing the activities in the TSFS plots may have encouraged farmers to use greater amounts of forage shrubs on their own farms.

There is some evidence that farmers are experimenting with the grasses and ground legumes to determine the costs and returns associated with these less familiar plants (as predicted by Antle and Crissman (1990)). The positive attitude towards the grasses and the lack of widespread adoption of ground legumes coincides with results of economic analyses carried out in this study. The grasses panicum and cenchrus were the introduced grass varieties most widely planted - although the amount of grasses planted was significantly less than the number of shrubs planted; and much less than the amount recommended by the TSFS project (as shown in Chapter 4). The ground legumes were usually not planted by farmers - the farmers claimed that the legumes had low production, and a short lifespan. Farmers who planted panicum and cenchrus claimed to be quite happy with the results, and indicated that they would grow more of these grasses in the future. The farmers often reported that the most limiting factor in planting more introduced grasses was a lack of time. If we assume that the farmer is free to devote as much time as desired to any particular activity, we may interpret this statement to indicate that the farmer has not yet desired, for any number of reasons, to allocate time to the production of TSFS grasses. The results of sensitivity analysis show that the TSFS grasses are more profitable than native grass where the price of the TSFS grasses is higher (unlikely if the nutritional value is very similar) and where the personal discount rate is less than the market rate (unlikely if farmers are responsive to market forces). Otherwise it appears that native grass is as profitable or more profitable than

panicum or cenchrus under most alternative economic conditions. The fact that native grass incurs no labour or materials costs for establishment (a very low benefit/cost ratio - in comparison to project grasses, which require the farmer to acquire seeds and to allocate labour to planting these seeds) would make it an attractive alternative to TSFS grasses. Research has shown that cattle perform well on a diet of native grass supplemented with Gliricidia (Panjaitan, 1988). Surveys of the cattle feeding practices of farmers in Pecatu revealed that native grass supplemented with Gliricidia is the most commonly found diet; and farmers agreed that their cattle were doing well (in comparison to TSFS project cattle[45]) on this diet. Under these conditions, there may not be sufficient incentive for farmers to allocate resources to the production of large areas of TSFS grasses.

There is no indication that farmers have modified their management of tree forages as a result of the project. In the budget analysis, the fodder trees showed negative returns after five years, relative to native grass production, but this is not unexpected. Farmers mentioned that they did not usually expect to harvest the trees until after 6 years and that the TSF system of harvesting three year old trees would stunt the growth of the trees. The TSFS project reports that the tree Lannea shed its leaves towards the late dry season, and was therefore not a good source of feed for the end of the dry season. The project also discovered that the tree Hibiscus required more fertile soils than the Ficus and Lannea trees. Observing the traditional feeding systems of farmers in Pecatu, and

[45] When asked directly, many farmers maintained their own cattle grew as fast or faster than the project cattle. These statements are supported by evidence of the superior performance of the Traditionally raised cattle in the TSFS project. In a sub-sample of 43 male cattle (castrated and intact bulls) of average age 4.2 years, the average weight is estimated to be approximately 303kg (this number depends upon the price/kg used to estimate the value of the cattle). TSFS cattle weighed an average of 331kg at an age of 4.5 - 5 years. It is very possible that there is little difference between the performance of TSFS and private cattle.

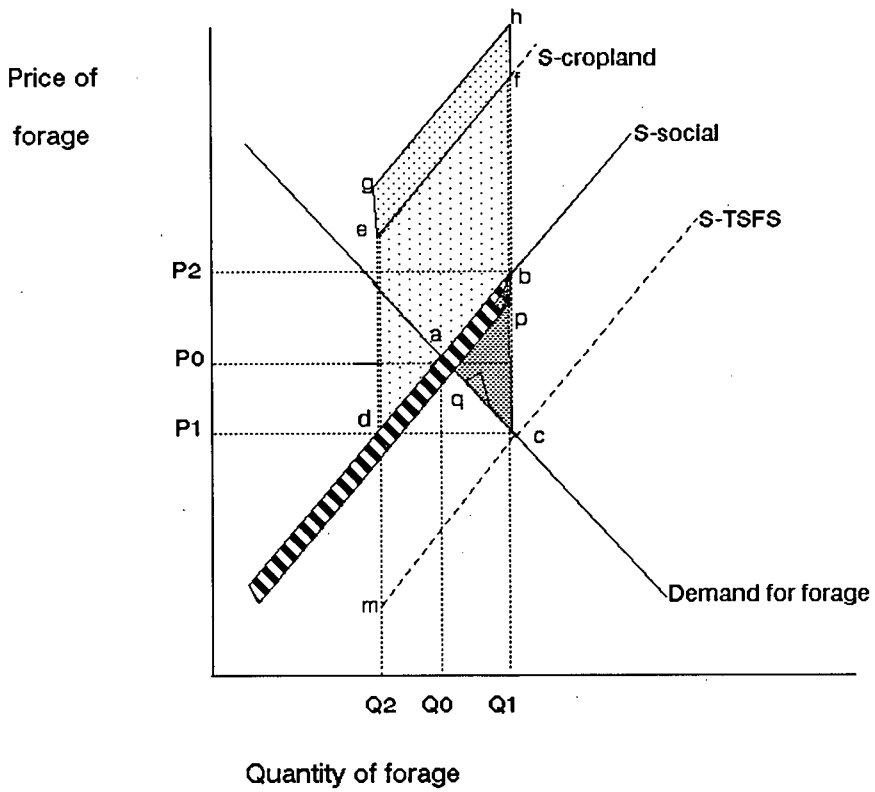
their comments towards the management of trees, it appears that the farmers were aware of these constraints before the project began. It is not apparent that the farmers have benefitted from TSFS instruction concerning the proper management of these traditional feed sources. Also suggested by these findings is that project researchers did not consult with farmers, at the beginning of the project, concerning these constraints to increased production of fodder trees.

The results obtained from this financial analysis indicate that the preference for native grass and gliricidia as feed sources are due to the high returns to producing these plants and the satisfactory performance of cattle fed on diets containing these plants. The relatively higher costs of establishment of the introduced grasses and low production of the legume have likely prohibited greater production of these forages. It appears that the decision to graze cattle on native grass, to plant great numbers of gliricidia shrubs, to maintain production of forage trees (especially Ficus trees, the major source of feed at the end of the dry season) is economically rational.

6.4 Social welfare costs of the TSFS

The purpose of this section is to use the results from previous analyses to infer the social welfare effects of the TSFS. Financial analysis has shown that the returns to the TSFS are negative; it has been shown that large subsidies are required to induce farmers to transfer crop land to forage production. These results suggest that the resource allocation costs (or economic costs) of the TSFS are also large. Figure 6.2 illustrates the economic costs associated with the TSFS.

Figure 6.2 Welfare effects of the TSFS



The description of forage suppply can be described as follows[46]. The social supply curve of forage (S-social) is upward sloping, reflecting the per unit increase in obtaining forage from increasingly costly sources - from the lowest cost marginal land which has few production alternatives to native grass, to the more costly fertile crop land on the farm.

The TSFS increases forage supplies by subsidizing the transfer of crop land to forage production. This will result in a shift to the right of the social forage supply curve (S-social) to S-TSFS along the aggregate demand curve for forage production (which is derived from the demand for livestock and meat in Indonesia or Bali). As the supply curve shifts, the price of forage drops from P0 to P1 and there is an increas in the total amount of forage produced as Q0 shifts to Q1. There is a simultaneous release of the lowest quality[47] marginal land from forage production (equal to the quantity Q0 - Q2). This land is left idle as the higher yielding forages increase the expected marginal returns to forage production; this lower quality land is no longer competitive, yielding much lower returns than the new minimum value of returns (shown at point m) imposed by the TSFS. Since the shift to S-TSFS is strictly a transfer of resources, there no welfare effects in this measure. However, there are welfare effects associated with the transfer.

S-cropland represents the supply of crop land transferred from crop production. As this land yields higher returns than forage land, the supply curve is located at some

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[46] The description of welfare costs has been adapted from a description by Barichello (1978).

[47] This land may be valued very low for a number of reasons: low productivity, poor accesibility due to distance or other physical barriers for example.

position above S-social. Subsidizing the transfer of crop land to forage production results in economic costs shown by the area DEFB. Since lower quality marginal land (previously profitable for the production of forage) has been left idle as a result of the increased use of crop land for forage production, social welfare costs are imposed from point D on the S-social curve.

Resource allocation costs are imposed when highly valued crop land is used to produce forage. The TSFS results in forages which are valued at P1, but which cost P2 to produce. As a result of this allocative inefficiency, resource allocation costs described by triangle ABC are incurred. The size of triangle ABC will be affected by the slope of the supply curve for forage and the slope of the demand (or marginal social benefit) curve, as well as the magnitude of the shift in the supply curve from S-social to S-TSFS. The results of financial analyses showing large negative returns to the TSFS plot, suggests that the welfare costs of such a transfer in land use are large.

Participation in the TSFS project is profitable; however, the potential returns to participation in the TSFS project were diminished by losses incurred by the inefficient management of labour and land resources allocated to the project. As the incentives offered to farmers in the project were paid with public funds, the losses incurred due to allocative ineffiencies are social welfare costs, which are represented by area EGHF. Any costs incurred as a result of administrative procedures required to distribute and regulate subsidies associated with extension of the TSFS to other regions will also contribute to welfare costs of the TSFS and area EGHF.

The rectangular barred area represents the net welfare gain achieved from the generation of a new technology useful to society; the losses associated with the TSFS plot in triangle ABC will be reduced by PQAB. This area is gained when a new technology results in a shift to the right of the S-social curve to S'-social due to profitable new production techniques, rather than a transfer of resources. However, as the shrubs and the grasses in the plot are already well-known throughout Asia (Blair et al, 1985; Jainudeen et al, 1986; Craswell and Tangendjaja, 1984), and the trees have long been used as traditional feed sources in Bali (Nitis et al, 1980), it would appear that the only features of the TSFS which are truly new or unique are the planting arrangement and the feeding system recommended by the TSFS; however, these features have resulted in negative returns to cattle production. Therefore, any welfare gains to society associated with the TSFS will result as an increase in the rate of adoption of the forage varieties promoted by the TSFS (through an increase in the discount rate associated with the social welfare gains of the adoption of these forages). As the trees, and some varieties of shrubs, are already well-known to farmers, the adoption of new varieties of shrubs was well under way before the beginning of the project, and the distribution of grasses and ground legumes had already been undertaken to some extent by the government of Bali, we may expect these gains in welfare associated with the promotion of the TSFS forages to be small.

Research has been misdirected to increase cattle production at the expense of crop production. Possibly this trade-off was made in the belief that there would be social gains to be made from an increase in cattle production. The impressions of livestock

researchers may have been mislead by domestic prices for beef which have been up to two times the world price. Artificially high prices for beef in Indonesia, and in general throughout Southeast Asia (Booth et al, 1986), induces research which aims to increase cattle production. As stated by Binswanger (1978), the welfare costs associated with the mis-directed research of the TSFS will be added to the social welfare costs of distorted domestic prices for beef.

Taking into account all gains and losses of welfare associated with the TSFS project it does not seem unreasonable to suggest that there are net welfare losses associated with the TSFS project.

Chapter 7 Summary and conclusions

The primary purpose of this thesis was to 1) determine which aspects of the TSFS constitute a new technology; 2) to determine whether there has been an increase in cattle or crop production as a result of the TSFS; and 3) to determine the profitability of the TSFS, relative to the traditional production system. Using the results of these analyses, it may be determined whether the investment of research resources into the TSFS project is profitable for donor agencies such as IDRC.

In this chapter the results obtained in the analysis of the TSFS technology are reviewed and recommendations concerning the extension of TSFS and further research related to the development of forage production systems are offered. Recommendations concerning the collection of data related to the analysis of the TSFS technology are also presented.

7.1 Recommendations to improve data collection

Anderson and Hardaker (1979) provide an excellent review of the attributes and difficulties encountered with various styles of data collection. There are a few points which can be made here to help others carrying out similar work. First, if time and manpower are sufficient, a monthly survey of farm and off-farm revenues is superior to the yearly collection of such data, as farmers are much more likely to accurately recall financial details over a shorter time period. Labour data for crop or cattle production is also extremely difficult to obtain, particularly where different members of a farm family contribute different quantities and quality of labour to farm production processes. If possible, direct timings of production activities provide excellent indications of labour

requirements. However, the production task being observed must be very accurately defined, to avoid confusion about which activities are to be included into a single task.

The use of village data, or other secondary data, can be very helpful, but only so far as these sources are accurate. It is very likely that the same difficulties in obtaining accurate information for the economic survey of a project are also encountered by officials attempting to obtain village statistics.

Finally, it should be acknowledged that the collection of income data from individuals is difficult under any circumstances where there are few incentives to give out information related to personal finances.

7.2 Recommendations to improve the selection of participating farmers

When selecting participants for the project, the project team based their decisions upon a number of factors, including land ownership, water resources and recommendations from the head of the village. Statistical analysis indicates that this selection process has resulted in a sample of farms which have greater land and labour resources than the average farms in the area. There is also some evidence that the more influential members of the village have been chosen for participation in the project. The bias in the sample has made it difficult to determine whether the estimated differences in the use of farm resources and farm output are due to the presence of project plots, or whether these differences in production are present because of differences in resource

endowments and management ability[48]. A sample which is more representative of the local farm population would prevent these problems from occurring.

7.3 Review of results

In chapters 1 and 3, the TSFS technology, the design of the project plots and the scientific results obtained from TSFS project research were presented. Comparing traditional and TSFS technology reveals that the major changes to the cattle feeding system involves re-allocating traditional feed resources to obtain a defined number of trees and shrubs per animal. Introduced grasses and ground legumes have been included into the feeding system, and are also defined in terms of area of grass grown per animal. Crop residues and the annual tree, Sesbania grandiflora, have been included in the diet of the TSFS cattle, but appear to have been included in a supplementary role, rather than as integral components of the crop-livestock system (as these feed sources appear in the traditional feeding system).

Experimental results obtained by the TSFS project concerning the performance of project cattle focused upon the differences between the performance of TSFS and NTS cattle. The TSFS reports maintain that while TSFS cattle did not demonstrate significantly higher rates of gain than the NTS cattle (which are meant to be a representation of traditionally raised cattle), they reached market weight in a similar period of time under higher stocking rates (higher numbers of cattle per hectare), indicating greater efficiency in the use of land for cattle production. Evaluating these claims, it has been argued in

[48] If the project was more concerned with promoting the adoption of the TSFS, choosing the best, most influential farmers in the village may be desirable. However, since the goal of the project was to investigate the biological and economic feasibility of the TSFS for the average farmer, the bias in the sample is not appropriate.

this study that the comparison between TSFS and NTS cattle is irrelevant, as the NTS production system was controlled to such a degree that there was very little resemblance to the traditional production system. Traditional cattle appeared to have performed the best of all animals in the project, but as no data was collected concerning the feed given to these cattle, it is difficult to reach conclusions concerning comparative performance of TSFS and the 'traditionally' raised cattle.

The results of the project do not support the notion that farmers are short of feed due to a mismanagement of feed resources; the project relied upon traditional feed resources found on the farmers' own property when shortages occurred in project plot[49]. The fact that shortages occurred on the project plots when feed sources were still available on the farmer's own property indicates that while the forages used in the plot may have been of higher quality, the feeding regime and forage management system imposed by the TSFS technology is not necessarily more reliable or more efficient than the traditional system. Observations of the feeding practices of farmers in Pecatu, and the performance of privately owned cattle, suggests that farmers have been more successful at managing traditional and modern resources for the production of cattle than the TSFS project.

The TSFS claims to have increased crop yields through decreased soil erosion and increased soil fertility. These claims were not supported when the revenues obtained per unit of crop land (using the four year average crop yields) in TSFS and NTS plots were

[49] These results are subtly ignored by project researchers who have estimated stocking rates which assume the use of preserved feeds - a technology not yet fully developed to a satisfactory form.

compared and therefore increased returns to TSFS plots were not included in the financial analysis.

Evaluating the TSFS technology using financial analysis shows negative returns accruing to the TSFS plot. While the TSFS project literature lists numerous benefits accruing to the TSFS plot, there does not appear to be sufficient evidence to support the notion that any of these lesser benefits (poultry or honey production, the positive environmental effects) will off-set the negative returns incurred by the plot.

Financial analyses also indicate that farmers participating in the TSFS project were heavily subsidized - to the extent that payments equivalent to the purchase of land were offered. The magnitude of these payments supports the findings that losses associated with TSFS technology are large. The fact that the net present value of the original cash payments to participating farmers is reduced by up to one-half indicates that there are welfare losses due to inefficient allocations of project research resources (land and labour rented from farmers).

There is some evidence that farmers participating in the project have benefitted from exposure to some forages species of the TSFS. Farmers have been observed experimenting with various species of grasses and ground legumes. As a result of their own experiments and observations of TSFS plots, farmers have shown preferences for particular species. Results of financial analyses estimating the comparative profitability of forage resources in Pecatu supports the preferences of the farmers. However, the purpose of a demonstration plot is to reduce the necessity and the risk and uncertainty of on-farm experimentation. It should be noted that as the TSFS project - it has failed to

some extent as a demonstration plot in that farmers must attempt a great deal of experimentation on their own. It is suggested here that because the project has chosen to locate the forage production on relatively higher quality crop land[50] - farmers who prefer to locate forage production on marginal land are forced to carry out individual research processes to determine the returns on this less fertile land. The results of the financial analyses were used to infer social welfare costs of the TSFS. The large negative losses associated with the plot, in addition to losses incurred through mismanagement of project resources, the losses associated with mis-directed research efforts (increase cattle production at the expense of crop production) have outweighed any gains due to an increase in the rate of adoption of the forages included in the TSFS suggesting that the net welfare effects of the TSFS plot are negative. The results indicate that investment into the generation of the TSFS is not profitable for donor agencies such as IDRC (which desire to improve the welfare of society).

7.4 Recommendations for future research and extension of the TSFS

Despite the large negative financial and welfare estimates associated with the TSFS, researchers have continued to foster and develop the TSFS as a production unit. The purpose of this section is to provide suggestions of how to improve the generation

[50] Some TSFS literature (Nitis et al, 1989) suggests locating demonstration plots on land which is about to be fallowed from crop production. Certainly, the costs of locating forage production on such land is less costly than fully productive crop land. However, individuals making these recommendations should bear in mind that there is a great deal of even cheaper marginal land available which never or rarely produces crops. Also, it has not been established what is to be done with the forages once fallowed crop land is brought back into crop production; once the land is capable of producing a crop, the opportunity costs of locating forage on this land will increase. Also, there is no evidence that farmers would willingly expend the resources to establish a forage plot and then break it up for crop production at a later date. Farmers surveyed in Pecatu were unanimous in maintaining that their established forage plots were not meant to be rotated with crop production - due to the labour involved in the initial establishment of these forage producing areas.

of technology for farmers in dry land regions similar to Pecatu, to avoid similar behaviour in future research projects.

Throughout this study, the production efficiency of resource-poor farmers in Pecatu has been observed (indicated by resource allocations which can be explained in terms of market prices of farm inputs and outputs), in accordance to the findings of other researchers studying traditional and modern production practices. Farmers appear to allocate labour resources between farm and off-farm employment in a manner which is consistent with the predictions of profit-maximizing behaviour (see Appendix A). Land resources are allocated to make optimal use of the productive capabilities of the soil. In using labour and land resources for cattle production, traditional methods appear to be as productive and, often enough, more efficient than the methods proposed by the TSFS. In addition, farmers were receptive to new technologies which could potentially improve the profitability of their own production practices and were willing to experiment with new inputs to determine optimal input levels of new forage species. The wide variety of management systems of these new forages observed in Pecatu suggests that some farmers may be more capable at quickly determining the most optimal use of the inputs, as predicted by Antle and Crissman (1990). Despite all the indications of efficient production behaviour of the farmers in Pecatu, researchers associated with the TSFS project have failed to recognize the rationality of 'traditional' production methods. Possibly, due to a simultaneous desire to sustain the appearance of success of the TSFS, researchers associated with the project have disregarded or subtly misrepresented the costs associated with the TSFS plot, while elaborating upon benefits associated with the

plot. In chapter three, it may be noted that in reporting the results of experiments to measure yields of crops, forages or the performance of cattle, TSFS literature has tended to ignore or neglect to report aspects of experimental results which do not support the original hypothesis of the TSFS team (that the TSFS will result in improvements to the productivity of traditional production system). As a result of this behaviour, a technology which is inappropriate to conditions faced by farmers and which leads to large social welfare costs has been generated.

Hayami and Ruttan (1971) have hypothesized that the greatest gains to research are achieved by identifying the most restrictive factors of production and searching for technologies which can reduce the requirements for these factors. Ruttan (1987) argues that In order to be more efficient in allocating research funds to agricultural projects, and to discourage the generation of technologies similar to the TSFS, it is suggested that funding agencies provide greater incentives to encourage research scientists to conduct *ex ante* economic evaluations to determine the costs and benefits of a proposed technology. By determining the true social value of production inputs and farm outputs, research will more likely be directed to technologies which contribute to the increase in net social welfare. For example, in Pecatu, more detailed economic research may find that the scarcity of water resources is a greater constraint to increased cattle production than a lack of feed resources. It may also be determined that research directed to producing higher valued crops on the productive land of Pecatu may yield greater social returns than projects aimed at increasing the production of livestock.

If research is to be directed towards increasing the production of cattle, a less restrictive approach to cattle feeding regimes is recommended. Farmers require accurate, relevant information concerning the potential costs and benefits of new forage species; however, these farmers are ultimately the best judges of how to allocate resources for the production of these forages and their use in animal diets (where substitution between forage species is possible - as appears to be very much the case with the TSFS). Future forage research should place emphasis upon identifying the cost constraints to adopting improved varieties of forages - by identifying the greatest cost constraints to adoption of these forages it may be possible to develop varieties with features that overcome these constraints. It is further recommended that researchers refrain from reliance upon imported inputs to cattle production - unless there are demonstrated large social welfare gains associated with an increase in the production of cattle, allocating scarce foreign reserves to the purchase of grass and ground legume seeds is an inefficient use of national resources.

Surveys carried out in this study have found that farmers prefer forages with low labour costs of establishment, which perform well on marginal land (an observation also noted in Perkins et al (1985)). It is recommended that future research efforts be directed with these observations in mind.

References

Ahmed, Iftikhar and Ruttan, Vernon W. (eds), 1988. Generation and Diffusion of Agricultural Innovations: The Role of Institutional Factors. Gower Publishing Company: Brookfield, Vermont, USA.

Anderson, Frank M. 1985. Directions for future trials - in Research Methodology for Livestock On-farm Trials - Proceedings of a workshop held at Aleppo, Syria, 25-28 March 1985. Ottawa, Canada: International Development Research Centre. pg303-309.

Anderson, J.R. and Hardaker, J.B., 1979, Economic analysis in the design of new technologies for small farmers, in Economics and the Design of Small-Farmer Technology, ed. Valdes, A., Scobie, G.M. , and Dillon, J. Iowa State University Press, Ames, Iowa.

Anonymous. 1986-1988. Laporan Departemen Peternakan. Denpasar, Bali, Indonesia.

Antle, J. and Crissman, Charles C. 1990. Risk, efficiency, and the adoption of modern crop varieties: evidence from the Philippines. Economic Development and Cultural Change, Vol(38), no.3:517-538.

Arga, I. W., 1990. Socioeconomic aspects of the three strata forage system in Bali. In Shrubs and tree fodders for farm animals: proceedings of a workshop in Denpasar, Indonesia, 24-29 July, 1989. Editor C. Devendra. Ottawa, Ontario, IDRC.

Barbier, Edward B. 1990. The economics of farm-level adoption of soil conservation measures in the uplands of Java. World Bank, Environment Department Working Paper No.11.

Barichello, Richard R. 1978. An economic and distributive evaluation of community pasture programs. Department of Agricultural Economics, University of British Columbia.

Biggs, Stephen and John Farrington. 1989. Agricultural Research: A review of social science analysis. Draft - Department of Agricultural Economics, University of British Columbia, Vancouver, Canada.

Binswanger, Hans P. 1978. The microeconomics of induced technical change. in H.P. Binswanger and V.W. Ruttan, Induced Innovation: Technology, Institutions, and Development. Baltimore:Johns Hopkins University Press.

Binswanger, Hans P. and Vernon W. Ruttan. 1978. Induced Innovation: Technology, Institutions, and Development. Baltimore: Johns Hopkins University Press.

Blair, G.J., Ivory, D.A., Evans, T.R. 1985. Forages in Southeast Asian and South Pacific Agriculture - Proceedings of an international workshop held at Cisarua, Indonesia, 19-23

August 1985. Australian Centre for International Agricultural Research: Canberra, Australia.

Bliss, C.T. and Stern, N.H. 1982. Palanpur: The Economy of an Indian Village. Oxford: Clarenden.

Booth, Anne and Cristina C. David. 1986. Food trade and food security in ASEAN and Australia. Kuala Lumpur: ASEAN-Australia Joint Research Project, 1986.

Chennareddy, V. 1967. Production efficiency in South Indian Agriculture. Journal of Farm Economics (vol 49, no 4).

Craswell, E.T., Tangendjaja, Budi. 1984. Shrub legume research in Indonesia and Australia. Proceedings of an International Workshop held at Balai Penelitian Ternak, Ciawi-Bogor, Indonesia, 2nd February, 1984. ACIAR Proceedings Series No. 3.

Darmadja, S.G. Nyoman Djiwa. 1980. Setengah Abad Peternakan Sapi Tradisional dalam Ekosistem Pertanian di Bali. PhD disertation. Universitas Padjadjaran.

Dillon, J.L., and Anderson, J.R. 1971. Allocative Efficiency, Traditional Agriculture, and Risk. American Journal of Agricultural Economics 53:26-32.

Darmawan, Delima H. Azahari. 1987. Soybean profile in Indonesia. Indonesian Agricultural Development Research Journal Vol. 9 nos. 1&2: 27-31.

Devendra, C. 1990. Shrubs and tree fodders for farm animals: proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. Ottawa, Canada:IDRC.

Ellis, Frank, 1988. Peasant Economics - farm households and agrarian development. Cambridge University Press: Great Britain.

Esparon, N.M. and Sturgess, N.H. 1989. The measurement of technical efficiency using frontier production functions of rice farms in West Java. Bulletin of Indonesian Economic Studies, Vol 25, no3, December: 99-119.

Feder, Gershon, Just, Richard E., Zilberman, David. 1985. Adoption of agricultural innovations in developing countries: A survey. Economic Development and Cultural Change: 255-298.

Gittinger, J.Price. 1982. Economic analysis of agricultural projects. Johns Hopkins University Press; Baltimore and London.

Hardaker, J., Anderson, J.R., and Dillon, J.L. 1984. Perspectives on assessing the impacts of improved agricultural technologies in developing countries. Australian Journal of Agricultural Economics
Vol. 28, no.2 and 3:87-108.

Hayami, Yujiro and Vernon W. Ruttan. 1971. Agricultural Development: An International Perspective. Baltimore: Johns Hopkins University Press.

Heady, Earl O. 1952. Economics of agricultural production and resource use. Prentice-Hall: Englewood Cliffs, N.J.

Hopper, D.W. 1965. Allocation Efficiency in a traditional Indian Agriculture. Journal of Farm Economics (vol 47, no3).

Jainudeen, M.R., Mahyuddin, M., Kuhn, J.E. 1986. Livestock production and diseases in the tropics. Proceedings of the fifth international conference on livestock production and diseases in the tropics held in Kuala Lumpur, Malaysia 18th - 22nd August, 1986. Volume 1.

Jamison, D.T. and Lau, L.J. 1982. Farmer Education and Farm Efficiency. Baltimore: John Hopkins University

Jegosothy, K., C.R. Shumway, and H. Lim. 1990. Production technology and input allocations in Sri Lankan multicrop farming. Journal of Agricultural Economics, Vol 41, no.1: 33-46.

Johnson, Aaron C., Marvin B. Johnson, Rueben C. Buse. 1987. Econometrics - Basic and Applied. Macmillan Publishing Company: New York, New York.

Khan, Mahmood H. and Maki, Dennis R. 1979. Effects of farm size on economic efficiency: the case of Pakistan. Amer. J. of Agric. Econ. 61:64-69.

Knipscheer, H. C., Sabrani, M., Soedjana, T.D., and DeBoer, A.J. 1987. The small ruminant market system in Indonesia: A review. Agricultural Systems 25:87-103.

Koutsoyiannis, A. 1978. Theory of Econometrics, Macmillan London.

IRRI. 1986. Farming systems socioeconomic research training course - Training materials vol 1-2. Agricultural Economics Department, IRRI, Los Banos, Laguna, Philippines.

Lau, L.J. and Yotopoulos, P.A. 1971. A test for relative efficiency and application to Indian agriculture. Amer. Econ. Rev. 61(1971):94-109.

Lipton, M. 1968. The theory of the optimizing peasant. Journal of Development Studies 4:327-51.

Mastika, M., Sutama, K., and Nitis, I.M. 1977 Pengaruh Penggembalaan Terhadap Pertumbuhan Pasture di Bukit Peninsula, Bali (The effect of grazing on the growth of sown pasture at Bukit Peninsula, Bali) Bull.FKHP - Unud no. 033/1977. Bali, Indonesia.

Mbwika, James M. 1990. "Kenya Smallholder Farmer Education and Farm Productivity" MSc thesis, University of British Columbia (April, 1990)

Mendenhall, W., Scheaffer, R. L., and Wackerly, D.D. 1986. Mathematical Statistics with Applications. Duxbury Press: Boston.

Mendra, I.K., and Supardjata, M. 1973 Feed Efficiency Sapi Bali Dan Friesian Holstein (Feed Efficiency of Bali cattle and Friesian Holstein). Bull. FKHP -Universitas Udayana, no.033/1973. Bali, Indonesia.

Moran, J.B. 1973. Light weight changes of Braham cross, shorthorn, Banteng, and Buffaloe steers grazing improved pastures at Darwin, N.T. Journal of the Australian Institute of Ag.Sci. March 1973, pg69-73.

Nitis, I.M. 1986. Three strata system for cattle feeds and feeding in dryland farming area in Bali. 3rd Year Progress Report to IDRC: Canada 197pp

Nitis, I. M., Lana, K., Suarna, M., Sukanten, W., Putra, S., Arga, W. 1987. Three strata system for cattle feeds and feeding in dryland farming area in Bali. 4th Year Progress Report to IDRC: Canada. 69pp

Nitis, I. M., Lana, K., Suarna, M., Sukanten, W., Putra, S. and Arga, W., 1988. Three stata system for cattle feeds and feeding in dryland farming area in Bali. 5th Year Progress Report to IDRC: Canada 82pp

Nitis, I M., Lana, K., Suarna, M., Sukanten, W., Putra, S., Arga, W., 1989. Three strata system for cattle feeds and feeding in dryland farming area in Bali. Final Report to IDRC: Canada 252pp.

Nitis, I. M., Lana,K., Suarna, M., Sukanten, W., Putra, S. 1990a. The concept and development of the three-strata forage system. In Shrubs and tree fodders for farm animals: proceedings of a workshop in Denpasar, Indonesia, 24-29 July, 1989. Editor C. Devendra. Ottawa, Ontario, IDRC.

Nitis, I. M., Lana,K., Suarna, M., Sukanten, W., Putra, S. 1990b. Research protocols appropriate to the development of methodology for the three-strata forage system. In

Shrubs and tree fodders for farm animals: proceedings of a workshop in Denpasar, Indonesia, 24-29 July, 1989. Editor C. Devendra. Ottawa, Ontario, IDRC.

Nitis, I.M., Lana, K., Sudana, I. B., Sutji, N. and Sarka, I.G. 1980. Survei data makanan ternak. Persediaan dan kebutuhan hijauan makanan ternak di Bali, FKHP, UNUD: Denpasar, Bali, Indonesia.

Nitis, I.M.1980 Makanan Ternak. Salah Satu Sarana Untuk Meningkatkan Produksi Ternak. Universitas Udayana, Denpasar, Bali, Indonesia.

Nitis, I.M., and Nurbudhi, K.D. 1975 The Growth of Stylosanthes in the island of Bali: A preliminary study. Dinas Peternakan Propinisi Bali, Indonesia.

Nurbudhi, I Ketut Dayuh. 1968. Marketing Sapi Bali. PhD thesis. Fakulatas Kedokteran Hewan & Peternakan, Denpasar, Bali, Indonesia.

Nugari, Ketut,and Winaya, Djapa. 1977. Pemetaan Tanah Bukit. Universitas Udayana, Bulletin 086/1977. Bali, Indonesia.

Putra, I.B. and Arga, I.W. 1979. Report on small holder farming in Bali. An economic survey. Report to AAUCS: Australia. Fakultas Dedokteran Hewan dan Peternakan, Universitas Udayana, Denpasar, Bali, Indonesia. 53pp

Panjaitan, M. 1988. Nutritive value of tree legumes introduced in Indonesia. Indonesian Agricultural Research Development Journal Vol 10 no 3: 73-77.

Panjaitan, M. 1988. Prospect of growing tree legume species in Indonesia. Indonesian Agricultural Research Development Journal Vol 10, no 4, 1988: 95-104.

Perkins, J., Petheram, R.J., Rachman, R., Semali, A. 1985. Introduction and management prospects for forages in Southeast Asia and the South Pacific. In Forages in Southeast Asian and South Pacific Agriculture - Proceedings of an international workshop held at Cisarua, Indonesia, 19-23 August, 1985. Editors Blair, G.J., Ivory, D.A., and Evans, T.R. ACIAR Proceedings Series No.12, 202p.

Raka, I Gusti Gde. 1955. Monografi Pulau Bali. Pusat Djawatan Pertanian Rakjat, Djakarta, Indonesia.

Rika, K. and Whiteman, P.C. 1976 Pasture Species Evaluation on the Bukit Peninsula, Bali, Indonesia. Bull FKHP - Unud, no.073/1976, Bali, Indonesia.

Robinson, C., McMahon,P., and Quiggin, J. 1982. Labour supply and off-farm work by farmers: theory and estimation. Australian Journal of Agricultural Economics Vol.26, no 1:23-38.

Rudra, Ashok. 1973. 'Allocative efficiency' of Indian farmers - Some methodological doubts. Economic and Political Weekly, Vol 8 (January).

Sahota, Gian S., 1968. Efficiency of resource allocation in Indian agriculture. American Journal of Agricultural Economics Vol L, no3.

Schultz, T.W. 1964. Transforming Traditional Agriculture. New Haven, Conn.: Yale University Press.

Shapiro, Kenneth H., 1983. Efficiency differentials in peasant agriculture and their implications for development policies. Journal of Development Studies, Vol 19,no 2:179-190.

Suardjaya, M., Supardjata, M., and Darmadja D., 1976. The effect of early and late castration on the growth of Bali cattle kept in the village. Seminar Lokakarya Ternak Potong & Penataran Inseminasi buatan dan Pemulyaan Ternak, Ujung Pandang.

Supardjata, M., 1973 Pengaruh Kastrasi Pada Sapi Bali Yang Belum Dewasa (The effect of castration on young Bali cattle) Bull, FHKP -Unud, no.034/1973. Bali, Indonesia.

Supardjata, M., and Djagra, I.B. 1974. The effect of age of castration on Bali cattle. Bull, FKHP - Unud, no. 042/1974, Bali, Indonesia.

Timmer, C.P. 1970. On measuring technical efficiency. Food Research Institute Studies. Vol IX. No.2.

Timmer, C.P. 1987. The Corn Economy of Indonesia. Ithaca: Cornell University Press.

Upton, M. 1979. The unproductive production function. Journal of Agricultural Economics 30:179-194.

Welch, F. 1970. Education in Production. Journal of Political Economy, Vol 78, No.1, (January/February): 35-59.

Yotopoulos, P.A. and Lau, L.J. 1973. A test for relative economic efficiency: some futher results. Amer. Econ. Rev. 63:214-23.

Yotopoulos, P.A. and Nugent, J.B. 1976. Economics of Development: Empirical Investigations. New York: Harper and Row, 1976.

Yotopoulos, Pan. A., 1968. On the efficiency of resource utilization in subsistence agriculture. Food Research Institute Studies. vol 8 no2.

Yotopoulos, Pan A., Lau, Lawrence J., and Somel, Kutlu. 1970. Labor intensity and relative efficiency in Indian agriculture. Food Research Institute Studies. Vol IX.

Appendix A: Derivation of shadow values for land, labour and capital from market prices.

A.1 Land

The concepts described in chapter two are used to derive approximate measures of the returns to farm land in Pecatu.

As described previously, the quality of farm land in Pecatu varies widely and farmers have adopted farming practices to accommodate this variance in quality. In addition to crops, land may be used to grow productive trees (for fruit or wood production), forage plants, grazing cattle or for quarrying limestone. The wide range of uses suggests that prices of land will also vary widely.

The value of crop land may be determined from rental rates, (share cropping) rates, and a form of borrowing rate observed in Pecatu. In Pecatu, a system of borrowing money where the right to the use of the borrowers' land is offered to pay the cost of the loan was reported. Under this system, a person who would like to borrow money will offer the use of a section of his land to the lender, until the loan has been repaid. The amount of land offered to pay the cost of a loan do not seem to be consistent, as seen in Table 4.1. The differences may be due to differences in the quality of land, the duration of the borrowing period, or the relationship of the borrower to the lender (money borrowed between friends or relatives may have terms to the lending agreement that result in lower or higher than usual lending rates).

In most cases, for land offered as a payment for a loan, the farmers questioned in this survey reported that the length of time to pay back the borrowed money was indefinite; there was no specified date to return the money. Under these conditions, it

seems reasonable to assume that the lender will lend the money as long as the returns to his investment (the amount of money lent to the borrower) is at least as great as the returns that would be obtained if the money was put to alternative uses. In other words, the returns to land may be treated as an annuity on an investment with an infinite time period (Value of the land at time zero * discount rate = the annuity payment (or yearly returns to investment)).

Table A.1 shows the estimated values of yearly returns to land used to cover the cost of a loan, for the seven samples obtained. Three different discount values were used to determine the yearly returns of the land. The values ranged widely with the highest value of Rp3600/0.01hectares/year for the 36% discount rate to Rp200/0.01hectares/year for the 20% discount rate. In some cases (farm 2 and farm 4, for example), it was observed that the land in question was used for grazing cattle only - the land was not suited for crops. In the case of farm 6, the land may be used for crops but was currently used for grazing cattle. Farm 8 had flat land that was continually used for crops; the recorded value for this land is Rp50000 for 50 are, but this value is very low; therefore Rp500000 was also tested and gave a more realistic result for returns to cropland.

Samples were also recorded for share-cropped (Rp2750/are/year) and rented crop land (Rp1000/are/year). Since these values are obtained specially for crop land, they provide an alternate indication of returns to crop land.

Land which is not used for crops ranges in value from Rp200/0.01ha to Rp3600/0.01 ha. A wide range in the value of grazing land may be expected - the value

of the land may differ due to the differences in quantity and quality of native forage plants growing on the land, the accessibility of the land for tethering cattle, and its potential for alternative uses - crops for instance. However, it does not seem likely that grazing land would be worth more than crop land - making values above Rp1000/0.01 hectares unlikely. (It may be possible that the land not cropped, which has such high reported value is merely in a temporary fallow condition; there also may have been conditions to the loan of money, not reported when the data was collected, which alters the returns to the land).

Table A.1: Estimated returns to land based on rental, sharecropping and collateral values.

Land values - based on collected data.					Rp/are/year (under alternative discount values)			
					final value 1	final value 2	final value 3	
Farm	system	0.01 ha. units	value	#of years	20%	28%	36%	
1	share crop				2750	2750	2750	cropped
2	lend money	50	250000	indefinite	1000	1400	1800	not cropped
	lend money	100	100000	indefinite	200	280	360	not cropped
4a	lend money	125	300000		480	672	864	not cropped
4b	borrow money	50	200000		800	1120	1440	not cropped
5	rent				1000	1000	1000	cropped
6	lend money	50	500000		2000	2800	3600	not cropped
7	lend money	50	200000		800	1120	1440	
8	lend money	50	50000		200	280	360	cropped
8*	lend money	50	500000		2000	2800	3600	

* number 8 has been re-calculated to correct an error in the data which has resulted in low values for crop land.

Based upon the above information it seems reasonable to suggest that returns to (or values for) cropland ranging above Rp1000/0.01 hectares and for grazing land ranges below a maximum of Rp1000/0.01 hectares.

A.2 Wage rate of labour

Economic theory related describing the allocation of labour between farm and off-farm employment will be used to determine a farm wage rate for use in a cost-benefit analysis.

Off farm wage rates obtained in January are described in Table A.2.

From the table it can be seen that net wage rates range from Rp4650 to Rp700 per day. These wage rates may be used to predict the on farm wage rates.

A study by Naylor, (1989) found that in 1987 in East Java (a region with areas similar in climate and topography to the Bukit peninsula) the wage rate for weeding ranged from Rp800 to Rp1500 (meals included) per eight hour day for women, and for men the wage for hoeing ranged from Rp1284 to Rp2336 per eight hour day (meals included). It seems reasonable to assume that wages in Pecatu would be in a similar range. If wages were higher in Pecatu than other regions of Bali, or other regions of East Java, there would be a visible trend of migration to the village of Pecatu, until wages were equivalent to those obtained in other regions. A survey of the population statistics of Pecatu indicate that there has been no migration into the village over the past 5 years. Also, from the survey carried out, it appeared that there was a trend for villagers to move away from the area, to the nearby cities of Kuta, Denpasar, or Benoa to obtain employment.

If the wages from East Java are compared to the wages for men in Pecatu, it would appear that a range from Rp1200 to Rp2000 (meals included) would seem reasonable for on farm labour. This assumption may be backed by the observation that

farm labourers (working on large operations) have wage rates ranging from Rp833 to 1666 per day (meals not included in the calculation). This approximation is further supported by the observation that men in Pecatu were often employed quarrying limestone or cutting trees for firewood. Quarrying limestone was physically demanding work, but requires no special training or capital. Because of the physically demanding nature of the work, it also seems reasonable to suggest that wages for quarrying limestone may be slightly higher than wages obtained from on farm work. For firewood, some people reported earning Rp300/hour, but monthly wages did not reflect this wage rate; firewood collection was done on a part-time basis - indicating that other work was more profitable. It also indicates that the wages were not as high as those for off-farm work such as quarrying limestone, which elicits full-time employment.

As discussed previously, the men in Pecatu most often work off the farm, while women usually stay on the farm and carry out the care of the house hold and small children, and the light field work on the farm. This situation indicates that the wage rate for work off the farm is lower for women than for men. As women usually weave mats, this employment gives the best indication of what their on-farm wages would be. The value of Rp2375 per day seems rather high when compared with wages observed in East Java. If the land required to grow the screw pine (the plant used as raw material for the mats) and the labour required to harvest and process the screw pine leaves for weaving were calculated, it is likely that the net wage rate would decrease. If not, one would expect that women in Pecatu would spend a large amount of their time weaving mats, and allocating a larger amount of land to the production of screw pine than was

observed. Instead, interviews conducted to determine how women spent their time indicated that weaving mats was more of a 'leisure time' activity, to be pursued after farm chores had been completed. Taking into account the observed wages rates from East Java, and the productivity of 'off farm' activities, an on farm wage rate of Rp1000 to Rp1500 per day for women in Pecatu is likely.

Table A.2: Off farm wages - Pecatu, January, 1989

type of employment	time	wage	transport cost	net wage/day (30 day/mo.)
quarry limestone bricks	full time - 27 to 30 days	Rp50000 - 68000/month	none	Rp1666-2266/day
docks labourer	full time	Rp150000/month	Rp450/day	Rp4650/day
docks labourer	casual labour	Rp3000/day	Rp450/day	Rp2550/day
labourer in city	full time	Rp30000/month	Rp450/day	Rp550/day
construction	full time	Rp75000/month	Rp450/day	Rp2050/day
farm labourer (pigs)	full time	Rp 25000/month	none	Rp833/day
foreman (TSFS project)	-	Rp60000/month	none	Rp2000/day
firewood	2-6 hours/day	Rp150 - 300/hour	carrying wood to local warung	(10 hours/day) Rp1500-3000/day
weaving mats	4-12 hours/mat	Rp700-950/mat	carrying tikar to local warung	Rp700-2375/day
farm labourer (pigs, cattle)	full time	Rp50000/month	none	Rp1666/day

Children attending school also reported working on the farm, and therefore must also be assigned a wage for on farm work. Most school children reported spending two to three hours per day working on the farm. The wage per day was assigned a value equal to that of women and was adjusted to account for the shorter hours.

Evidence to support the notion that farmers in Pecatu allocated their time to maximize returns to labour resources was found in interviews with farmers working off the farm. There was evidence to suggest that work was carried out on the farm as long as it was profitable - the less pressing work or work with lower returns was left to lower paid family members. Interviews describing such decision-making are presented below.

A.2.1 Transcripts of interview with limestone quarry labourers.

Farmer A:
The price of bricks right now is Rp190 to Rp195/brick. Each month I make 500 bricks. I own this land [for quarrying limestone].

"Why do you like this work?"

Answer:
1. Because some months, like the months of April until October, there is no pressing work in the fields, so that rather than sit quiet at my house, it is better that I earn money quarrying limestone.
2. By chance, I own land close to the road, so selling the bricks is easy.
3. Making bricks is profitable work.
4. I cannot do other work, because I do not have a lot of training.

"When do you sell the bricks?"

Answer:
It is not certain, because if the seller comes, I sell my bricks, even if I do not have 500 yet. Usually, by grouping together with other people [there are enough bricks], for example;
person A - 200 bricks
person B - 100 bricks
person C - 200 bricks for a total of 500 bricks.
Later the money is split between us according to how many bricks we had.

"How do you manage the care of your livestock?"

Answer:
My house is close, and my wife helps me with the work.
Usually during the day, after the midday break, I gather feed. Sometimes, I gather feed after finishing work.

"How about your work in the fields?"

Answer:
Before the start of the rainy season, I stop quarrying and cultivate the fields, improve the terraces.

"Is there any other type of work?"

Answer:
There is, such as plowing, but I pay someone to do that. The cultivation of the fields is done around November. Usually, halfway through November to December, the rain falls, and I join my family for planting the crops and the first weeding.

After that, sometimes I quarry limestone, sometimes I work in the fields.

If the weeds are small and few, so that the weeding goes very quickly, there is time for me to work at quarrying limestone. It also depends upon the weather; if the weather is good, sometimes after the first weeding, I can get back to quarrying quickly.

At harvest time, I help to harvest the crops in the field.
After that I can return to quarrying limestone.

"What months do you most often work at quarrying limestone?"

Answer:
From April to September.

"Do you work everyday [quarrying limestone]?"

Answer:
Clearly not! Because I am the head of my family, for certain I have many duties, such as:

- seeing to important family matters
- traditional ceremony
- work with the village
- other work with society

Because of these duties, I can not always work.

Farmer B:

Age: 35 years
Education: SD
Primary occupation: farmer
Off-farm work: quarry limestone to make bricks

"How long have you been quarrying limestone, Pak?"

Answer:
I have been making bricks since more or less 10 years ago and have continued up until now.

"Why are you attracted to making bricks?"

Answer:
Before I tried it myself, I heard information from friends of mine in the village. At that time, they said that at least with making bricks, we increase our income, at least every month we sell bricks, and already its certain we can make money.
Because of that information, I tried making bricks. The first time I quarried limestone to make bricks, it appeared easy, but there was some difficulty with the marketing. Sometimes two months would pass, and I had not sold any brick, and the price at that time was not very good (low price).

"Why was it like that, Pak?"

Answer:
I think because of the location of the stone pits in our village was not yet known to other regions, especially the city region.

"How about now, Pak?"

Answer:
Yah! Like that Pak Wayan, the supply of brick is always in shortage, otherwise the buyer always comes, so that my friends and I are always given a down payment. And the price I get is always going up.

"Talking about price, what is the price of bricks now, Pak?"

Answer:
Now the price per brick is Rp195.

"Do you ever bargain about the price you can get from the buyer?"

Answer:
Clearly! If my buyer feels under some pressure, I bargain for a 'bonus' per brick, I bargain for as much as Rp200 per brick. But that is only sometimes.

"How much is your income from making bricks, per month?"

Answer:

It depends upon how many bricks I make.

"Can you explain about your brick production per month?"

Answer:
On average each month I can make 400 bricks.

"Recalling that you are also a farmer, how do you divide your time between the farm and this work?"

(Farmer C does not understand the purpose of this question)

"In the rainy season, do you still make brick, Pak?"

Answer:
No, in the plowing season I stop making brick around the month of October, and then if the rain starts to fall, I plant crops in the fields. Later continuing with the first weeding. When the first weeding is finished, sometimes I go back to making bricks. But not every day.

"Why not every day, Pak?"

Answer:
Because I look after the crops, and do light work in the fields.

"Maybe you could explain further? Every week how many times can you dig stone?"

Answer:
On average, two times.

"How about at harvest time, Pak?"

Answer:
Also at harvest time, I quit quarrying limestone. Because I must bring the crops from the fields.

"If there is a second weeding, do you join in the work?"

Answer:
Usually I don't join.

"Why? Because that work is not too pressing?"

Answer:

Because there are enough other family members to do that work.

"How about the time of harvest. Can this work not be done by other family members as well?"

Answer:
No. Because harvesting of the crops must be done quickly, especially if there is a lot of rain.

"Around which months do you quarry limestone continually?"

Answer:
Around 1/2 March, April, May, 1/2 June, 1/2 July, August, September.

"Why in those months? Because in those months there is almost no work in the fields?"

Answer:
!

"Do you join in the care of the livestock?"

Answer:
Yes.

"How is that time organized?"

Answer:
I look for feed each morning and each evening, before and after I quarry stone. Otherwise the moving of the cattle is done by other members of my family (my wife).

"Are you ever interested in other off farm work, besides quarrying limestone?"

Answer:
Remind yourself that I don't have a lot of ability for other skills, so that it is difficult to attempt other work. With making bricks, I am already used to making enough money, yah, each month, for sure I can sell bricks. With capital cheap enough, and without having to buy tools for making bricks often.

"From around March, to September, you said that you do this work continually. Do you make bricks every day?"

Answer:
On average, clearly not.

"Why?"

Answer:
Because there other many other activities, that I must do, especially those related to my family, society, and traditional ceremonies.

"How many times are you absent from making bricks in one month?"

Answer:
Around 3-5 times.

"Who owns this land? [for digging limestone]"

Answer:
It is owned by someone else.

"How is the division of the profits?"

Answer:
If I make 500 bricks, -100 bricks for the owner of the land
-400 bricks for the brick maker.

A.3 The rate of discount

To analyze the profitability of the plot from the point of view of the investor, the farmer, the market rate of interest is used. There is evidence that the rate of interest on borrowed capital from banks is 36%/year. It is also not uncommon for farmers to obtain credit from the local warung. Because of the complicated nature of the social structures and obligations between members of society in the village, it is difficult to obtain an exact estimate of the cost of a loan from the warung (answers related to questions of this relationship ranged from 'no interest rates are charged' to loan rates of 2-4% per month). Loans from local farmers groups were also available; the cost of these loans were as cheap as 24% per year.

The interest rates are adjusted for inflation. The rate of inflation is assumed to be between 8 and 11%.

Based upon the above information, the discount rate used in the cost benefit analysis was 28%. In sensitivity analysis, rates of 20% and 36% were also used.

Appendix B Collection of data

The purpose of this section is to describe the collection of the data, and the types of data collected.

B.1 Family labour

Information was gathered concerning the participation of family members in farm production activities. Farmers were asked to estimate their monthly earnings for all farm activities, as well as to describe on-farm activities. The farmers were asked to estimate the labour requirements for tasks related to crop production, livestock husbandry, and household maintenance activities. Information was collected on the age, level of education, and family relationship of each family member. For children attending school, information was collected concerning their place of residence during the school year, as this would affect their availability for farm labour tasks.

Family members were asked to estimate their earnings from off farm employment. They were also asked to describe the difference in earnings between the wet season (cropping season) and the dry season, and to describe which months they would devote full-time to their off farm activities.

B.2 Land

In January, farmers participating in the project were asked to draw a map of their farm (or to describe the farm to the interpreter - who would draw the map) and to describe the land use patterns on the farm. Since the crop-fallow cycle varies over different topographies and soil types, the farmers were asked to describe the crop-fallow cycle of each section of land and the current use of each piece of land. Farmers were

also asked to estimate the amount of land (outside the project) devoted to the production of improved species of grasses and ground legumes and other forages. Later, in the months of February and March, farmers were asked about their preferences for different forage species, and the decisions involved in choosing a location for the planting of forages. Farmers were also asked about the use of land currently not used for crops or forages.

B.3 Farm production practices

Information about farm production practices would have been obtained from information on land and labour use. Additional information was collected from a sub-sample of farmers to determine common practices concerning the selection of crop varieties, timing of production tasks, and specific cattle husbandry practices.

B.4 Construction of farm sample groups

In addition to data collected in this survey, data was available for use from previous surveys by the TSFS project researchers. This data is useful for comparison of information on farm revenues and farm resources. However, there will be some differences between TSFS project data and the data of this study, in the way the TSFS, NTS and Traditional farm groups in the samples are constructed. When the project was first initiated, farmers contributed land and labour resources for the set-up and maintenance of project plots and project cattle. In some cases, two members of a family donated land and labour to the project, and were responsible for two different types of plots (TSFS or NTS). During the collection of TSFS project data, each member reported separate farm revenue data. However, in this study, there is no division of farm revenue (or farm land) where two different project treatments are encountered on one family farm. It is believed that attempting to divide revenues between different treatments will lead to incorrect conclusions about the allocation and returns of farm resources. However, there is some difficulty encountered in attempting to group the data to test for differences between treatment groups of average farm revenues or resources, since it is no longer clear which sample group (TSFS, NTS, Traditional) should include the farm with two

different treatments. Therefore an arbitrary decision was made: farms with both NTS and TSFS plots were included with the TSFS sample, farms with NTS and Traditional cattle treatments were included in the NTS sample group.

In addition to the TSFS, NTS and Traditional farm sample groups, fourteen non-project farmers were chosen from two different farmers groups in Pecatu. The farmers were chosen on the basis of their land holdings. An attempt was made to chose a sample such that the mean land-holdings of the non-project groups would be as close as possible to 3 hectares and the sample would include as wide a range as possible.

In the TSFS project, twelve farmers were assigned TSFS plots, 14 farmers were assigned NTS plots, and six farmers were given cattle to raise Traditionally; the economic survey included 6 more farmers in the sample for Traditional farms. In this study, there are ten farms with TSFS plots, two farms with both NTS and TSFS plots; ten farms with NTS plots (three NTS farms dropped out of the study); nine farms included in the Traditional farm group (six of which cared for project cattle) and 14 farmers included in the Non-project group.

Appendix C Budget sheets for financial analyses.

Table C.1: Net present value of a TSFS plot.

Project budget			TSFS Year 0	year 1	year 2	year 3	year 4	year 5
COSTS:								
TSS forage and cropland price/0.01ha			1900					
TSS forage land	Rp1900/0.01ha	0.09ha/plot	17100	17100	17100	17100	12600	0
Forage planting	seeds	16000/kg, 2kg/Ha	2880	0	0	0	0	0
materials - for	shrub stakes	Rp5/stake 2000/plot+20%	12000	0	0	0	0	0
0.25 ha. (includes	tree stakes	Rp25/stake 56/plot+25%	1750	0	0	0	0	0
replacement shrubs		fertilizer	680	0	0	0	0	0
&trees)								
	labour - planting TSS forages		46038	0	0	0	0	0
stable: (4*25(trees)+5000(roof)+5*100(shrubs)+2000(bamboo))			0	7600	0	0	0	0
feeding costs and other labour costs:			1500					
gathering feed and feeding cattle (per year)		20 min/day	0	18250	18250	18250	18250	18250
clean stall per year TSFS		5 min/day	0	4563	4563	4563	4563	0
veterinary care - fly spray, antibiotics				5167	9433	8449	5082	0
Total costs including cost of calf:			80448	208839	49345	48361	40495	18250
		cost of calf:	0	156160	0	0	0	0
		price/kg cattle	1600					
RETURNS:								
returns to crop land Rp1900/0.01hectares			0	0	0	0	0	0
revenues from firewood			0	0	16175	17456	26236	26238
		cattle revenue:	0	0	0	0	0	480000
	RETURNS:		0	0	16175	17456	26236	506238
	COSTS:		80448	208839	49345	48361	40495	18250
	RETURNS - COSTS:		-80448	-208839	-33170	-30906	-14259	487988
	Prices:	return to crop	1900					
		return to graze	-					
		wage/day	1500					
		Rp/kg cattle price	1600					
		irr	cannot calculate					
	20%	npv	-106166					
	28%	npv	-141875					
	36%	npv	-163509					

Table C.2: Net present value of a 0.09 hectare crop field.

Project budget	year 0	year 1	year 2	year 3	year 4	year 5
COSTS:						
TSS forage and cropland price/0.01ha						
TSS forage land Rp1900/0.01ha 0.09ha/plot	0	0	0	0	0	0
Forage planting seeds 16000/kg, 2kg/Ha	0	0	0	0	0	0
materials - for shrub stakes Rp5/stake 2000/plot+20%	0	0	0	0	0	0
0.25 ha. (includes tree stakes Rp25/stake 56/plot+25%	0	0	0	0	0	0
replacement shrubs fertilizer	0	0	0	0	0	0
&trees)						
labour - planting TSS forages	0	0	0	0	0	0
stable: (4*25(trees)+5000(roof)+5*100(shrubs)+2000(bamboo))	0	0	0	0	0	0
feeding costs and other labour costs:						
gathering feed and feeding cattle (per year) 20 min/day	0	0	0	0	0	0
clean stall per year TSFS 5 min/day	0	0	0	0	0	0
veterinary care - fly spray, antibiotics						
Total costs including cost of calf:	0	0	0	0	0	0
cost of calf:	0	0	0	0	0	0
price/kg cattle	0	0	0	0	0	0
RETURNS:						
returns to crop land Rp1900/0.01hectares	0	17100	17100	17100	17100	17100
revenues from firewood	0	0	0	0	0	0
cattle revenue:	0	0	0	0	0	0
RETURNS:	0	17100	17100	17100	17100	17100
COSTS:						
RETURNS - COSTS:	0	17100	17100	17100	17100	17100

Prices:	return to crop	1900
	return to graze	-
	wage/day	1500
	Rp/kg cattle price	1600
	irr	
20%	npv	51139
28%	npv	43297
36%	npv	37291

Table C.3: Net present value of participation in TSFS project - with TSFS plot

	Year 0	year 1	year 2	year 3	year 4	year 5
COSTS:						
TSS forage and cropland price/0.01ha	1900					
TSS forage land Rp1900/0.01ha 0.09ha/plot	17100	17100	17100	17100	17100	0
Forage planting seeds 16000/kg, 2kg/Ha	0	0	0	0	0	0
materials - for shrub stakes Rp5/stake 2000/plot+20%	0	0	0	0	0	0
0.25 ha. (includes tree stakes Rp25/stake 56/plot+25%	0	0	0	0	0	0
replacement shrubs fertilizer	0	0	0	0	0	0
&trees)						
labour - planting TSS forages	46038	0	0	0	0	0
stable: (4*25(trees)+5000(roof)+5*100(shrubs)+2000(bamboo))	0	0	0	0	0	0
feeding costs and other labour costs: wages/day	1500					
gathering feed and feeding cattle (per year) 40 min/day	0	36500	36500	36500	36500	0
clean stall per year TSFS 5 min/day	0	4563	4563	4563	4563	0
	0	0	0	0	0	0
Total costs not including cost of calf:	63138	58163	58163	58163	58163	0
cost of calf:	0	0	0	0	0	0
price/kg cattle	1600					
Costs of feed (due to feed shortages in plot) per year:	0	0	4870	9168	0	0
price/kg of feed:	10					
RETURNS:						
returns to crop land Rp1900/0.01hectares	0	0	0	0	0	0
revenues from firewood	0	0	16175	17456	26236	26238
revenues from land rental (project plot):	334933					
cattle revenue:	0	0	0	0	0	164592
TOTAL COSTS:	63138	58163	63033	67330	58163	0
TOTAL RETURNS:	334933	0	16175	17456	26236	190830
TOTAL RETURNS - TOTAL COSTS:	271795	-58163	-46858	-49874	-31927	190830
Prices: return to crop:	1900					
return to graze:	-					
wage/day	1500					
Rp/kg cattle price:	2400					
20% npv	223217					
28% npv	217619					
36% npv	215551					

Table C.4: Net present value of participation in TSFS project with NTS plot.

		Year 0	year 1	year 2	year 3	year 4	year 5
COSTS:							
NTS cropland price/0.01ha		1900					
	Rp1900/0.01ha 0.09ha/plot	0	0	0	0	0	0
NTS grazing plot	price of land = price of grazing land	0	25000	25000	25000	25000	25000
	price of grazing land:	1000					
Forage planting	seeds 16000/kg, 2kg/Ha	0	0	0	0	0	0
materials - for	shrub stakes Rp5/stake 2000/plot+20%	0	0	0	0	0	0
0.25 ha. (includes	tree stakes Rp25/stake 56/plot+25%	0	0	0	0	0	0
replacement shrubs	fertilizer	0	0	0	0	0	0
&trees)							
	labour - planting TSS forages	0	0	0	0	0	0
stable: (4*25(trees)+5000(roof)+5*100(shrubs)+2000(bamboo))		0	0	0	0	0	0
feeding costs and other labour costs:	wages/day	1500					
gathering feed and feeding cattle (per year)	60 min/day	0	54750	54750	54750	54750	0
clean stall per year	5 min/day	0	4563	4563	4563	4563	0
open new field (40/100 ha)- every 3 years Trad		0	0	0	0	0	0
Total costs not including cost of calf:		0	59313	59313	59313	59313	0
	cost of calf:	0	0	0	0	0	0
	price/kg cattle	1600					
Costs of feed (due to feed shortages in plot) per year:		0	0	17210	19157	0	0
	price/kg of feed:	20					
RETURNS:							
returns to crop land Rp1900/are		0	0	0	0	0	0
revenues from firewood		0	0	0	0	0	0
revenues from land rental (project plot):		334933					
	cattle revenue:	0	0	0	0	0	164592
TOTAL COSTS:		0	84312.5	101523	103470	84312.5	25000
TOTAL RETURNS:		334933	0	0	0	0	164592
TOTAL RETURNS - TOTAL COSTS:		334933	-84313	-101523	-103470	-84313	139592
Prices:	return to crop:	1900					
	return to graze:	-					
	wage/day	1500					
	Rp/kg cattle price:	1600					
20%	npv	149732					
28%	npv	166979					
36%	npv	182274					

Table C.5: Net present value of grass, shrubs, and trees

yield per sq.meter	panicum	cenchrus	verano	gliricidia	ficus	lannea	hibiscus
year 0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
year 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
year 2	0.96	1.12	0.70	2.34	0.13	0.25	0.24
year 3	0.61	1.08	0.29	1.80	0.13	0.49	0.52
year 4	0.80	1.14	0.35	2.06	0.11	0.08	0.31
year 5	1.34	1.44	0.35	2.76	0.13	0.28	0.39
average over years 1-5	0.74	0.95	0.34	1.49	0.08	0.22	0.29
labour (year 0)	0.015	0.015	0.015	0.007	0.007	0.007	0.007
(days/m² or days/shrub)							
cost of labour/day	1500	1500	1500	1500	1500	1500	1500
total labour cost	23	23	23	11	11	11	11
price of land/0.01ha	1000	1000	1000	1000	1000	1000	1000
land price/m² forage	10	10	10	10	20	20	20
assume: 10 shrubs/m², one square meter of grass, one tree per two square meters							
Materials costs:							
seed	3.2	3.2	3.2	50.0	25.0	25.0	25.0
total cost per year:							
year 0	35.7	35.7	35.7	165.0	55.5	55.5	55.5
year 1	10	10	10	10	20	20	20
year 2	10	10	10	10	20	20	20
year 3	10	10	10	10	20	20	20
year 4	10	10	10	10	20	20	20
year 5	0	0	0	0	0	0	0
Price of forages (Rp/kg)	10	10	10	10	10	10	10
%dm	25.61	24.75	26.73	21.51	29.80	30.58	28.24
value of yields (includes water %):							
year 0	0	0	0	0	0	0	0
year 1	0	0	0	0	0	0	0
year 2	37	45	26	68	1	3	3
year 3	24	43	11	52	1	5	6
year 4	31	46	13	60	1	1	3
year 5	52	58	13	80	1	3	4
total value/year (firewood + forage value):							
year 0	0	0	0	0	0	0	0
year 1	0	0	0	0	0	0	0
year 2	37	45	26	163	1	3	3
year 3	24	43	11	173	1	5	6
year 4	31	46	13	241	4	3	10
year 5	52	58	13	222	4	7	9
discount rate:	0.280						
returns-costs:							
year 0	-36	-36	-36	-165	-56	-56	-56
year 1	-10	-10	-10	-10	-20	-20	-20
year 2	27	35	16	153	-19	-17	-17
year 3	14	33	1	163	-19	-15	-14
year 4	21	36	3	231	-16	-17	-10
year 5	52	58	13	222	4	7	9
Net present value:	3	24	-28	149	-96	-93	-90

Appendix D Derivation of forage prices

This section investigates the relative prices of selected forage plants according to total yield and labour costs of harvest. Data collected on the market value of forages showed a wide variation of prices; it has been determined from village sources and from data obtained from the Balinese government records, that the price of forages ranges from Rp10/kg for native grass to Rp20/kg for higher quality grass (elephant grass). In order to check this range a rough estimate of the market value of forages using land values and harvest labour costs was calculated. The steps involved and the results are shown in Table D.1.

The first section of the table shows the estimated costs[51] of harvesting the forages (the labour estimates were obtained from direct observation in Pecatu during the months of February, and May through August, 1989). It is evident that labour costs are very similar the between forages (with the exception of the shrub gliricidia). The harvest costs per 0.01 hectare of forage are estimated and added onto the cost of 0.01hectares of land[52]. This value is divided by the total yield of the forage per 0.01hectares (calculated to include the water content), to obtain a rough indicator of the value in Rp/kg of the forage. The results shown here indicate that a range of Rp10-30/kg of forage is not unreasonable (the very low price of Rp2/kg for gliricidia is unrealistic - prices were observed to be lower than for good quality grass, but were within the same range).

[51] Wages are set at Rp1500/day, or Rp2.5/min.

[52] The value used for the cost of land, Rp1000/0.01 hectares is believed to be the maximum price of land not used for crops.

Table D.1: Value of forages per kilogram

Value of forages per kilogram (wet weight)								
	native grass	panicum	cenchrus	verano	gliricidia	hibiscus	ficus	lannea
Cost of harvest in Rp/kg of forage:								
harvest minutes/kg	1.1	0.9	0.8	1.1	0.5	0.8	0.8	0.8
Rp/kg	2.8	2.3	2.0	2.8	1.3	2.0	2.0	2.0
Yield kg/0.01ha forage:								
average kg/0.01ha (DM)	32.00	74.20	95.33	33.84	179.23	14.60	5.01	11.03
average kg/.01ha (wet)	140.7	289.7	385.2	126.6	833.2	51.7	16.8	36.1
price of land/0.01ha	1000	1000	1000	1000	1000	1000	1000	1000
cost of land + harvest	1387	1652	1770	1348	2042	1103	1034	1072
final price Rp/kg	10	6	5	11	2	21	61	30

The estimated price of Rp61/kg for Ficus tree is very high but, as the Ficus is generally the only forage source available at the end of the dry season, and is also a very slow growing tree, it is would not be not surprising to observe prices which are higher than prices received for other forages.

For the cost-benefit analysis, Rp10/kg is chosen as the base value when estimating the relative profitability of TSFS forages. Rp20/kg is the chosen value for the purchase price of forage (very likely tree forages) to supplement the diets of TSFS and NTS cattle, as this forage would be required at a time of year when forage is scarce and therefore more costly. These prices are varied in sensitivity analysis to account for differences in quality in the forages.