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ECONOMIC ANALYSIS OF THE MODEL FARM PROGRAM AND ITS SUBSIDIZATION UNDER THE CITANDUY II PROJECT

by

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The opinions and views expressed in this paper are the views of the authors and do not necessarily represent the views of USAID or any other agency.

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EXECUTIVE SUMMARY

The Citanduy II Project was started in 1981 with the dual goals of increasing farmer incomes and reducing erosion. The project established 48 model farm units and impact areas over a five-year period. The model farms are located in the Citanduy watershed at the eastern edge of West Java.

The project established a model farm program that consists of introducing a package of upland agricultural technologies. The model farm package includes constructing bench terraces and using new cropping patterns, seed varieties and inputs of chemical fertilizers and insecticides on land with slopes up to 50 percent. Land with slopes of more than 50 percent get an agro-forestry package. Subsidies are provided for the construction of bench terraces and the purchase of inputs.

This analysis differentiates between evaluating the technology and evaluating the program. The technology is defined as the package consisting of building bench terraces and utilizing new cropping and input mixes; the program is defined as the process of getting farmers to adopt the model farm technology. The evaluation of the model farm technology requires that we assess its benefits and costs; the evaluation of the model farm program requires that we determine the degree to which it spreads the model farm technology.

This summary examines the success of the model farm technology, the success of the model farm program, the need for subsidies, and additional research needs.

SUCCESS OF MODEL FARM TECHNOLOGY

The model farm technology is intended to yield both on- and off-site benefits. On-site, the technology is supposed to improve farm incomes. Data are available for assessing the on-site returns from the model farm technology in terms of farmer incomes, where farmer incomes measure the net value of production, including that production which is consumed on the farm.

Off-site, the model farm technology may also yield benefits due to the reduction of soil erosion. Sediment and other pollutants resulting from water erosion are carried to streams and rivers, and can cause a variety of in-stream and off-stream damages. In-stream damages include damages to aquatic organisms, water-storage facilities and navigation. Off-stream damages include flooding damages and damages to water-conveyance systems. However, insufficient data are currently available to assess the off-site effects.

Average gross farm incomes increased over the span of time the model farm program has been in existence. It appears that both

project and outside project farmers shared in these gains. The most important factor explaining the increase in farm incomes appears to be a shift in the cropping mix. During the early years of the project, the shift was into rice and out of cassava production and, more recently, the shift has been into cassava and out of rice production. This shifting cropping mix has been triggered by fluctuations in the relative prices of cassava and rice.

Farmers whose production is nearly exclusively cassava or rice are worse off than producers who grow a combination of both crops. Using 1985 prices, net incomes are highest for those farmers with a cropping mix that includes approximately 40 percent cassava by weight. This is approximately one half of a typical farm's cassava production prior to 1981. At 1987 prices, the optimum output mix rises to approximately 60 percent cassava by weight.

Bench terracing appears to facilitate a shift in the cropping mix towards rice production. During the early stages of the model farm program, when rice prices were rising relative to cassava prices, farm incomes rose both because of the rising prices and because bench terracing permitted the shift into rice production.

But as the relative price of cassava has risen in recent years, the benefits of weighing the cropping mix towards rice production and, thus, the benefits of bench terracing, have declined. Bench terracing appears more important for rice production than for cassava production. Because the relative contribution of rice production to farm income has declined with declining rice prices, there has been an associated decline in the income benefits attributable to bench terracing.

That is, bench terraces yield the greatest income benefits when the optimum cropping mix is weighted towards rice; they yield the least income benefits when the optimum cropping mix is weighted towards cassava. During the 1981 to 1987 period examined by this study, the overall effect of relative prices moving in favor of cassava production has been to diminish the income benefits of bench terracing and to yield a negative net return to the technology.

The Unit Studi dan Evaluasi Sosial Ekonomi (USESE) data sets used for this analysis were subjected to a wide range of statistical tests in order to examine alternative explanations proposed to us for the apparent lack of success of the model farm technology. The data represent a relatively short time period, however, so the results should be treated with caution. The statistical tests indicate that we can rule out the learning process, soil degradation, source of income, diversion of subsidies to lowland rice fields, and differences in soils (i.e., volcanic versus sedimentary) as reasons for the apparent lack of success of the model farm technology to increase incomes.

The value of the model farm technology and, particularly, bench terracing, in terms of increasing farm incomes may be more of a long-run phenomenon than is observable with the available short-run data. Cyclical changes in rice and cassava prices induce changes in the cropping mix of farmers. Farmers with terraces are better able to take advantage of these price changes than farmers without terraces, especially when the shift is into rice production. Therefore, farmers with terraces are likely to have higher average incomes over the long run than farmers without terraces. But the present data are insufficient for testing this hypothesis.

SUCCESS OF MODEL FARM PROGRAM

The model farm program is designed to extend the project's technology beyond the model farm. The model farm itself is intended as a demonstration of the model farm technology. Once the model farm is established, the visual presence of the model farm and the efforts of extension workers are anticipated to convince other farmers to adopt the technology. First, farmers are induced with subsidies to emulate the model farmers. These are the dampak subsidi (DS) or subsidized expansion area farmers. Next, the additional returns from utilizing the technology are demonstrated to other farmers, who are expected to adopt the technology using their own resources. These are the luar proyek (LP) or unsubsidized outside project group.

Bench terracing, which is the major component of the model farm technology, spread rapidly during the 1981 to 1985 period, indicating that the program is a success. Not only is bench terracing within model farm projects nearly total, but bench terracing by nearby farms outside the project lags only slightly behind those in the project.

Extension workers are the primary source of information regarding bench terracing. This is the case not only for farmers in the project, but also for outside project farmers. The extension component of the model farm program for spreading the technology appears successful.

The need for many model farms for spreading the technology, however, is not obvious. Extension workers, not the visual presence of the model farm, seem to be the catalysts for change. Moreover, the improved "before" condition of model farm sites since 1981 may be due to extension workers spreading the technology in advance of the model farms.

SUBSIDIES

Under certain conditions, bench terracing appears to pay for itself. Unsubsidized farmers outside the project are bench

terracing using their own resources and their net incomes are increasing. The fact that the net incomes of the model farmers declined may be a function of input and output restrictions imposed upon them by the model farm program. If these mixes are somehow important to the demonstration function of the model farms, then subsidies are needed for these farmers. But neither subsidies for/terracing nor program input subsidies are economically justified for other farmers.

There may be other purposes of the subsidies. For example, it has been suggested that they contribute to the support of the extension workers. If this is the case, then there may be justification for subsidies beyond the model farms, but in terms of on-farm economics they do not appear warranted. Credit may be needed more, but data are not sufficient to assess this need.

RESEARCH NEEDS

A number of questions have been raised by this analysis. In order to complete the analysis of the model farm program and build confidence in the results reported here, the following questions need to be answered.

Flexibility to change the cropping mix in response to shifting relative prices is a prime determinant of the farmer's income. Terracing appears to enhance this flexibility, at least for some crops such as rice. The role of terracing in cassava production is less clear. Moreover, how the sustainability of cultivation on steep slopes is affected by terracing is not well defined. Research is needed to assess the physical relationships between terracing and changing cropping patterns and the sustainability of this type of agriculture over time.

Erosion from upland agriculture is thought to have negative downstream impacts. The model farm program may reduce these downstream costs, but in order to assess the magnitude of the benefits produced we need to know how much on-farm erosion is reduced by the model farm program, how much on-farm erosion contributes to downstream sediment problems, and what is the magnitude and cost of downstream sediment problems. The study being conducted by Dr. David Harper should contribute to answering the first question, but further research is needed to determine whether or not reductions in on-farm erosion have appreciable impacts on downstream sediment loads and what costs this sediment imposes.

The macroeconomics of the "uplands problem" have not yet been systematically explored. The limited success of the model farm program to increase net incomes appears due to the rise of cassava prices in recent years. At least in part, these rising cassava prices have resulted from a national policy seeking alternative

exports to oil. Since cassava is not a terrace dependent crop and the effects of terracing on cassava production are not clear, the model farm program and national export policy may be working at cross purposes. Moreover, rising cassava prices may be encouraging further expansion of cropping on steep upland slopes. This expansion will likely justify more government programs and expenditures to control erosion. These issues merit further investigation.

Finally, the experience gained in the process of conducting this study provides insights into how data collection might be improved. The large data set utilized by this study was invaluable, but as was discovered, it was also inflexible. We recommend that in the future smaller, more directed data sets be collected. That is, well defined hypotheses should be formulated at the outset, data should then be collected to test these hypotheses, and the testing should lead to both conclusions and new hypotheses to be tested, perhaps with new data. Sequential testing and evaluation will shorten the time required to collect and analyze the data, while focusing attention on the most important issues. In addition, the use of carefully controlled experiments, although possibly more expensive than interview surveys, would contribute to the credibility and accuracy of the information. In our opinion, this strategy would contribute greatly to reducing the confusion and differences of opinion which inevitably arise when interpreting less structured surveys.

EXECUTIVE SUMMARY

Proyek Citanduy II dimulai pada tahun 1981 dengan tujuan ganda yaitu untuk meningkatkan pendapatan para petani dan mengurangi erosi. Proyek ini membuka 48 unit lahan pertanian percontohan dan daerah yang akan memperoleh dampaknya dalam kurun waktu lima tahun. Lahan pertanian percontohan tersebut terletak di daerah aliran sungai Citanduy di tepi sebelah timur Jawa Barat.

Proyek ini menyusun suatu program pertanian percontohan termasuk memperkenalkan paket teknologi pertanian di dataran tinggi. Paket pertanian percontohan meliputi pembuatan teras-teras bangku dan penggunaan pola penanaman baru, variasi bibit dan pemakaian pupuk kimia dan insektisida pada lahan dengan kemiringan lereng hingga 50 persen. Lahan dengan kemiringan lereng lebih dari 50 persen mempergunakan paket agro-forestry. Subsidi diberikan untuk pembuatan teras-teras bangku dan pembelian pupuk dan obat pembasmi serangga.

Analisa ini membedakan antara evaluasi teknologi dan evaluasi program. Teknologi dirumuskan sebagai suatu paket yang terdiri dari pembuatan teras-teras bangku serta penggunaan cara penanaman dan campuran pupuk yang baru; sedangkan program dirumuskan sebagai suatu cara untuk mengajak para petani agar menggunakan teknologi pertanian percontohan. Evaluasi mengenai teknologi pertanian percontohan mengharuskan kita menilai manfaatnya dan biayanya; evaluasi program pertanian percontohan mengharuskan kita menentukan sampai sejauh mana program ini dapat menyebar-luaskan teknologi pertanian percontohan.

Ringkasan ini akan mengupas tentang keberhasilan teknologi pertanian percontohan, keberhasilan program pertanian percontohan, kebutuhan akan subsidi, dan kebutuhan riset tambahan.

KEBERHASILAN TEKNOLOGI PERTANIAN PERCONTOHAN

Teknologi pertanian percontohan dimaksudkan untuk menghasilkan keuntungan di dalam maupun di luar proyek. Pada lokasi proyek, seharusnya teknologi dapat meningkatkan penghasilan para petani. Tersedia data untuk menilai keuntungan-keuntungan yang diperoleh dari teknologi pertanian percontohan ditinjau dari penghasilan para petani yang menjadi ukuran nilai netto produksi; termasuk hasil produksi yang dipergunakan untuk usaha tani itu sendiri.

Di luar lokasi, teknologi pertanian percontohan mungkin juga akan menghasilkan keuntungan-keuntungan dengan adanya pengurangan erosi tanah. Endapan dan bahan-bahan pengotor lainnya yang ditimbulkan oleh erosi air terbawa ke sungai, dan dapat menimbulkan kerusakan-kerusakan di dalam dan di sekitar sungai. Kerusakan di

dalam sungai termasuk kerusakan-kerusakan organik air, fasilitas penyimpanan air dan pelayaran. Kerusakan-kerusakan yang timbul di daerah sekitar sungai termasuk bahaya banjir dan kerusakan sistem pengangkutan air. Namun demikian, data yang ada kurang memadai untuk menilai pengaruh-pengaruh yang timbul di luar lokasi.

Pendapatan kotor para petani rata-rata meningkat sejak adanya program pertanian percontohan. Nampak bahwa baik para petani di dalam proyek maupun di luar proyek bersama-sama memperoleh keuntungan-keuntungan, tsb. Nampaknya perubahan tanaman campur merupakan faktor yang paling utama dari meningkatnya penghasilan para petani. Dalam tahun-tahun permulaan proyek, perubahan yang dilakukan mengarah ke produksi beras dan produksi ubi kayu ditinggalkan. Namun baru-baru ini perubahan mengarah ke ubi kayu dan beras ditinggalkan. Usaha merubah tanaman campur didorong oleh turun naiknya harga ubi kayu dan beras.

Keadaan para petani yang menghasilkan ubi kayu saja atau beras saja lebih buruk daripada penghasil kedua-duanya. Dengan harga tahun 1985, penghasilan bersih paling tinggi diperoleh para petani dengan tanaman campur yang sekitar 40% beratnya terdiri dari ubi kayu. Ini kira-kira setengah dari produksi penghasil ubi kayu sebelum tahun 1981. Dengan harga tahun 1987, campuran hasil yang maksimum meningkat menjadi kira-kira 60% ubi kayu.

Pembuatan teras-teras bangku nampaknya memudahkan adanya perubahan dalam usaha tanaman campur ke arah produksi beras. Pada tahap permulaan program pertanian percontohan, setelah harga beras meningkat, dibandingkan dengan harga-harga ubi kayu pendapatan para petani meningkat baik karena naiknya harga-harga maupun karena pembuatan teras-teras bangku yang memungkinkan adanya perubahan kearah produksi beras.

Namun demikian, oleh karena harga ubi kayu mengalami kenaikan pada tahun-tahun belakangan ini, manfaat dari lebih banyak mencampur beras serta keuntungan-keuntungan dari pembuatan teras-teras bangku menjadi berkurang. Pembuatan teras-teras bangku nampaknya lebih bermanfaat bagi produksi beras daripada ubi kayu. Oleh karena berkurangnya pengaruh produksi beras bagi penghasilan para petani dengan turunnya harga beras, keuntungan pendapatan dengan adanya pembuatan teras-teras bangku menjadi merosot.

Pembuatan teras-teras bangku menghasilkan laba penghasilan yang paling besar apabila tanaman campur lebih mengarah ke beras; sebaliknya pembuatan teras-teras bangku menghasilkan laba pendapatan yang terendah apabila tanaman campur lebih mengarah ke ubi kayu. Dalam kurun waktu tahun 1981 sampai 1987, sebagaimana telah diuji dalam studi ini, pengaruh secara keseluruhan dari harga-harga yang bergerak kearah yang menguntungkan bagi produksi ubi kayu telah mengurangi manfaat-manfaat adanya pembuatan teras-teras bangku dan karena itu memberikan keuntungan netto yang minus bagi teknologi.

Untuk memeriksa kembali penjelasan yang diajukan mengenai kurang berhasilnya teknologi pertanian percontohan, kumpulan data dari Unit Studi dan Evaluasi Sosial Ekonomi (USESE) yang dipergunakan untuk analisa ini telah mengalami banyak pemeriksaan statistik. Namun, data tersebut mencakup kurun waktu yang relatip singkat, sehingga hasil-hasil pemeriksaan harus dipergunakan secara hati-hati. Pemeriksaan statistik menunjukkan bahwa kita dapat mengesampingkan "learning process", degradasi tanah, sumber pendapatan, pengalihan subsidi ke sawah-sawah di dataran rendah, dan perbedaan-perbedaan dalam tanah (misalnya, yang berasal dari gunung api lawan pengendapan) sebagai sebab-sebab kurang berhasilnya teknologi pertanian percontohan untuk meningkatkan penghasilan.

Pentingnya teknologi pertanian percontohan dan khususnya pembuatan teras-teras bangku dipandang dari segi peningkatan pendapatan petani, mungkin lebih merupakan perwujudan jangka panjang daripada yang dapat terlihat dengan data jangka pendek yang ada. Perubahan-perubahan harga beras dan ubi kayu yang berputar menyebabkan timbulnya perubahan dalam tanaman campur yang dilakukan oleh para petani. Para petani yang memiliki teras-teras lebih berhasil memanfaatkan perubahan-perubahan harga ini daripada yang tidak, terutama apabila perubahan dilakukan ke arah produksi beras. Oleh karena itu, dalam jangka panjang para petani yang memiliki teras-teras mungkin akan mempunyai penghasilan rata-rata yang lebih tinggi daripada yang tidak. Namun data yang ada sekarang ini kurang memadai untuk menguji kebenaran hipotesa ini.

KEBERHASILAN PROGRAM PERTANIAN PERCONTOHAN

Program pertanian percontohan dimaksudkan untuk memperluas teknologi pertanian percontohan tersebut ke luar. Lahan pertanian percontohan itu sendiri dimaksudkan sebagai suatu alat untuk membuktikan manfaat teknologi pertanian percontohan. Setelah pertanian percontohan dibentuk, adanya lahan pertanian percontohan yang nyata dan usaha-usaha para petugas penyuluhan diharapkan dapat meyakinkan para petani lainnya agar mereka berminat untuk menggunakan teknologi tersebut. Pertama-tama, para petani dibujuk dengan pemberian subsidi untuk dapat meniru para petani percontohan. Inilah yang disebut dampak subsidi (DS) atau para petani daerah perluasan yang memperoleh subsidi. Kemudian, keuntungan tambahan yang diperoleh dari penggunaan teknologi ini dipertunjukkan kepada para petani lainnya yang diharapkan akan memanfaatkan teknologi baru ini dengan mempergunakan sumber penghasilan mereka sendiri. Inilah yang disebut luar proyek (LP) atau kelompok di luar proyek yang tidak memperoleh subsidi.

Pembuatan teras-teras bangku, yang merupakan bagian penting dari teknologi pertanian percontohan, meluas dengan cepat dalam tahun 1981-1985. Hal ini menunjukkan keberhasilan program tersebut. Selain pembuatan teras-teras bangku pada proyek-proyek

pertanian percontohan yang hampir menyeluruh, pembuatan teras pada lahan pertanian sekitarnya yang ada di luar proyek pun hanya ketinggalan sedikit dengan yang ada dalam proyek.

Para petugas penyuluhan merupakan sumber informasi yang utama mengenai program pembuatan teras-teras bangku. Hal ini tidak hanya untuk para petani di dalam proyek tetapi juga untuk petani di luar proyek. Usaha penyuluhan program pertanian percontohan untuk menyebar-luaskan teknologi ini nampaknya berhasil.

Namun demikian, perlu tidaknya tanah pertanian percontohan dalam jumlah banyak untuk menyebar-luaskan teknologi tsb. memang tidak jelas. Para petugas penyuluhan nampaknya yang menjadi perantara untuk dapat menimbulkan semangat untuk mengadakan perubahan, dan bukannya tanah pertanian percontohan yang sudah jelas terlihat. Di samping itu, kondisi yang lebih baik dari lokasi pertanian percontohan sejak tahun 1981 mungkin disebabkan oleh usaha para petugas penyuluhan yang menyebar-luaskan teknologi tersebut sebelum lahan pertanian percontohan dibuka.

SUBSIDI

Dalam situasi tertentu, pembuatan teras-teras bangku nampaknya harus diusahakan sendiri. Para petani di luar proyek yang tidak memperoleh subsidi membuat teras-teras bangku dengan mempergunakan modal mereka sendiri, dan penghasilan bersih mereka bertambah. Kenyataan bahwa penghasilan bersih para petani percontohan menurun, mungkin disebabkan karena adanya batasan-batasan dalam hal masukan (input) dan keluaran (output) yang dibebankan pada mereka dalam program pertanian percontohan. Bagaimanapun juga, apabila usaha campuran ini penting sebagai alat untuk memperkenalkan pertanian percontohan, maka subsidi diperlukan oleh para petani tersebut. Namun demikian, ditinjau dari segi ekonomis, para petani lain tidak berhak atas subsidi untuk pembuatan teras-teras dan subsidi untuk pembelian pupuk dan obat pembasmi serangga.

Mungkin ada maksud-maksud lain dari pemberian subsidi. Misalnya, diharapkan agar subsidi dipergunakan untuk membantu para petugas penyuluhan. Jika demikian halnya, mungkin dapat dibenarkan untuk memberikan subsidi ke luar dari pertanian percontohan. Namun jika dipandang dari segi ekonomis pertanian di dalam proyek, pemberian subsidi ini nampaknya tidak dapat dibenarkan. Kredit mungkin lebih dibutuhkan, namun data yang ada kurang memadai untuk memperkirakan kebutuhan ini.

KEBUTUHAN RISET

Beberapa pertanyaan telah diajukan dalam analisa ini. Untuk menyusun analisa mengenai program pertanian percontohan dan menumbuhkan kepercayaan akan hasil-hasil yang dilaporkan di sini, pertanyaan-pertanyaan berikut ini perlu dijawab.

Tanaman campur yang mudah diubah-ubah sebagai reaksi terhadap adanya perubahan harga merupakan faktor utama yang sangat menentukan penghasilan para petani. Pembuatan teras-teras bangku nampaknya dapat mempertinggi kemudahan ini, setidak-tidaknya untuk beberapa hasil panen seperti beras. Peranan pembuatan teras-teras dalam produksi ubi kayu tidak begitu jelas. Di samping itu, bagaimana pembuatan teras-teras mempengaruhi daya tahan penanaman pada lereng yang curam tidak diterangkan secara jelas. Riset diperlukan untuk menilai hubungan antara pembuatan teras-teras dan perubahan pola penanaman serta daya tahan jenis pertanian ini untuk beberapa waktu lamanya.

Erosi yang disebabkan karena adanya usaha pertanian di dataran tinggi diperkirakan akan menimbulkan dampak negatip pada daerah hilir. Program pertanian percontohan mungkin dapat mengurangi kerugian-kerugian yang timbul di daerah hilir, namun untuk dapat menilai seberapa besar manfaat yang dapat diperoleh, harus diketahui dulu seberapa besar erosi tanah pertanian dapat dikurangi oleh program pertanian percontohan dan seberapa besar erosi tanah pertanian menimbulkan masalah pengendapan di daerah hilir. Juga perlu diketahui seberapa besar masalah pengendapan daerah hilir dan berapa besar biayanya. Studi yang diadakan oleh Dr. David Harper semestinya dapat menjawab pertanyaan pertama, namun riset lebih lanjut perlu diadakan untuk memastikan apakah pengurangan erosi tanah pertanian mempunyai dampak yang cukup besar pada endapan daerah hilir yang sudah bertimbun dan berapa biaya yang harus dikeluarkan karena adanya pengendapan ini.

Makro-ekonomi dari "masalah dataran tinggi" belum diselidiki secara sistematis. Terbatasnya keberhasilan program pertanian percontohan untuk meningkatkan penghasilan bersih nampaknya disebabkan karena adanya kenaikan harga ubi kayu dalam tahun-tahun belakangan ini. Setidak-tidaknya kenaikan harga ubi kayu ini sebagian merupakan akibat dari adanya kebijaksanaan nasional untuk mencari bahan ekspor non-migas. Oleh karena ubi kayu bukanlah hasil panen yang tergantung pada adanya teras-teras dan pengaruh pembuatan teras dalam penanaman ubi kayu tidak begitu jelas, maka program pertanian percontohan dan kebijaksanaan ekspor nasional masing-masing mungkin akan berjalan dengan maksud yang berlawanan. Selain itu, harga ubi kayu yang meningkat dapat memberi dorongan untuk lebih memperluas penanaman pada lereng di dataran tinggi yang curam. Perluasan tersebut mungkin akan memperkuat alasan untuk adanya program pemerintah dan pengeluaran biaya yang lebih besar guna mengendalikan bahaya erosi. Masalah-masalah ini patut diselidiki lebih lanjut.

Akhirnya, pengalaman yang diperoleh dari studi ini memberikan pengetahuan yang lebih dalam mengenai bagaimana pengumpulan data dapat dilakukan dengan lebih baik. Sebagian besar data yang dipergunakan dalam studi ini sangat bermanfaat, namun sebagaimana

telah diketahui, data tersebut kurang fleksibel. Kami sarankan bahwa untuk di masa mendatang dikumpulkan data yang lebih sederhana atau ringkas namun lebih terarah dan tepat. Hipotesa yang tepat harus sudah dirumuskan pada permulaan, lalu data dikumpulkan untuk menguji hipotesa-hipotesa tersebut, dan pengujian harus dilanjutkan dengan kesimpulan-kesimpulan serta hipotesa baru untuk diuji, mungkin juga dengan mempergunakan data yang baru. Pengujian dan evaluasi yang bertahap akan mempersingkat waktu yang diperlukan untuk mengumpulkan dan menganalisa data, dan sementara itu perhatian dapat dipusatkan pada persoalan-persoalan yang paling penting saja. Disamping itu, meskipun biayanya akan lebih tinggi daripada survei dengan tanya jawab, percobaan-percobaan yang diatur secara teliti akan menghasilkan informasi yang lebih dapat dipercaya dan tepat. Menurut pendapat kami, strategi ini akan dapat mengurangi kebingungan serta timbulnya perbedaan pendapat yang tak dapat dihindarkan dalam menginterpretasikan penelitian-penelitian yang kurang teratur.

1. INTRODUCTION

Indonesia has the fifth largest population in the world, with a 1984 population of nearly 160 million.[1] Approximately two-thirds or 107 million of this population live on the island of Java. Java has a land area of 136,000 square kilometers, which is about the size of the state of New York.[2] The average population density on Java is approximately 787 people per square kilometer. While efforts are being made to slow the population growth rate, the Indonesian population is predicted to grow to 361 million before stabilizing in the year 2010.[3] If current population growth and migration rates continue, the population of Java may exceed 240 million, or more than 1,760 people per square kilometer, within the next 23 years.

Java is a mountainous island with limited level land for cultivation. As Java's population continues to grow, farmers are being forced to clear and cultivate increasingly steep slopes. Satellite pictures indicate that all but 12 percent of the island's tree cover has been cleared.[4] Forests have been replaced by crop cultivation, often by subsistence farmers who, it is feared by many, have neither the means nor the motivation to invest in measures to conserve the soil. As a consequence, soil erosion may be accelerating.

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[1] The World Bank. 1986. World Development Report 1986. Washington, D.C.: International Bank for Reconstruction and Development/The World Bank.

[2] Eckholm, Erik P. 1976. Losing Ground. New York: W. W. Norton & Company, Inc.

[3] The World Bank. op. cit.

[4] Eckholm. op. cit.

Thirteen watersheds on Java are considered to have critical erosion problems. Critical lands outside of forests on Java have an area of approximately 568,506 hectares. While no systematic monitoring of erosion rates has been conducted, it is estimated that soil erosion rates range from 10 to 40 tons/hectare/year. Moreover, these rates seem to be increasing.[5]

Upland soil erosion may pose a serious threat to the continued productivity of steep sloped upland regions as topsoil and nutrients are washed away. Moreover, upland erosion may cause a number of off-site damages: (1) It may cause siltation of downstream irrigation systems, thus reducing the productivity of the lowlands; (2) it may contribute to the filling of riverbeds, which exacerbates the potential for flooding; (3) it may contribute to the sedimentation of reservoirs, hence reducing their useful life; and (4) it may contribute to the silting of estuaries, which reduces the production of fisheries, and causes the clogging of navigation channels in rivers and ports. It is argued by some that the ability of Java's land to support its population is being threatened by the present form of upland farming.[6]

In response to these potential problems, the Indonesian government, with support from USAID, formally began an uplands conservation program in 1976. This paper evaluates one component of this conservation program, the model farm program of the Citanduy II Project.

[5] Tarrant, James, et al. 1987. Natural Resources and Environmental Management in Indonesia, Annex 3: Natural Resources and Environmental Issues. Jakarta, Indonesia: U.S. Agency for International Development. October.

[6] Eckholm. op. cit.

2. BACKGROUND

The Citanduy II Project was started in 1981 with the multiple goals of reducing erosion and increasing farmer incomes and employment. The project established 48 model farm units and impact areas over a five-year period. The model farms are located in the Citanduy watershed at the eastern edge of West Java.

2.1 NATURE OF THE PROGRAM

The project established a model farm program that consists of introducing a package of upland agricultural technologies. The model farm package includes constructing bench terraces and using new cropping patterns, seed varieties and inputs of chemical fertilizers and insecticides on land with slopes up to 50 percent. Land with slopes of more than 50 percent get an agro-forestry package. Subsidies are provided for the construction of bench terraces and the purchase of inputs.

Initially, a model farm is established. Since farmland is typically fragmented into a number of relatively small parcels of less than one hectare each and because an area of approximately 10 hectares is needed to make bench terracing feasible, the selection of the model farm site depends upon the cooperation of a number of farmers on 10 hectares of contiguous land. Moreover, implementors of the project supposedly seek sites with the worst erosion conditions in order to provide the most dramatic demonstration of the benefits of the program and, presumably, produce the greatest soil conservation benefits.

After the model farm is established, extension agents try to persuade groups of nearby farmers, in what is called the impact or expansion areas, to adopt the model farm package. Extension agents induce farmers to adopt the model farm package by providing them with terracing and input subsidies for one year.

The purpose of this study is to assess the economic efficiency of the model farm program under the Citanduy II Project and to determine the need for and the level of subsidization required for the success of the program.

2.2 NATURE OF THE SUBSIDIES

The model farm program contains two types of subsidies: subsidies for terracing (i.e., capital subsidies) and subsidies for inputs such as improved seeds, fertilizer and pesticides (i.e., program input subsidies). These two types of subsidies are fundamentally different.

The capital subsidy is expected to produce a stream of additional income over the life of the terrace. That is, terracing results in internal benefits to the farmer in the form of increased production and income. If the present value of this stream of additional future income to the farmer is greater than the costs of terracing (including the cost of obtaining any necessary credit), then the farmer would be expected to undertake the terracing on his own. On the other hand, if the present value of this additional income is less than the terracing costs, then a capital subsidy is needed to induce the farmer to terrace.

From a societal standpoint, capital subsidies are justified up to the value of the social benefits they produce. In addition to the internal benefits of increased farmer incomes, subsidies for terracing may result in external or off-site benefits which include reduced soil erosion and siltation of downstream irrigation systems, floodways and fisheries. Also, to the extent that the components of the program spread to farmers outside the project and enhance their production and income, further external benefits are produced. Subsidies are socially justified up to the present value of the external benefits they produce.

The program's input subsidies are different from capital subsidies. Like a capital subsidy, an input subsidy is needed if the return to the farmer is less than the cost of the input; otherwise, the farmer will purchase the input on his own. Unlike terracing, however, returns from inputs are realized primarily on-site.

With free choice, the farmer can be expected to purchase inputs up to the level where the marginal value of the inputs, in terms of the value of additional output they produce, is equal to the additional cost of the inputs. Subsidized inputs will simply be used to substitute for inputs the farmer would have otherwise purchased on his own.

However, if participation in the model farm program restricts the farmer's choices of inputs, then an input subsidy may be necessary. A justification for such restrictions, accompanied by the necessary subsidies, may be made in terms of the demonstration function of farms in the model farm and, perhaps, in the expansion area. Further, administration of the subsidies by extension agents may provide these agents with additional income, thus providing them with an incentive to promote the model farm program aggressively.

Neither the capital nor the input subsidies of the model farm program should be confused with structural price subsidies administered at the national level. The prices of fertilizers and pesticides are both subsidized by the Indonesian government. Fertilizer prices are subsidized about 38 percent of the farmgate price and pesticides are subsidized more than 40 percent of the farmgate price.[7] The model farm subsidies are provided in-kind. Our evaluation is restricted to the model farm subsidies, but it should be recognized that price subsidies exist in addition to these grants in-kind.

[7] Tarrant, James, et al. 1987. Natural Resources and Environmental Management in Indonesia: An Overview. Jakarta, Indonesia: U.S. Agency for International Development. October.

3. DATA COLLECTION AND MANAGEMENT

3.1 DATA SETS

The analysis is based upon three interdependent data sets: data collected by the Unit Studi Dan Evaluasi Sosial Ekonomi (USESE), a subset of the initial USESE data that was prepared by Mr. Tampubolon at USESE, and data collected by us in conjunction with USESE's and Dr. David Harper's study of erosion rates on the model farms. Phase 1 of our research and analysis, conducted during July and August, 1987, was based upon the initial USESE data set.[8] Phase 2 of our study, conducted during January, 1988, was based largely upon the revised data set prepared by Mr. Tampubolon.[9] This third and final phase of the study incorporates data available from the USESE/Harper study along with the previous data.

3.1.1 Phase 1: USESE Data Set

The USESE conducted a survey in 1985 of farmers in villages containing model farms. The USESE survey selected 24 villages from the 48 villages in the Citanduy watershed having model farms. Three groups of 10 farmers each were selected within each village; the

[8] Cochrane, Harold C. and Huszar, Paul C. 1987. Economic Analysis of the Model Farm Program and Its Subsidization under the Citanduy II Project: Phase 1 Report. Report to U.S. Agency for International Development, Jakarta, Indonesia and Unit Studi Dan Evaluasi Sosial Ekonomi, Ciamis, Indonesia. August 20.

[9] Cochrane, Harold C. and Huszar, Paul C. 1988. Economic Analysis of the Model Farm Program and Its Subsidization under the Citanduy II Project: Phase 2 Report. Report to U.S. Agency for International Development, Jakarta, Indonesia and Unit Studi Dan Evaluasi Sosial Ekonomi, Ciamis, Indonesia. January 20.

three groups are: (1) model farm farmers (MF), (2) expansion area farmers (i.e., farmers who adopted the model farm package) consisting of subsidized (DS) and unsubsidized (DSW) farmers, and (3) farmers/within the village that were not part of the model farm program (LP). The selection process is reported to have been random.

Surveys were completed for 630 farmers. The data set contains information concerning each farmer's input and output levels, and subsidies received for the time periods "before" and "after" the model farm. The "before" period is the year preceding implementation of the model farm (e.g., if the model farm was implemented in 1981, then the "before" period is 1980; if it was implemented in 1982, then "before" is 1981; and so on). The "after" period is 1985 (i.e., the year of the survey) for all cases.

The data set received by us in July, 1987 contained observations with incomplete data and coding errors. With the help of our assistants at USESE, we were able to find 235 observations with complete and consistent information. The reduced data set consists of 83 model farmers (MF), 58 expansion area farmers receiving subsidies (DS), 22 expansion area farmers not receiving subsidies (DSW), and 72 outside project farmers (LP). Moreover, the reduced data set contains 60 observations for model farms implemented in 1981, 63 observations for 1982, 88 for 1983, and 24 for 1984. This data set was utilized for our phase 1 analyses.

3.1.2 Phase 2: USESE Revised Data Set

The initial USESE data set was revised by Mr. Tampubolon and received by us in late August, 1987. Mr. Tampubolon used the original, completed questionnaires to check the USESE data set and correct obvious errors. His data set contains 542 before and after observations. Even after additional screens, which are explained below, the Tampubolon data set contains a total of 438 observations, with 139 model farmers (MF), 78 expansion area farmers receiving

subsidies (DS), 16 expansion area farmers not receiving subsidies (DSW), and 205 outside project farmers (LP).

Due to the small number of DSW farmers, this group is not included in the analysis. Moreover, the DSW group is likely unimportant, because they are simply farmers who were promised subsidies if they adopted the model farm technology, but after adopting the technology, available subsidies were insufficient to subsidize them.

The Tampubolon data set contains 62 observations for areas where model farms were implemented in 1980, 85 observations for 1981 model farm areas, 86 for 1982, 112 for 1983, and 93 for 1984. This data set was used for the phase 2 analysis and provides the basis for most of the final results.

3.1.3 Phase 3: Updated Input-Output and Soils Data

Additional data were collected during January, 1988 for two primary purposes: (1) to corroborate the findings and trends derived from the Tampubolon data set and (2) to correlate input-output data with soils and erosion data being collected and analyzed by Dr. Harper. The new survey data provide information on the levels of inputs and outputs in 1986 and 1987, the costs of terracing and the means for meeting those costs, field characteristics, soil types and soil erosion rates.

The new survey is confined to three villages: Andropraja and Mekarsari with volcanic soils and Margajaya with sedimentary soils. A total sample of 180 farm plots with 60 in each village were selected. Within each village, the sample contains 20 model farm plots (MF), 20 expansion area plots which had received subsidies (DS) and 20 plots outside the project which did not receive subsidies (LP).

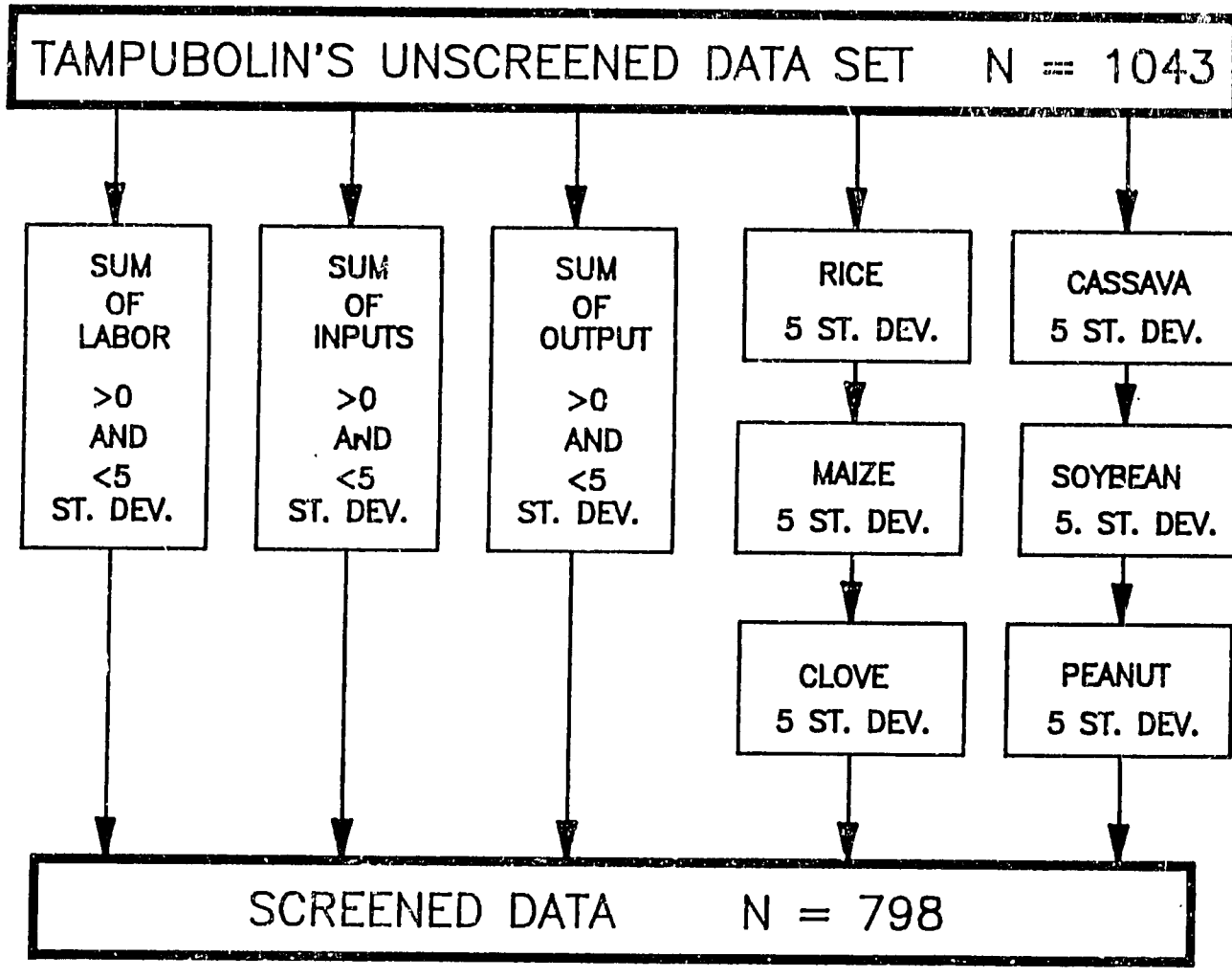
Analyses of the additional input-output data are included in this final report. Erosion data are being computed separately by Dr. Harper under a separate contract. The tabulation of terracing cost and soil type data has been delayed and was not available for this report.

3.2 SCREENING DATA SETS

The data were screened according to the procedure displayed in Figure 3.1 to exclude observations containing zero entries and "unusually" high levels of inputs, labor and outputs. Observations were eliminated if: 1) all labor (on and off farm--mandays/Ha) summed to zero or exceeded the mean by more than five standard deviations; 2) all inputs (seeds, fertilizer, pesticides-- Rp/Ha) summed to zero or exceeded the mean by more than five standard deviations; 3) the value of each crop (Rp/Ha) exceeded the mean by more than five standard deviations; and 4) no output was reported. As a result of applying this screen, the number of observations was reduced from 1043 to 798.

The five standard deviation upper bound was selected after experimentation. Figures 3.2 and 3.3 show how changes in the cutoff affect the number of observations clearing the screen and the resultant impact on output value. Note that only 4.7 percent of the observations were excluded when the number of standard deviations was reduced from 10,000 (no upper bound) to 5. Yet this same 4.7 percent of the sample was responsible for increasing output value by 24.7 percent. In all likelihood such a large impact is due to coding and reporting errors, and therefore the five standard deviation limit was adopted. Figure 3.4 illustrates how stringent this limit is when viewed from the standpoint of rice yields (mean of 70 Rp/Ha and standard deviation of 144 Rp/Ha).

FIGURE 3.1. SCREENING PROCEDURE



NOTE: ST. DEV. IS STANDARD DEVIATIONS
N IS NUMBER OF OBSERVATIONS

FIGURE 3.2. IMPACT OF SCREENING ON NUMBER OF OBSERVATIONS

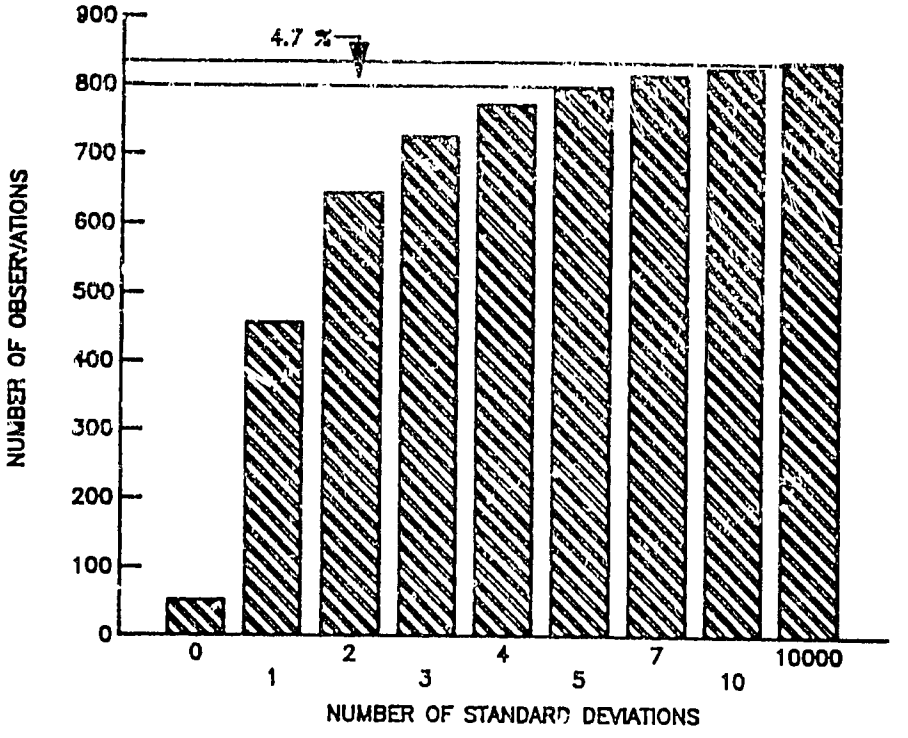


FIGURE 3.3. IMPACT OF SCREENING ON VALUE OF OUTPUT

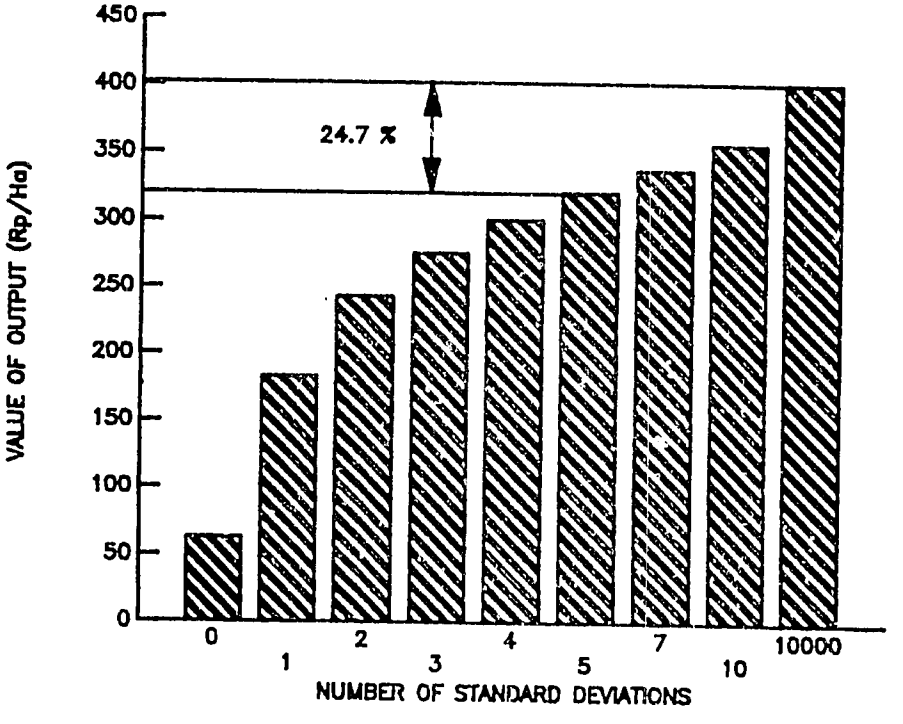
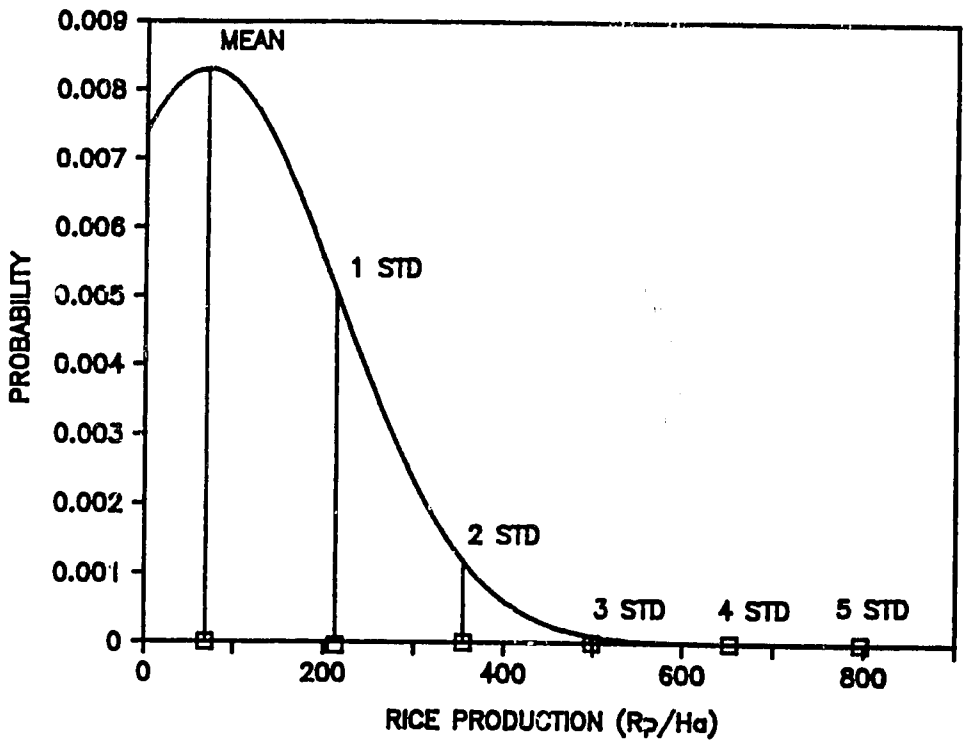


FIGURE 3.4. PROBABILITY DENSITY FUNCTION RICE PRODUCTION (Rp/Ha)



4. SUMMARY PERFORMANCE STATISTICS

The purpose of this section is to describe the performance of the model farms (MF), the expansion area farms receiving subsidies (DS) and the outside project or unsubsidized farms (LP). Changes in farm incomes, input usage and the value of outputs before and after the model farm program are examined for each of these farm groups. Moreover, changes in the performance of these farm groups are examined in terms of the year the model farm program is started in an area. Finally, the level and distribution of subsidies is examined.

4.1 FARM INCOMES

Table 4.1 shows the average gross incomes, total costs, net incomes and returns to labor, computed in terms of 1985 prices, for model farm areas established during the period from 1981 to 1984. As can be seen, the gross income earned by the model farmers increased 17 percent. But while gross incomes increased, costs increase more. Total costs for the model farms increased 70 percent,

Table 4.1. Incomes & Costs By Farm Type For All Model Farm Areas

Farm Type		Gross Income	Total Cost	Net Income	Returns to Labor
		(1985 Rp1000/HA)			
MF	Before	518.45	352.19	166.25	207.88
	After	607.79	597.15	10.64	114.16
DS	Before	524.97	314.45	210.52	248.64
	After	752.94	489.23	263.71	368.80
LP	Before	406.00	335.49	70.51	123.15
	After	492.35	389.96	136.15	208.47

when labor costs are included. The result is that net income declined by 94 percent. If labor costs are netted out, then returns to labor declined by 45 percent.

On the other hand, the net incomes of expansion area farmers who received subsidies (DS) increased. Their gross incomes increased an average of 43 percent and, while their total costs increased 55 percent, their net income increased 25 percent. Furthermore, returns to DS farm labor increased 48 percent.

However, in both relative and absolute terms, the farmers not receiving subsidies (LP) did the best. Their gross incomes increased an average of 21 percent, but their costs only increased 16 percent, so that their net incomes rose 94 percent and returns to labor increased 69 percent.

The "before" and "after" net incomes for all model farm areas are summarized in Figure 4.1 Net incomes of model farms declined by Rp 155,610/ha, net incomes of expansion area farms receiving subsidies increased by Rp 53,190/ha, and net incomes of farms not in the model farm program increased by Rp 65,640/ha.

Considering the net incomes of the model farms in terms of the year when the model farm was started indicates that more recent model farms have progressively done worse, as shown in Figure 4.2 and Table 4.2. That is, model farms built in 1981 had a net income increase of Rp 148,500/ha, but 1982 farm incomes declined by Rp 216,100/ha, 1983 incomes declined by Rp 235,800/ha and 1984 incomes declined by Rp 291,400/ha.

This pattern of decline also holds for the subsidized expansion area farms, as shown in Figure 4.2. Net incomes increased by Rp 268,500/ha for subsidized expansion farms located in 1981 model

FIGURE 4.1. AVERAGE NET INCOME

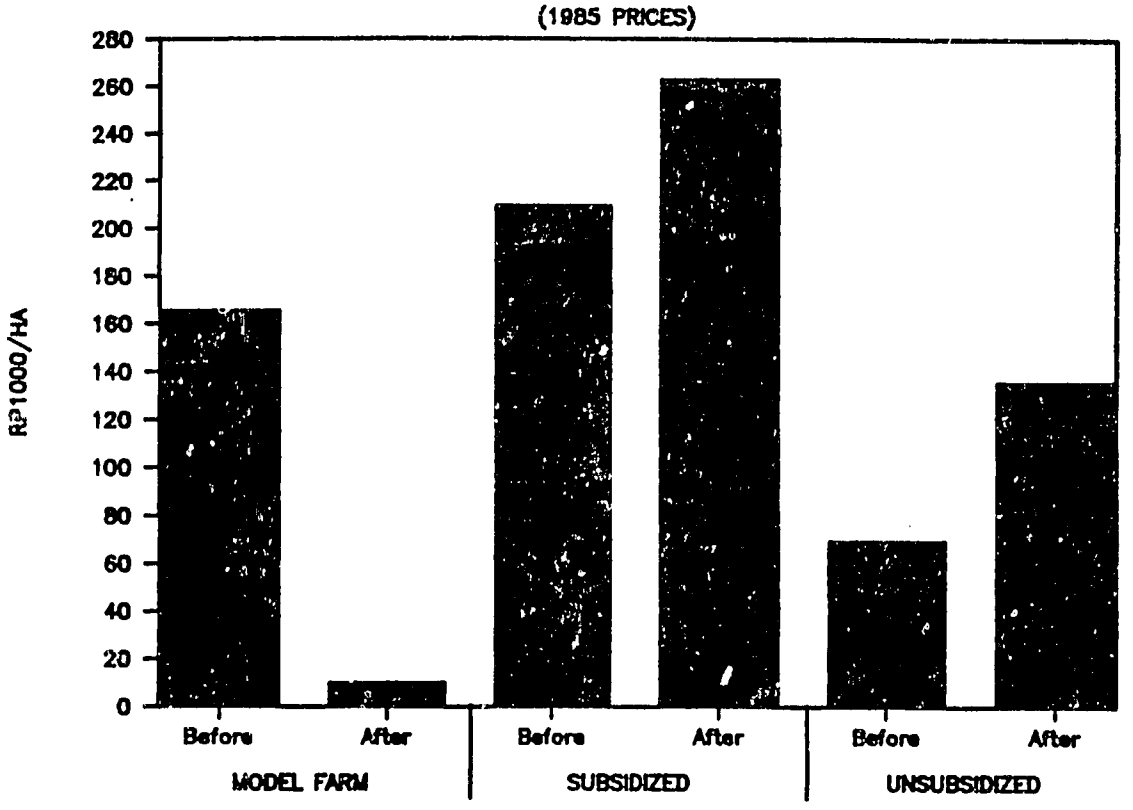
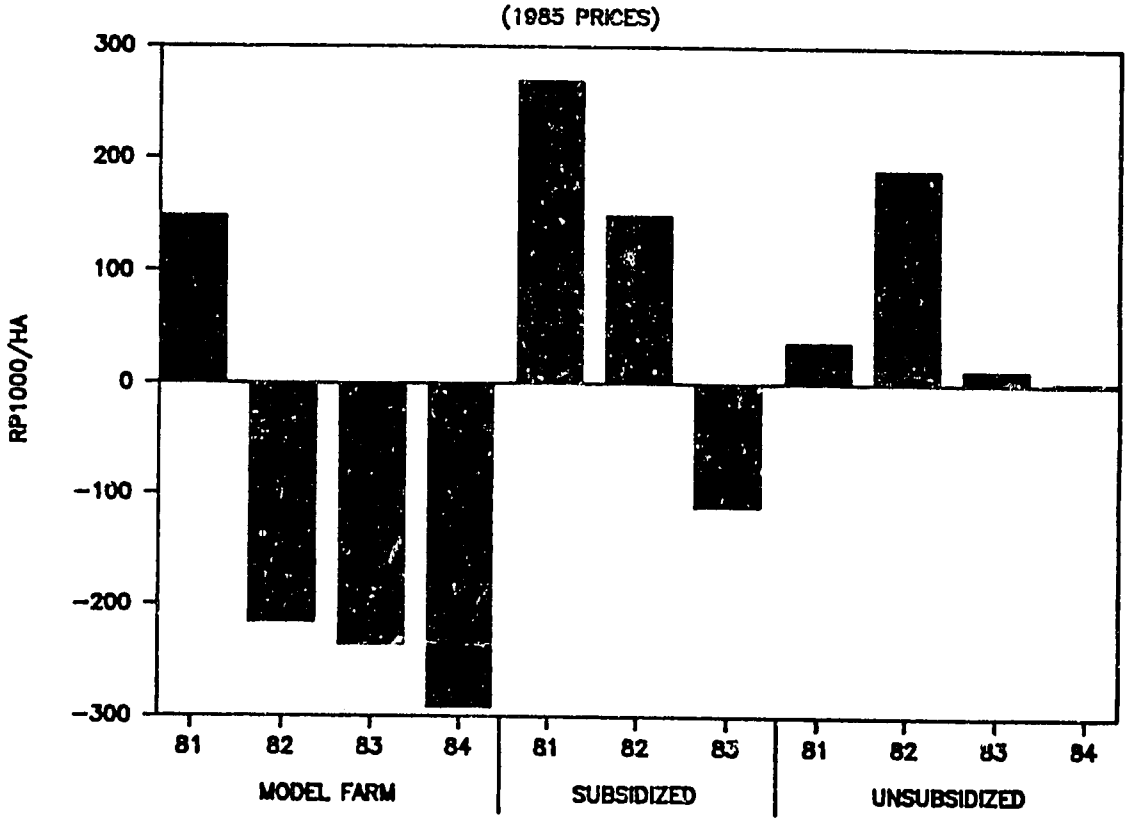


Table 4.2. Net Income By Model Farm Year

Farm Type	MF Year	Net Income Before	Net Income After	Change In Net Income
		(Rp1000/Ha)		
MF	81	(25.8)	122.7	148.5
	82	164.2	(51.9)	(216.1)
	83	323.9	88.1	(235.8)
	84	207.2	(84.2)	(291.4)
DS	81	37.7	306.2	268.5
	82	310.3	459.6	149.2
	83	263.3	151.9	(111.4)
LP	81	125.0	162.4	37.5
	82	4.7	194.8	190.1
	83	78.8	91.3	12.5
	84	94.3	95.6	1.3

farm areas and Rp 149,200/ha for 1982 sites, but declined by Rp 111,400/ha for 1983 sites. Data are not sufficient to assess what happened to expansion farm incomes in 1984 model farm areas.

FIGURE 4.2. CHANGE IN NET INCOME BY MODEL FARM YEAR



The unsubsidized LP farms have positive increases in net incomes for all model farm years, but again there tends to be a decline in more recent years. Figure 4.2 shows that the 1981 LP farmers increased their net incomes by Rp 37,500/ha, 1982 LP farmers by Rp 190,100/ha, 1983 farmers by Rp 12,500/ha and 1984 farmers by Rp 1,300/ha.

4.2 FARM INPUTS

Table 4.3 shows how inputs have increased for the three farmer groups. Model farmers increased the use of on-farm labor by 112 mandays/ha (54 percent), off-farm labor by 71 mandays/ha (68 percent), seeds by Rp 21,550/ha (64 percent), fertilizer by Rp 34,290/ha (455 percent), and pesticides by Rp 6,050/ha (976 percent).

The expansion area farmers receiving subsidies (DS) also increased their use of inputs, though less so than the model farms. They increased their use of on-farm labor by 61 mandays/ha (33 percent), off-farm labor by 47 mandays/ha (52 percent), seeds by Rp 32,460/ha (116 percent), fertilizer by 28,150/ha (337 percent), and pesticides by Rp 6,380/ha (382 percent).

Table 4.3. Inputs By Farm Type For All Model Farm Areas

Farm Type		Land	Labor On-Farm	Labor Off-Farm	Seed	Fertilizer	Pesticide
		(Ha)	(Mandays/Ha)			(Rp1000/Ha)	
MF	Before	0.27	206.39	104.18	33.47	7.54	0.62
	After	0.27	318.65	174.98	55.02	41.83	6.67
DS	Before	0.37	186.29	90.05	28.08	8.36	1.67
	After	0.38	247.10	137.04	60.54	36.51	8.05
LP	Before	0.38	185.37	97.48	41.09	10.08	1.47
	After	0.34	201.91	124.38	46.28	13.86	3.53

Only small increases in inputs are observable for the farmers not receiving subsidies (LP). They increased their use of on-farm labor by only 17 mandays/ha (9 percent), off-farm labor by 27 mandays/ha (28 percent), seeds by Rp 5,190/ha (13 percent), fertilizer by Rp 3,760/ha (38 percent) and pesticides by Rp 2,060/ha (140 percent). The increases are small and, likely, statistically insignificant.

Figure 4.3 summarizes the changes in input use. Labor inputs are valued at Rp 1,000/manday. Average total input use by model farms increased by Rp 244,960/ha (70 percent), expansion area farms receiving subsidies increased by Rp 174,780/ha (56 percent), and farmers not receiving subsidies increased Rp 54,470/ha (16 percent).

Whereas the pattern of net incomes declined over time with newer model farm areas, input costs increased. Figure 4.4 and Table 4.4 show the input costs for each of the three farm groups for different model farm years. Input costs for model farms increased 37 percent for 1981 model farms, 53 percent for 1982 model farms, 58 percent for 1983 model farms, and 106 percent for 1984 model farms.

Input use by subsidized expansion area farmers increased proportionately less. Figure 4.4 shows that subsidized farmers increased input usage by 28 percent in 1981 model farm areas, 39

FIGURE 4.3. AVERAGE TOTAL INPUT USE

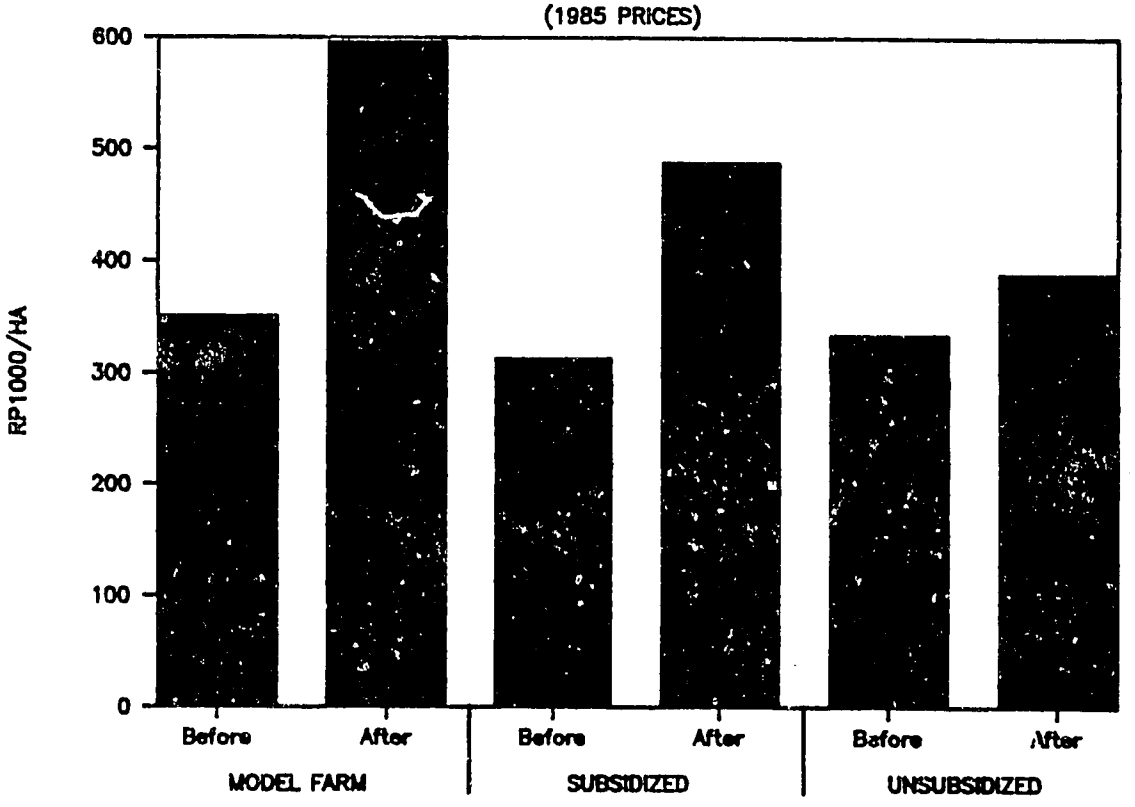
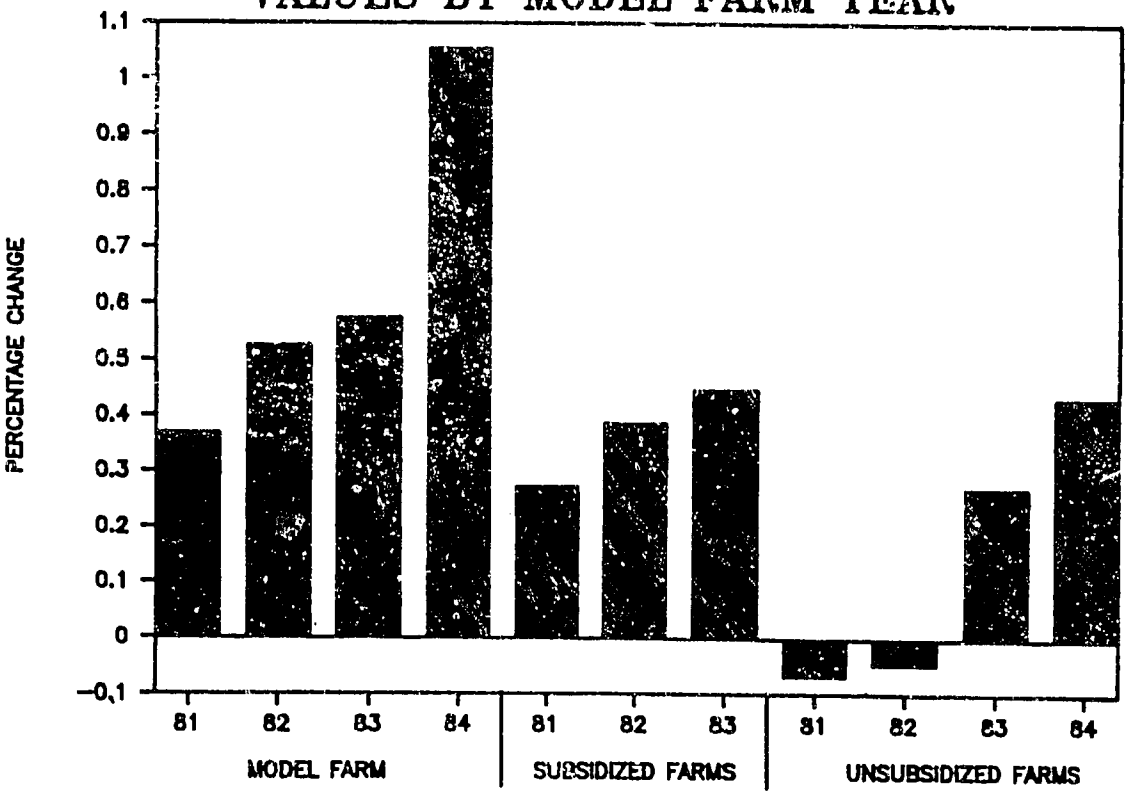


Table 4 .4. Value Of Inputs & Outputs By Model Farm Year

Farm Type	MF Year	Value of Inputs Before (Rp1000/Ha)	After	% Change	Value of Output Before (Rp1000/Ha)	After	% Change
MF	81	357.65	490.68	37%	331.85	613.39	85%
	82	432.63	662.20	53%	596.84	610.31	2%
	83	406.88	642.51	58%	730.82	730.63	-0%
	84	291.47	599.51	106%	498.65	515.34	3%
DS	81	297.74	380.21	28%	335.41	686.37	105%
	82	263.15	365.73	39%	573.48	825.30	44%
	83	411.26	596.54	45%	674.61	748.45	11%
LP	81	326.29	303.41	-7%	451.28	465.85	3%
	82	389.69	370.68	-5%	394.41	565.52	43%
	83	370.45	471.85	27%	449.24	563.14	25%
	84	281.11	403.29	43%	375.45	498.93	33%

FIGURE 4.4. PERCENTAGE CHANGE IN INPUT VALUES BY MODEL FARM YEAR



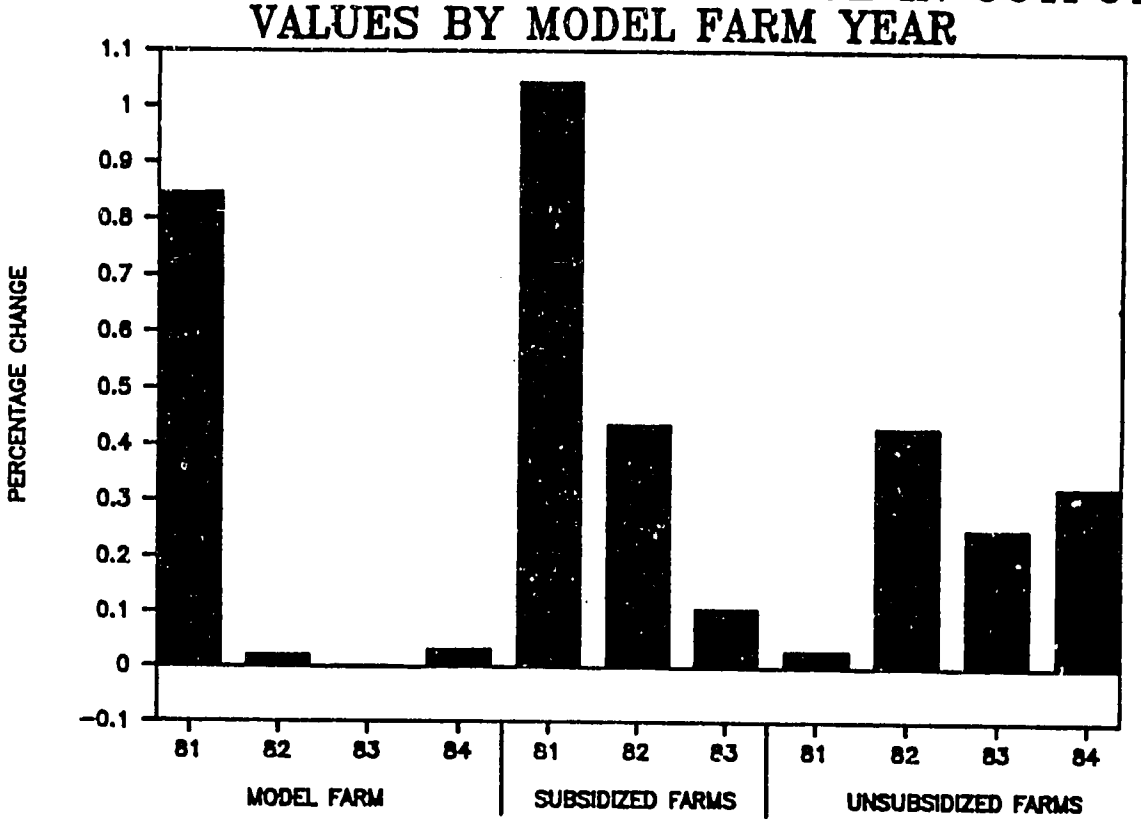
percent in 1982 model farm areas, and 45 percent in 1983 model farm areas.

Unsubsidized farmers tended to increase inputs by smaller amounts. Input costs for unsubsidized farms declined by 7 percent in 1981 model farm areas and by 5 percent in 1982 model farm areas. Input costs increased by 27 percent in 1983 model farm areas and by 43 percent in 1984 model farm areas, as shown in Figure 4.4.

4.3 FARM OUTPUTS

On the output side, growth in the value of outputs declined for both the model farms and the subsidized expansion area farms over time, but remained relatively constant for the unsubsidized farms. Figure 4.5 and Table 4.4 show the percentage changes in the value of

FIGURE 4.5. PERCENTAGE CHANGE IN OUTPUT VALUES BY MODEL FARM YEAR



outputs for each of the farm groups over time. Model farm output values increased 85 percent in 1981 model farm areas, 2 percent in 1982 model farm areas, 0 percent in 1983 model farm areas and 3 percent in 1984 model farm areas.

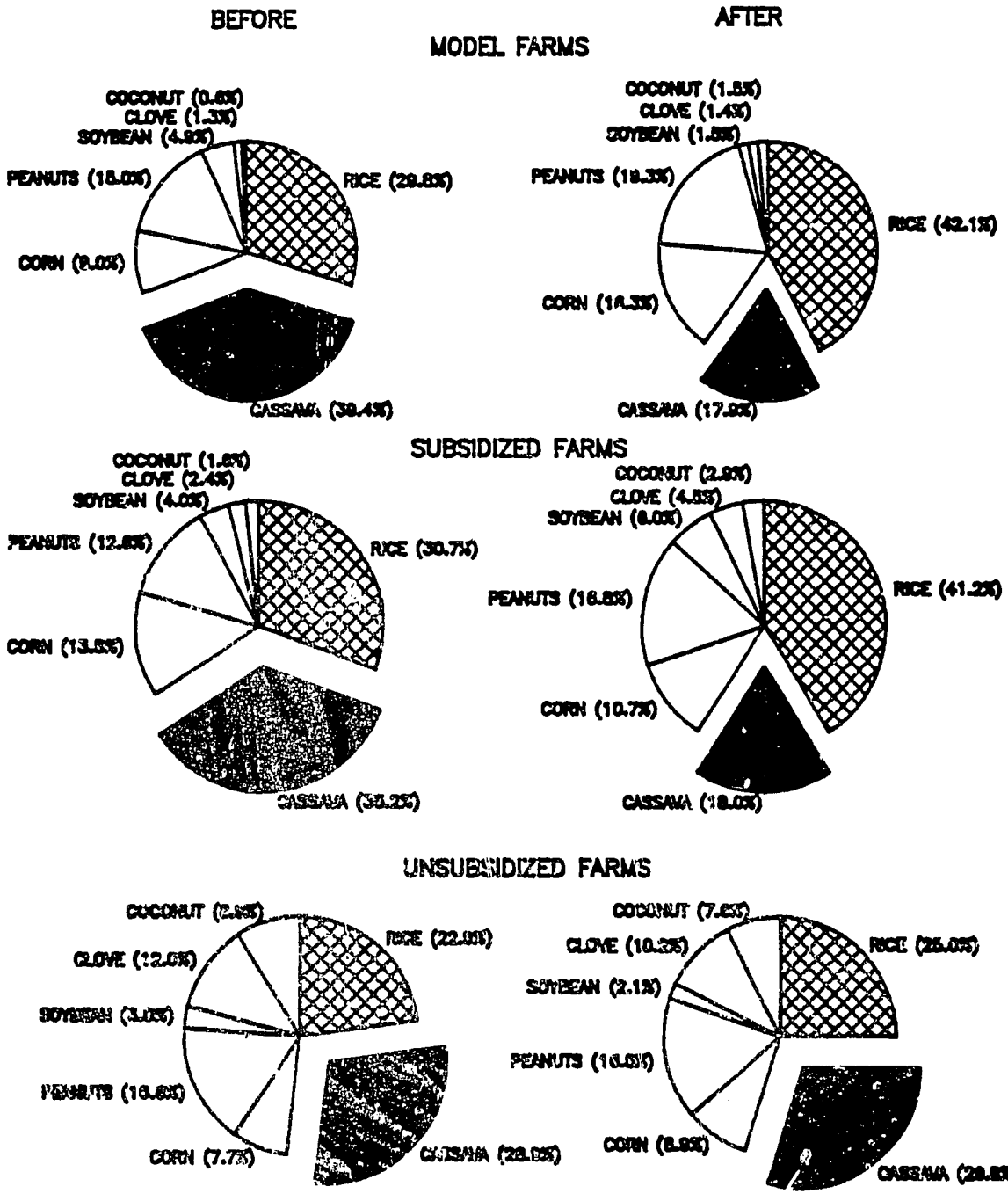
Subsidized expansion area farms did better. Figure 4.5 and Table 4.4 show that output values increased 105 percent in 1981 model farm areas, 44 percent in 1982 model farm areas, and 11 percent in 1983 model farm areas.

The outside project or unsubsidized farms tend to have more constant growth in their output values. While output values in 1981 model farm areas increased only 3 percent, they increased 43 percent in 1982 model farm areas, 25 percent in 1983 model farm areas, and 33 percent in 1984 model farm areas, as shown in Figure 4.5.

This pattern of changing output values seems to be attributable to shifting cropping patterns and changing crop prices. Figure 4.6 shows the pattern of before and after returns from crops produced, in constant 1985 values, for the model farms, subsidized farms and unsubsidized farms. Both the model farmers and the subsidized expansion area farmers shifted out of cassava production and into rice production.

On average, model farmers went from a cropping mix in which cassava represented 39 percent and rice represented 30 percent of the value to a cropping mix in which cassava represented only 18 percent and rice represented 42 percent of the value. Subsidized expansion area farmers went from a 35 percent cassava and 31 percent rice mix to an 18 percent cassava and 41 percent rice mix. On the

FIGURE 4.6
PATTERN OF RETURNS FROM CROPS FOR ALL MODEL FARM AREAS



other hand, unsubsidized farmers not participating in the model farm program had essentially a constant mix, going from 29 percent cassava and 23 percent rice before the program started to 30 percent cassava and 25 percent rice by 1985.

The shift out of cassava and into rice by the model farmers and subsidized expansion area farmers went counter to the shift in the relative prices of these two crops. Rice prices increased only 27 percent, from Rp 220/kg in 1981 to Rp 280/kg in 1985, while cassava prices rose 110 percent from Rp 20/kg in 1981 to Rp 42/kg in 1985. If the before cropping pattern was optimal for the prevailing crop prices, then farmers should have shifted towards cassava and away from rice with the changing relative prices of these two crops.

Model farmers and subsidized farmers shifted out of cassava and into rice production because of incentives in the model farm program. Cassava was considered to be an erosive crop and one to be discouraged. Extension workers advised against planting cassava and encouraged the use of improved varieties of rice. The model farm program seems to have imposed either formal or informal constraints on the farmer's choice of crops.

The unsubsidized farmers were not similarly influenced and could more freely respond to market conditions. Because their rice production is largely needed for on-farm consumption, they could not reduce the level of rice production in order to grow more cassava. But their production of cassava did continue at the same level, thus causing the gross value of their outputs to rise with the changing price structure.

This pattern of shifting cropping mixes is also observable by model farm year. Figure 4.7 shows the before and after cropping patterns for model farms started in 1981, 1982, 1983 and 1984. The 1981 model farms display the largest shift, with cassava declining from 62 percent of the value of production before the model farm to 11 percent after the model farm and rice production increasing from 21 percent to 43 percent.

Figure 4.8 shows the before and after cropping patterns for subsidized expansion area farms in areas where model farms were started in 1981, 1982 and 1983. Again, the pattern of shifting out of cassava and into rice production is observable. And again, the largest shift occurred in the 1981 model farm area, with cassava production declining from 63 percent to 11 percent of the value of production and rice production increasing from 13 percent to 59 percent.

Figure 4.9 shows the before and after cropping patterns for the unsubsidized farms not in the model farm program. As can be seen, within each model farm year, the mix of cassava and rice production remains relatively constant.

Figures 4.7, 4.8 and 4.9 all show variability in the cropping mix before the model farm is started. This variability is likely due to the farmers' ability to respond to relative price changes before the program is implemented, but also may be due to varying agro-climatic conditions in the geographically different model farm sites. Yet the overall pattern of changes in the cropping pattern observed in Figure 4.6 for the model farms, subsidized expansion area farms and unsubsidized outside farms is observed within each of the model farm years as well.

FIGURE 4.7
PATTERN OF RETURNS FROM CROPS ON MODEL FARMS

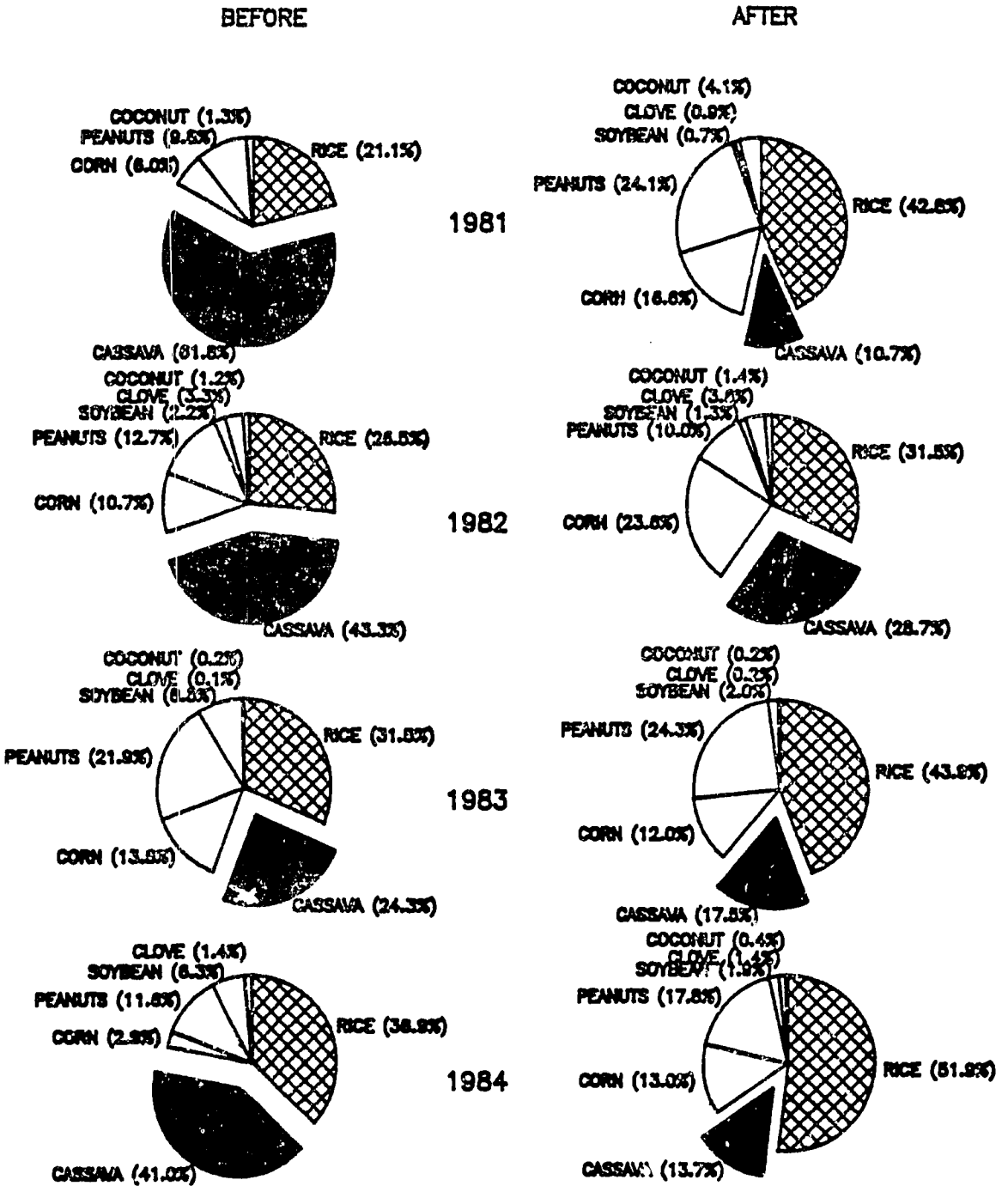


FIGURE 4.3
PATTERN OF RETURNS FROM CROPS ON SUBSIDIZED FARMS

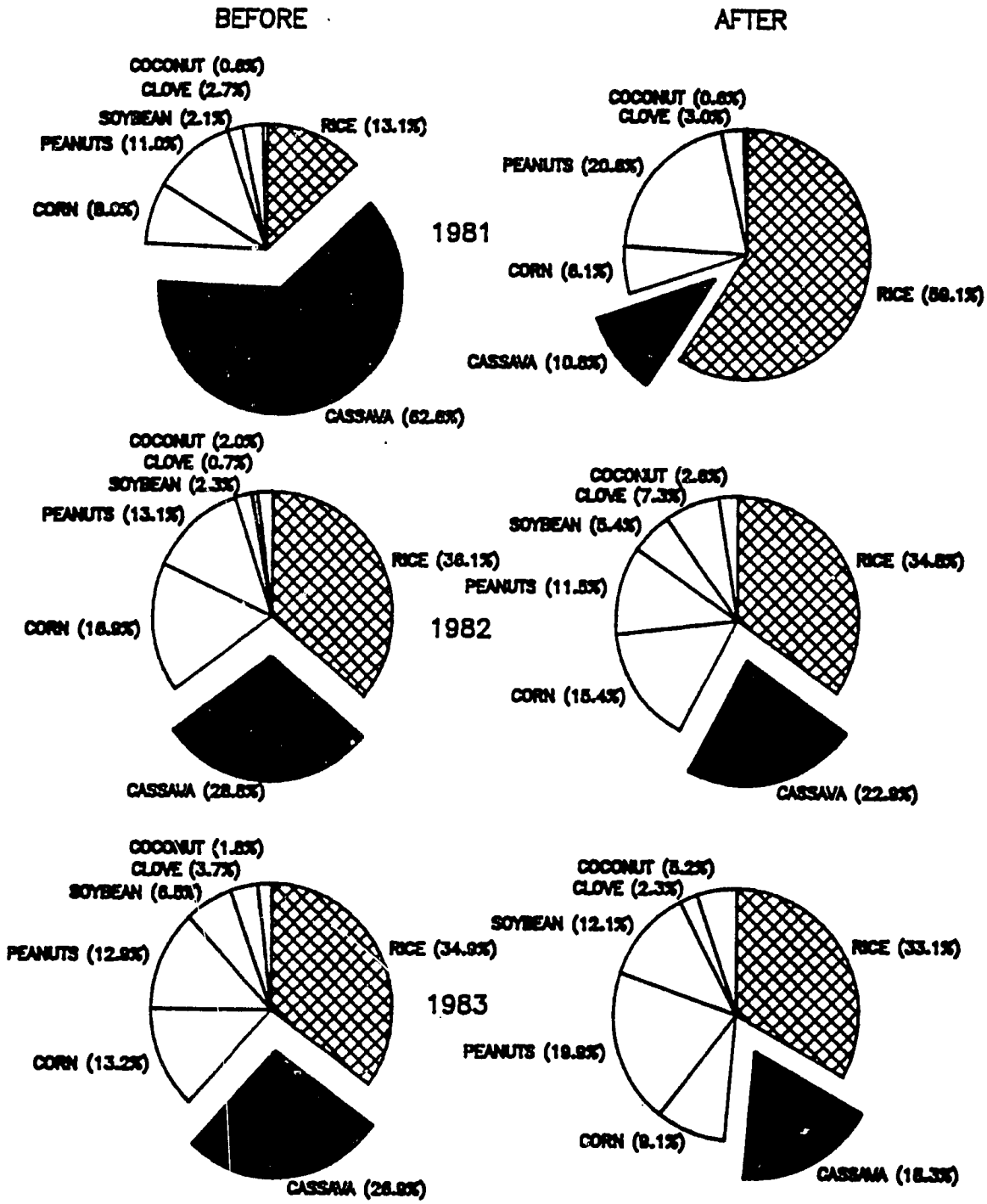
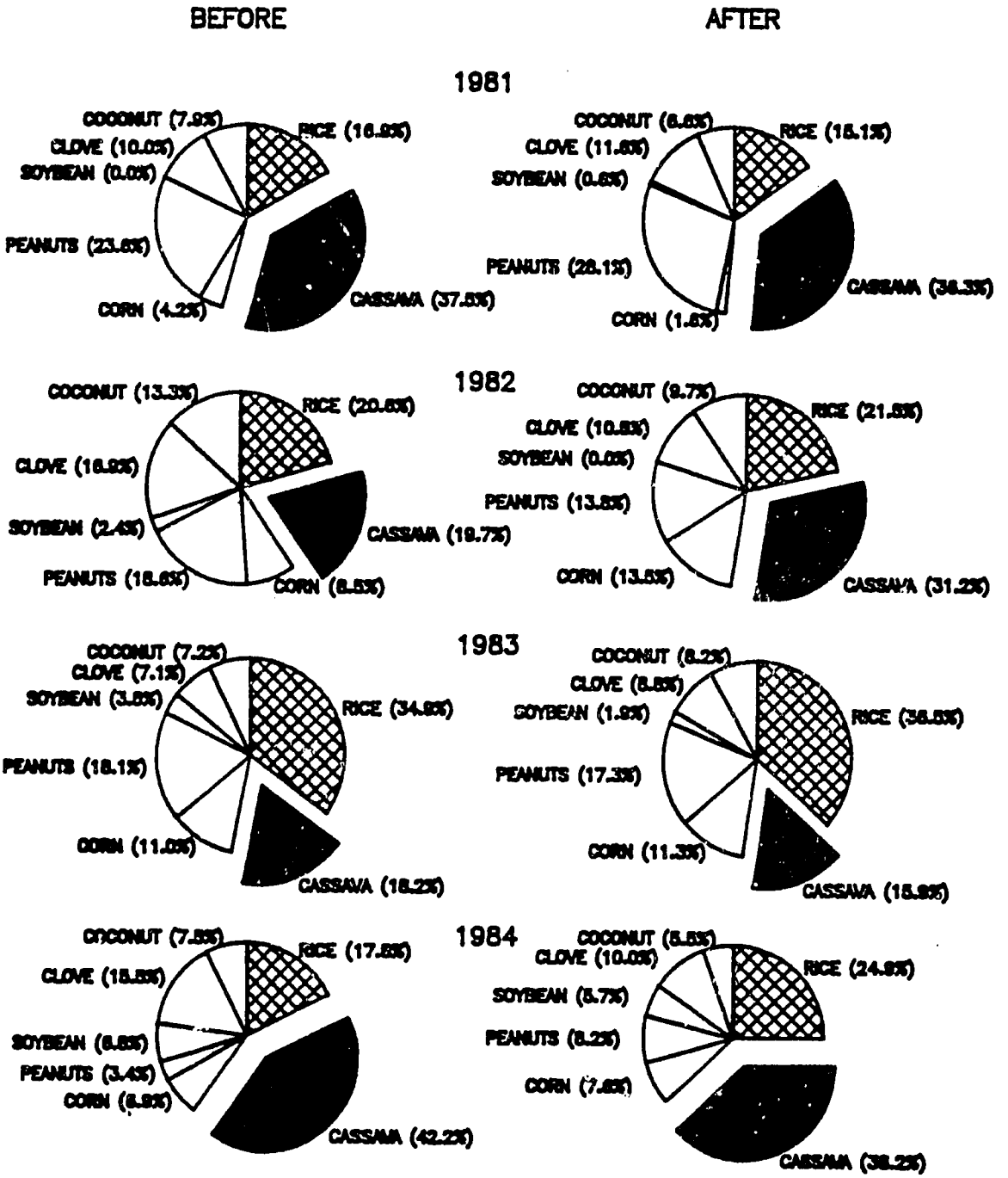


FIGURE 4.9
PATTERN OF RETURNS FROM CROPS ON UNSUBSIDIZED FARMS



4.4 EFFECTS OF CROPPING MIX ON INCOME

Another way of examining the effects of changing cropping patterns on the returns to farming is to develop a value function dependent upon the proportion of cassava in the cropping mix. Figure 4.10 shows such a function for 1981, 1985 and 1987 crop prices.

Using 1985 prices, Figure 4.10 shows that as the proportion of cassava in the cropping mix decreases from nearly 100 percent to approximately 11 percent, gross farm incomes increase. Decreases in the proportion of cassava in the cropping mix below 11 percent, however, cause gross farm incomes to decline.

Furthermore, using the lower 1981 price of cassava causes the value function to shift downward and to become more steeply sloped, while using the higher 1987 price of cassava causes the value function to shift upward and become less steeply sloped. With the higher 1987 cassava price, the value function reaches a maximum with a cropping mix consisting of approximately 52 percent cassava, while the lower 1981 cassava price has a maximum at approximately the same 11 percent level as for 1985 prices.

Production costs also vary with the proportion of cassava in the cropping mix. Typically, cassava requires less labor inputs. Figure 4.11 shows the costs of production for different proportions of cassava in the cropping mix. Production costs reach a maximum when the proportion of cassava is approximately 11 percent and decline as greater amounts of physical production are comprised of cassava.

Subtracting production costs from gross incomes gives the net incomes anticipated for different proportions of cassava in the

FIGURE 4.10. EFFECTS OF CROPPING MIX ON GROSS FARM INCOME

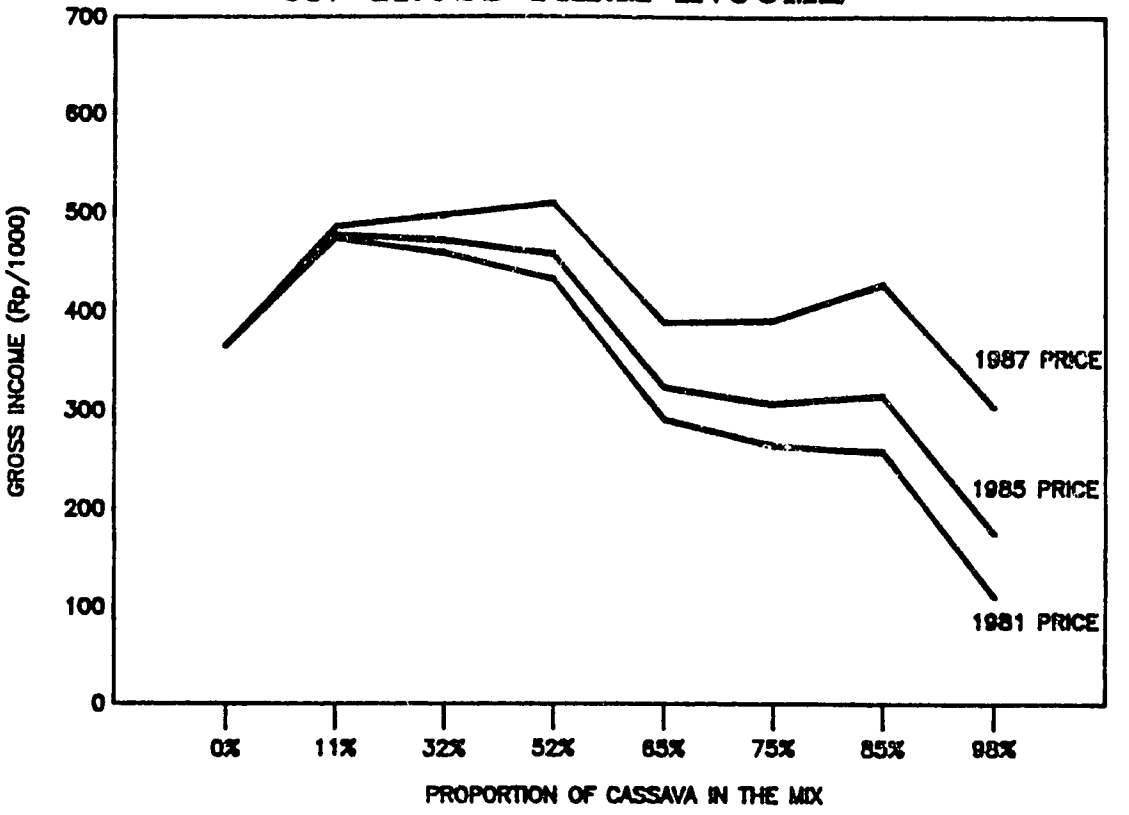
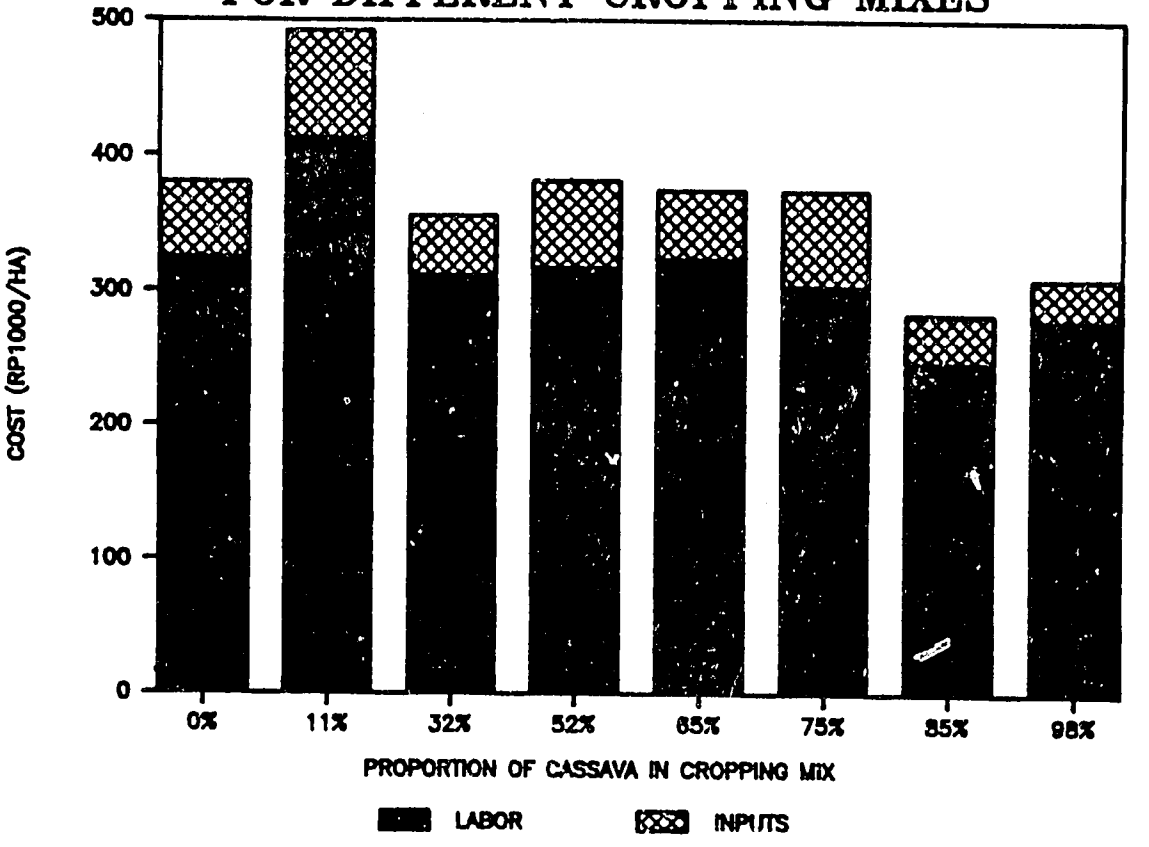


FIGURE 4.11. COST OF PRODUCTION FOR DIFFERENT CROPPING MIXES



cropping mix, which are shown in Figure 4.12. Net income is maximized for 1981, 1985 and 1987 prices with an output mix consisting of approximately 32 percent cassava. Both very small and very large proportions of cassava in the cropping mix are associated with negative net returns.

The actual cropping mixes, in terms of the proportion of the mix constituted by cassava, are shown in Figure 4.13 for before and after the model farm for all farmer groups. As can be seen, before the model farm, farm production was weighted heavily towards cassava; after the model farm, production is weighted heavily towards other crops. Few farms are producing at the optimum either before or after the model farm program.

The model farm program is associated with a movement towards the optimum cropping mix, but overshoots it. As seen earlier in Figure 4.6 and as shown in Table 4.5, the model farmers and subsidized expansion area farmers shifted heavily out of cassava in response to the model farm program. This trend appears to be continuing. The recent survey results for Andropraja, Margajaya and Mekarsari, which are shown in Tables 4.6 and 4.7, indicate that cassava is the predominate crop, in terms of the value of production.

The income benefits of the program would have been greater if farmers had not been influenced to change their cropping mix beyond the price signals of the market and their personal needs. The unsubsidized farmers outside the model farm program have more nearly optimal cropping mixes, because they are able to adjust more freely to market conditions.

4.5 TIME PATTERN OF ADOPTION

The model farm program is designed to extend the project's technology beyond the model farm. The model farm itself is intended

FIGURE 4.12. NET INCOME WITH DIFFERENT CROPPING MIXES

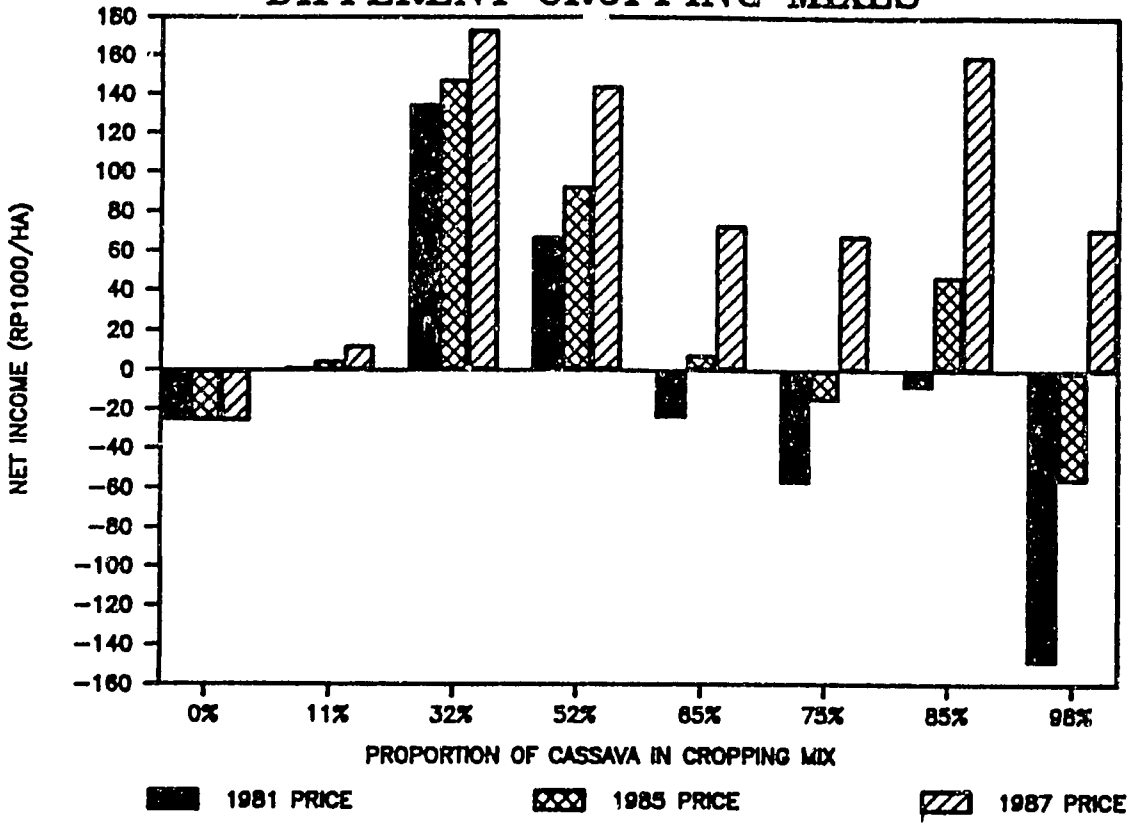


FIGURE 4.13. ACTUAL CROPPING MIXES BEFORE AND AFTER MODEL FARMS

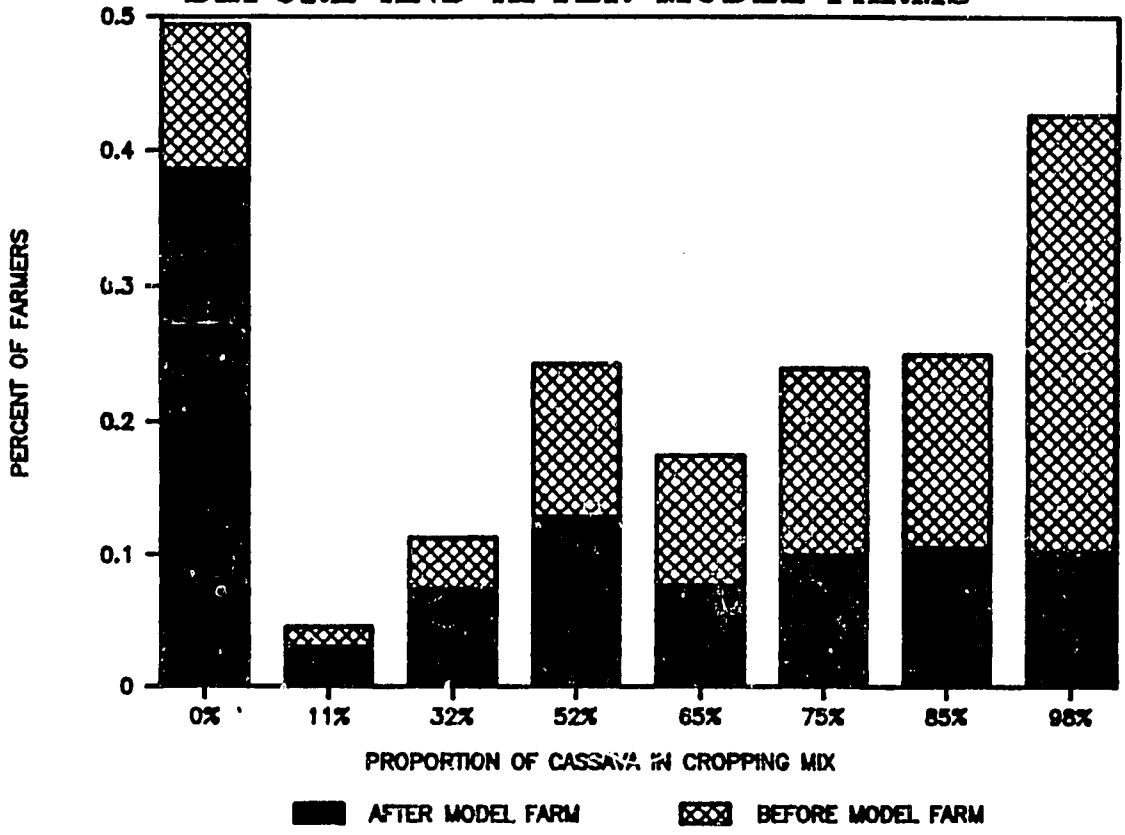


Table 4.5. Percent Of The Value Of Production Represented By Cassava By Model Farm Year

Farm Type	MF Year	Percent Cassava Before	Percent Cassava After
MF	1981	85%	17%
	1982	81%	52%
	1983	63%	34%
	1984	81%	23%
DS	1981	75%	20%
	1982	68%	48%
	1983	58%	28%
	1984	---	---
LP	1981	77%	55%
	1982	58%	59%
	1983	60%	48%
	1984	79%	62%
	1985	61%	---

Table 4.6. Percent Of The Value Of Production Represented By Cassava During 1987-88 Period By Farm Type For Three Model Farm Areas

Farm Type	Andropraja	Margajaya	Mekarsari
MF & DS	60%	72%	73%
LP	66%	76%	70%

Table 4.7. Percent Of The Value Of Production Represented By Cassava In 1987 & 1988 For Three Model Farm Areas

Year	Andropraja	Margajaya	Mekarsari
1986	57%	70%	72%
1987	66%	77%	73%

as a demonstration of the model farm technology. In order to make the demonstration as dramatic as possible, farmers on the "most critical land" are supposed to be selected for the model farm.

Once the model farm is established, the visual presence of the model farm and the efforts of extension workers are anticipated to convince other farmers to adopt the technology. First, farmers are induced with subsidies to emulate the model farmers. These are the dampak subsidi (DS) or subsidized expansion area farmers. Next, the additional returns from utilizing the technology are demonstrated to other farmers, who are expected to adopt the technology using their own resources. These are the luar proyek (LP) or unsubsidized outside project group.

In both cases, the procedure is similar. Extension workers contact farmers and invite them to the model farm for a demonstration. Farmers choosing to adopt the technology are trained in the construction of bench terraces, the application of inputs and alternative cropping mixes, with the construction of bench terraces being an integral part of the technology package.

The time period over which this procedure takes place is difficult to determine. Our field work and, particularly, conversations with extension workers and farmers indicate that within the model farm area, the technology spreads relatively rapidly. The rapidity and the extent of the spread seem to depend largely upon the ability, motivation and energy of the extension worker.

As shown in Figure 4.14 and Table 4.8, over half of the model farm plots had no terracing prior to the model farm program in their respective villages. The remaining plots had what are referred to in the USESE data set as "credit terracing," which appears to mean any form of terracing other than bench terracing. Only 20 percent

FIGURE 4.14. TYPE OF TERRACING

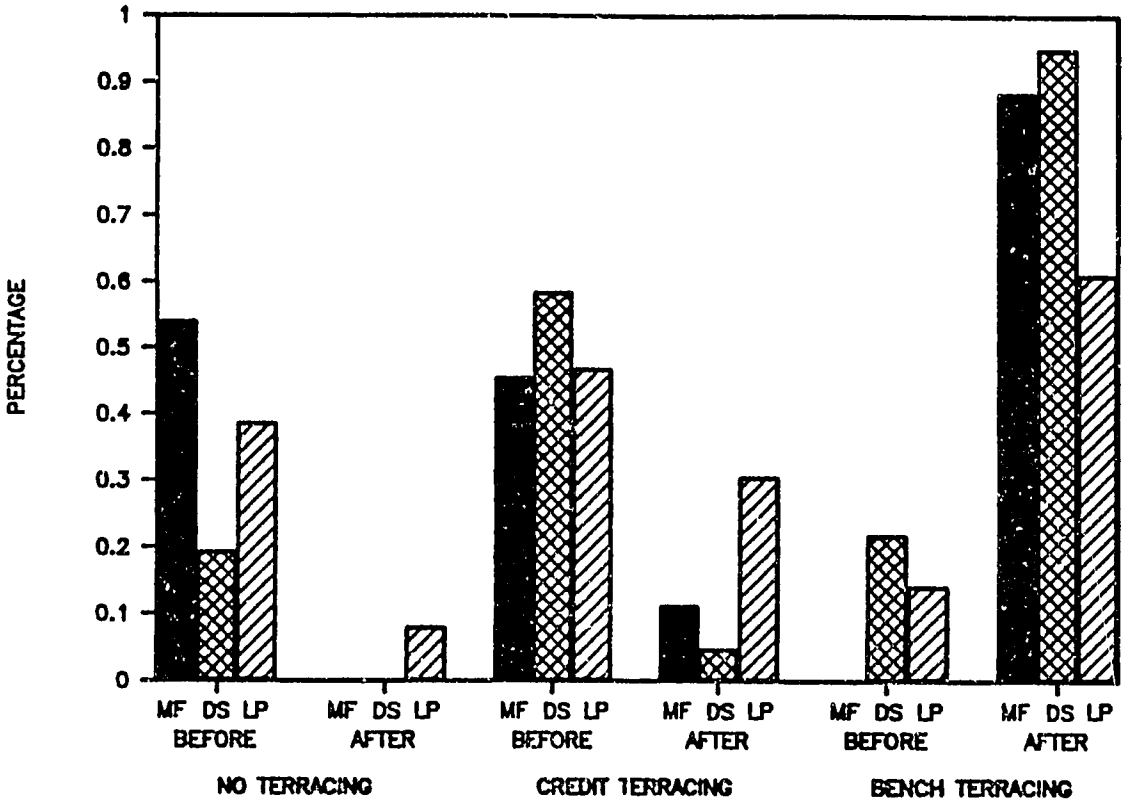


Table 4.8. Type Of Terracing

TYPE OF FARM	NO TERRACE		CREDIT		BENCH	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
MF	54%	0%	46%	11%	0%	89%
DS	20%	0%	59%	5%	22%	95%
LP	39%	8%	47%	31%	14%	61%

of the subsidized expansion area (DS) farmers had no terracing before the model farm program, with 59 percent having credit terracing and 22 percent already bench terraced. Thirty-nine percent of the unsubsidized outside project (LP) plots were unterraced, 47 percent had credit terracing and 14 percent had bench terracing prior to the project. In terms of the quality of

terracing (where bench terracing is considered best, credit terracing next best, and no terracing worst), the model farms before the model farm program are the worst, followed by the subsidized expansion area farms and then the unsubsidized farms.

By 1985, as shown in Figure 4.14, the USESE data indicate that 89 percent of the model farm plots have bench terraces and 11 percent have credit terracing. This statistic, however, may be in error, since by definition model farms are all bench terraced. Why 11 percent indicate they are only credit terraced is not clear. Furthermore, subsidized farm plots are 95 percent bench terraced and unsubsidized plots are 61 percent bench terraced by 1985. The fact that unsubsidized plots have proportionately less bench terracing may be due to the time lag before extension workers approach these farmers. On the other hand, the fact that no model or subsidized farms and only 8 percent of the unsubsidized farms are unterraced after the model farm program indicates that the concept and technique of bench terracing are spreading rapidly in these upland areas, likely due to the model farm program.

Figure 4.15 and Table 4.9 consider these shifts in terracing in a different manner. The data are partitioned in terms of the type of terracing farmers had before the model farm and the kind of terracing they changed to after the model farm. Forty-nine percent of the model farms, 20 percent of the subsidized farms and 18 percent of the unsubsidized farms shifted from no terracing to bench terracing with the implementation of the model farm program. Forty percent of the model farms, 54 percent of the subsidized farms and 29 percent of the unsubsidized farms shifted from credit terracing to bench terracing. Only 6 percent of the model farms, none of the subsidized farms and 12 percent of the unsubsidized farms shifted from no terracing to credit terracing. Finally, 5 percent of the model farms, 26 percent of the subsidized farms and 41 percent of the unsubsidized farms did not change their type of terracing.

FIGURE 4.15. SHIFT IN TERRACING TYPE

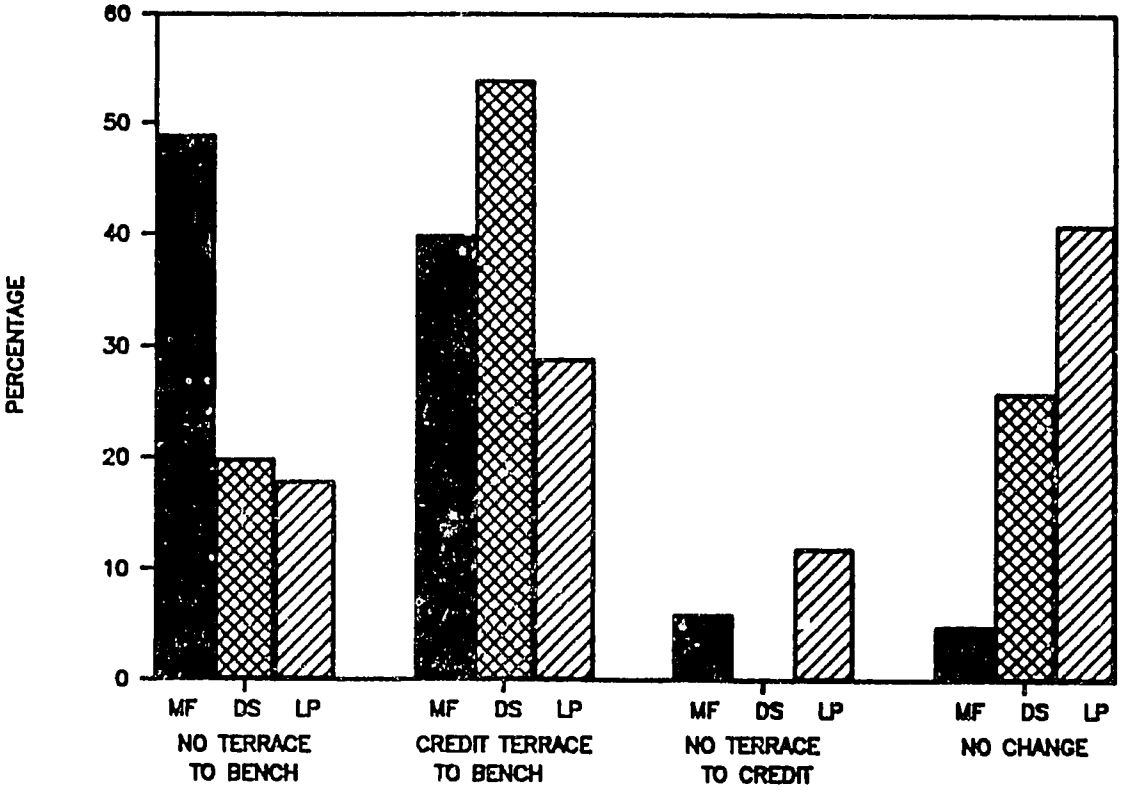


Table 4.9. Shift Of Terracing Type

FARM TYPE	NO TERRACE TO BENCH	CREDIT TERRACE TO BENCH	NO TERRACE TO CREDIT	NO CHANGE
MF	49%	40%	6%	5%
DS	20%	54%	0%	26%
LP	18%	29%	12%	41%

Again, the statistics for model farms either not changing their terracing type or shifting to credit terracing are not consistent with the definition of model farms, but the numbers are relatively small and, likely, insignificant.

The inference from these statistics is that the model farm plots are relatively worse than either the subsidized or the unsubsidized plots prior to the model farm program. The proportion of model farm plots shifting to bench terracing from an initial condition of no terracing is nearly two and a half times greater than for either the subsidized or the unsubsidized farms. The fact that unsubsidized farms have the largest proportion of farms with no change in terracing may be indicative of the time lag identified above in the activities of extension workers in the unsubsidized outside project areas.

Overall, Figures 4.14 and 4.15 indicate a relatively rapid spread of bench terracing in the model farm areas. The first model farm was started in 1981 and the last one in the USESE data set was started in 1984. Spread of the model farm technology, which is primarily bench terracing, is probably less in the more recent model farm areas, but data are not sufficient to test this hypothesis. Yet, by 1985 nearly all of the model and subsidized farms were bench terraced and unsubsidized outside project farms were moving rapidly in that direction.

5. SUBSIDIES AND EXTENSION

This chapter describes the level of capital and input subsidies, the opinions of farmers regarding the adequacy, importance and need for the subsidies, and the relative importance of extension workers in providing terracing information.

5.1 LEVEL OF SUBSIDIES

Average capital and input subsidies of the model farm program which are received by project farmers are shown in Figure 5.1 and Table 5.1. Capital subsidies for terracing average Rp 32,130/ha/for model farms and Rp 9,300/ha for expansion area farms. Input subsidies average Rp 207,170/ha for model farms and Rp 117,840/ha for expansion farms. The largest input subsidy appears to be for

FIGURE 5.1. AVERAGE SUBSIDY LEVELS

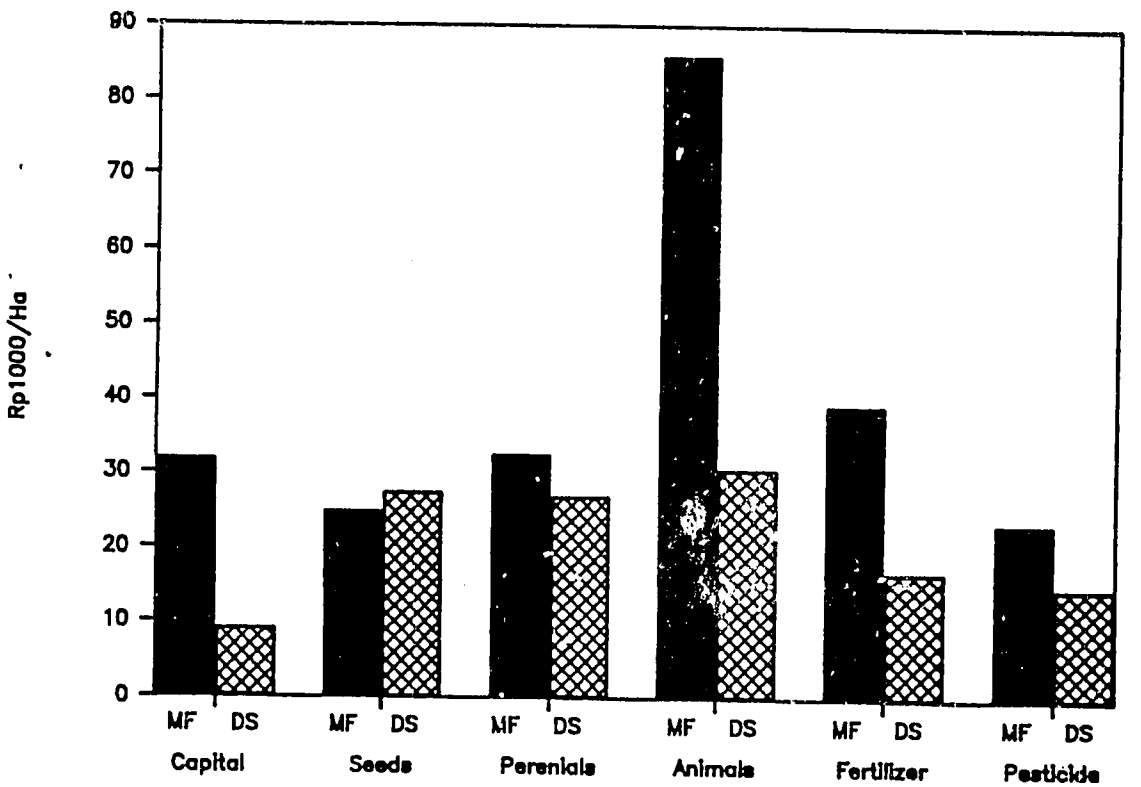


Table 7.1. Average Subsidy Levels

Type of Subsidy	Year	Model Farms	Expansion Farms
		(Rp 1000/Ha)	
Capital	1	31.59	9.30
	2	0.54	0.00
	3	0.00	0.00
	Subtotal	32.13	9.30
Program Input			
Food Crop Seeds	1	21.50	27.68
	2	3.53	0.00
	3	0.11	0.00
	Subtotal	25.14	27.68
Perennial Crops	1	32.39	27.17
	2	0.39	0.00
	3	0.00	0.00
	Subtotal	32.78	27.17
Animal Husbandry	1	9.10	30.86
	2	73.59	0.00
	3	3.39	0.00
	Subtotal	86.08	30.86
Fertilizer	1	32.49	17.07
	2	7.05	0.00
	3	0.00	0.00
	Subtotal	39.54	17.07
Pesticide	1	16.71	15.07
	2	6.93	0.00
	3	0.00	0.00
	Subtotal	23.64	15.07
Total Program	1	112.19	117.85
	2	91.49	0.00
	3	3.50	0.00
Total Capital & Program		239.31	127.15

animal husbandry, but this is deceptive because farmers are reported to pay back this "subsidy" in-kind. In fact, they return/two goats for each goat received. The other subsidies, however, do appear to be grants to the farmer.

The fact that net incomes for model farmers decreased indicates that subsidies are likely necessary for this group. In order to perform their task as demonstration farms, these farms may have higher than normal operating costs, so that it is not possible to have a positive net income. On average, the net income of model farmers declined by Rp 155,610/ha and returns to labor declined by Rp 93,720/ha, which is only partially covered by the model farm's average annual input subsidy of Rp 69,057. This subsidy is paid the model farmers for three years, after which time they are presumably allowed to return to a more normal and, hopefully, more profitable operation.

Net incomes of expansion area farms would have increased by Rp 53,190/ha and returns to labor would have increased by Rp 120,160/ha without the subsidy. The average one-year input subsidy of Rp 117,840/ha simply represents additional income and does not appear necessary.

Terracing seems to pay for itself. The survey results and econometric analysis which follow support this finding, but also the preceding analysis of adoption shows that unsubsidized farmers are also bench terracing. The capital subsidy may be necessary for model farmers to induce them to demonstrate the new technology. But beyond the model farm, the need for capital subsidies is doubtful. Other, later adopters probably do not need the subsidy.

5.2 OPINIONS ON SUBSIDIES

5.2.1 Adequacy of Subsidies

Figure 5.2 and Table 5.2 indicate the farmers' opinions regarding the adequacy of the capital and program input subsidies. When asked if they thought the terracing subsidy was adequate, only 40 percent of the farmers interviewed felt that it was adequate, while 24 percent considered it "grossly" inadequate and the

FIGURE 5.2. OPINION ON ADEQUACY OF SUBSIDIES

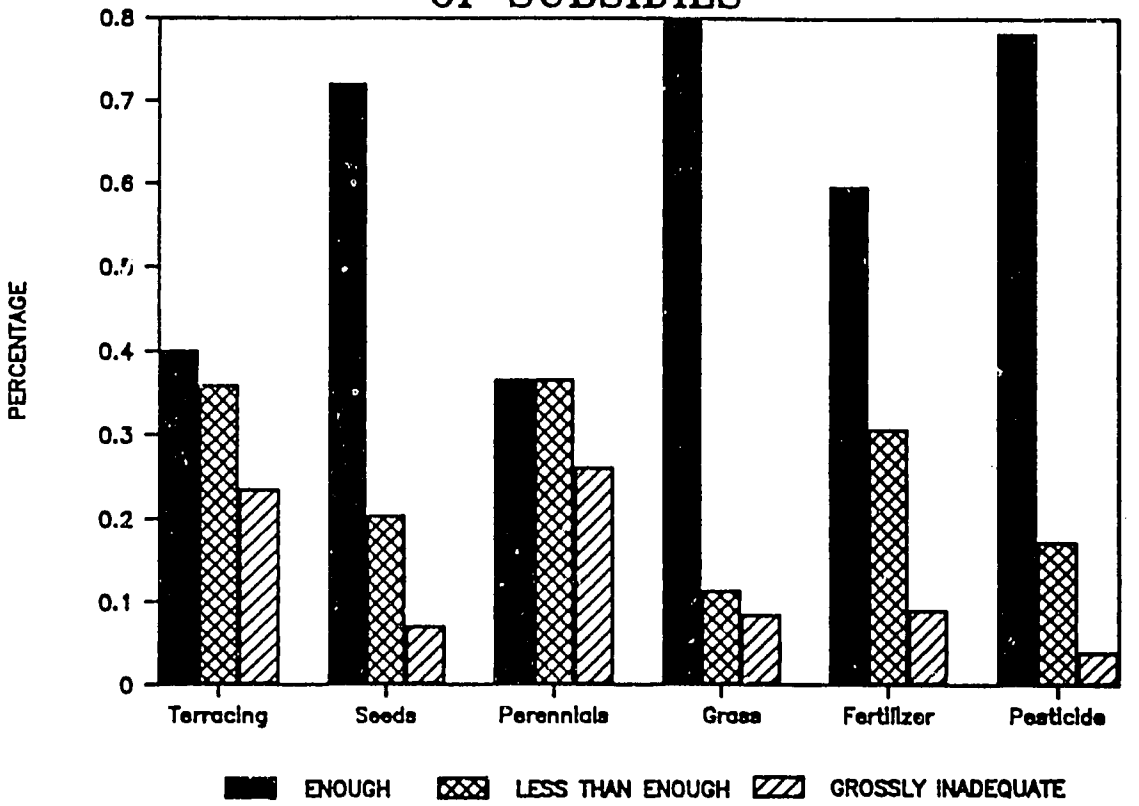


Table 5.2. Adequacy Of Subsidies

Type of Subsidy	Level Of Subsidy		
	Enough	Less Than Enough	Grossly Inadequate
Terracing	40.2%	36.1%	23.7%
Seeds	72.2.%	20.6%	7.2%
Perennials	36.8%	36.8%	26.3%
Grass	79.7%	11.6%	8.7%
Fertilizer	59.8%	30.9%	9.3%
Pesticide	78.4%	17.5%	4.1%

remaining 36 percent simply considered it "less than enough." The meaning of the farmers' responses to this question, however, is not clear. They may have been responding with respect to whether or not the subsidy covered the entire cost of terracing, rather than responding with respect to the subsidy's adequacy to bridge the gap between the farmer's resources and those needed to construct the terrace. It seems that the subsidy's goal is to bridge the gap between what the farmer can afford and what it costs to bench terrace, so if the farmers' responses are in terms of subsidies covering all of the terracing costs, then the measure of adequacy may be underestimated.

Figure 5.2 and Table 5.2 indicate that over 50 percent of the respondents consider the program input subsidies for seeds, grass, fertilizers, and pesticides to be adequate. Less than 40 percent consider the subsidy for perennials to be adequate. Again, however, the farmer's definition of adequacy is not known.

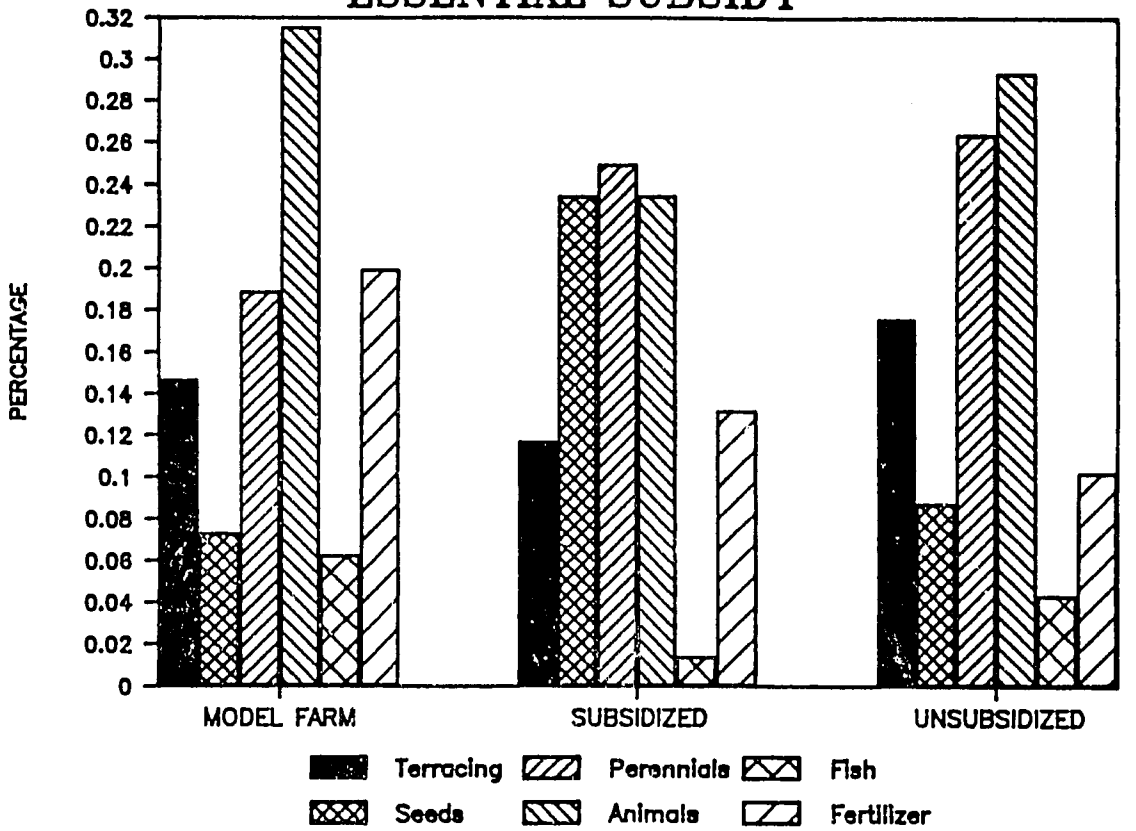
5.2.2 Importance of Subsidies

Table 5.3 and Figure 5.3 show the farmers' opinions regarding which subsidies are most essential. The subsidies for perennials,

Table 5.3. Opinion Of Most Essential Subsidy

Type of Subsidy	Farm Group		
	MF	DS	LP
Terracing	14.7%	11.8%	17.6%
Seeds	7.4%	23.5%	8.8%
Perennials	18.9%	25.0%	26.5%
Animals	31.6%	23.5%	29.4%
Fish	6.3%	1.5%	4.4%
Fertilizer	20.0%	13.2%	10.3%
Pesticides	1.1%	1.5%	2.9%
Tools	0.0%	0.0%	0.0%
Fuel	0.0%	0.0%	0.0%
Grass	0.0%	0.0%	0.0%

FIGURE 5.3. OPINION ON MOST ESSENTIAL SUBSIDY



animals and fertilizer are ranked high by each of the three types of farmers. Interestingly, these subsidies also tend to be the largest, as shown by Figure 5.1, which may indicate that farmers interpreted "most essential" as "largest amount." On the other hand, the fact that these subsidies are larger may indicate that they are more needed.

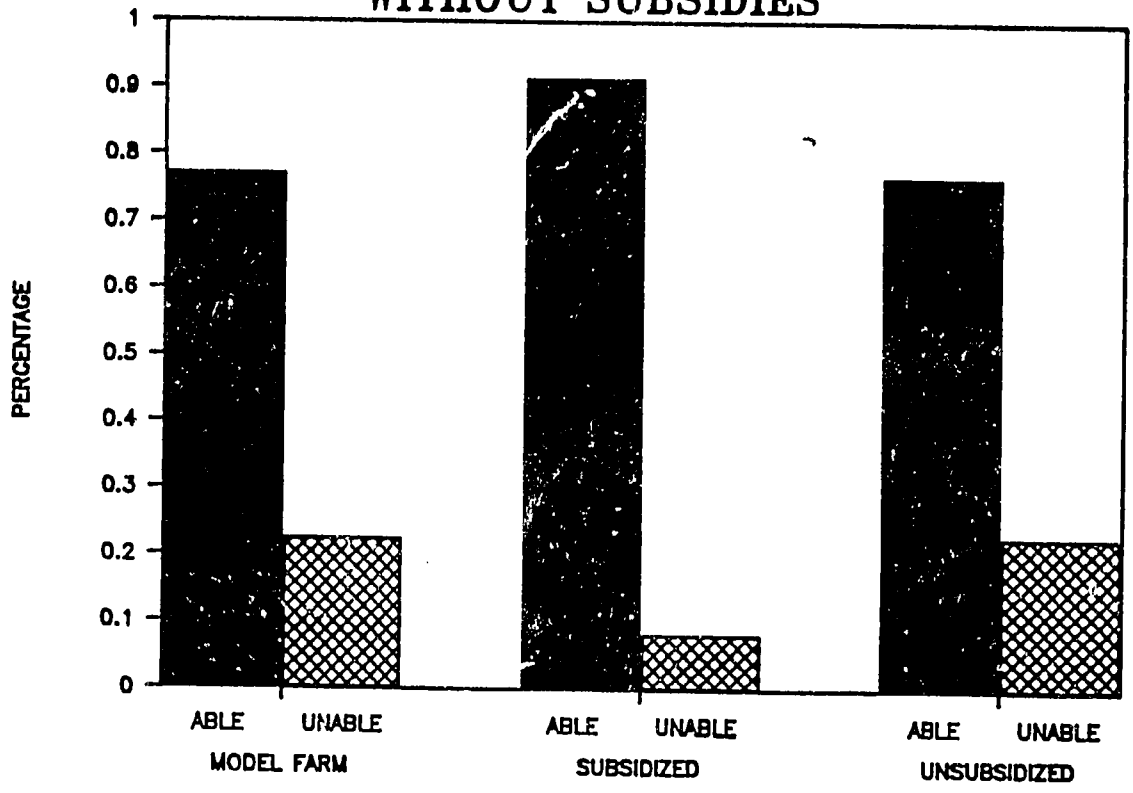
5.2.3 Need for Subsidies

Finally, Figure 5.4 and Table 5.4 summarize the farmers' responses for a question regarding their ability to construct the

Table 5.4. Ability To Terrace Without Subsidy

	MF	DS	LP
Able	77.3%	91.5%	76.9%
Unable	22.7%	8.5%	23.1%

FIGURE 5.4. ABILITY TO TERRACE WITHOUT SUBSIDIES



bench terraces without subsidies. Seventy-seven percent of the model farmers, 92 percent of the subsidized expansion area farmers, and 77 percent of the unsubsidized farmers responded that they could build bench terraces without the subsidies of the model farm program. Interestingly, the proportion of each type of farmer that responded that he could build bench terraces without subsidies corresponds closely with the proportions that actually constructed bench terraces, as shown in Figure 4.14. Of course, the unsubsidized outside project farmers did not receive subsidies and bench terraced anyway, which validates their response that subsidies are not needed. But the responses of the model farmers and subsidized expansion area farmers indicate that bench terracing would still occur among these farmers even without subsidies, if the benefits outweighed the costs as they do for the unsubsidized outside project farmers.

5.3 EXTENSION ACTIVITY

Figure 5.5 and Table 5.5 summarize how farmers learned about bench terracing. The most important source of information regardin terracing is the extension worker. Fifty-two percent of the model farmers, 49 percent of the subsidized expansion area farmers, and 47 percent of the unsubsidized outside project farmers listed the extension worker as their primary source of terracing information. Seeing the model farm itself seems relatively unimportant. However this may be misleading, since the standard procedure of the extension workers is to invite farmers to the model farm for a demonstration of the benefits and the method of construction of bench terracing.

FIGURE 5.5. SOURCE OF TERRACING INFORMATION

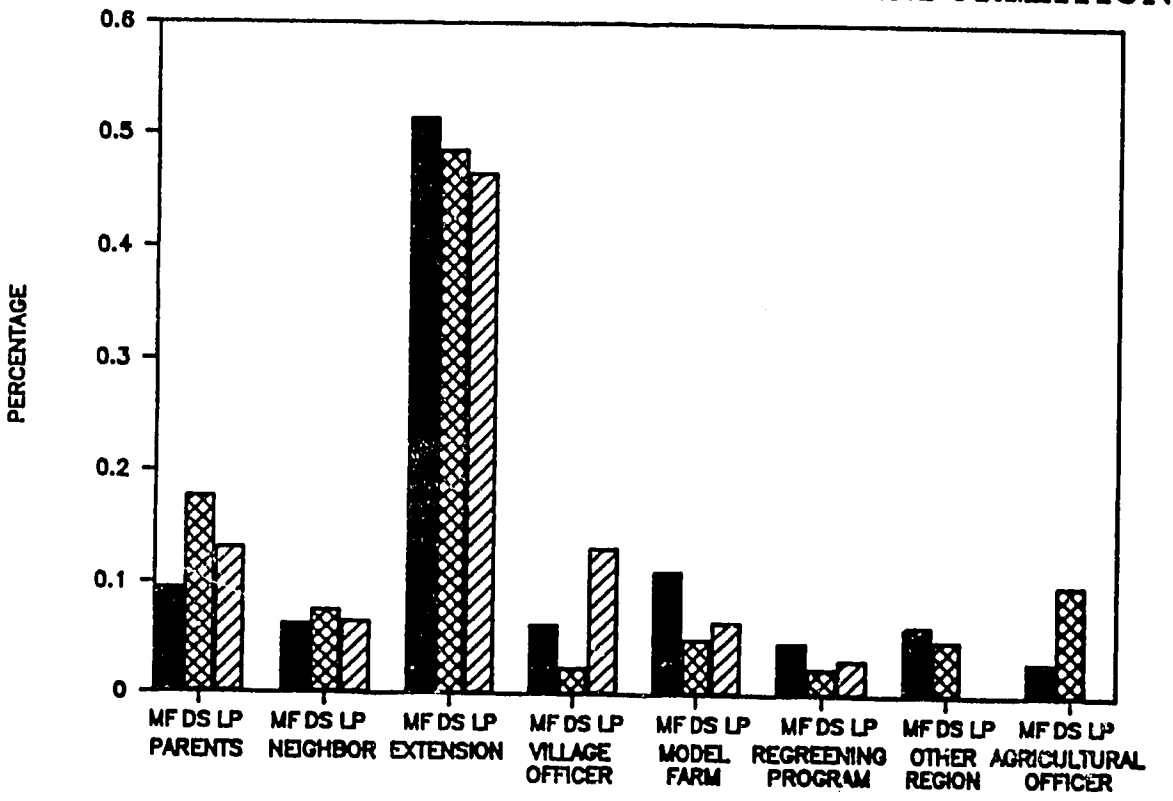


Table 5.5. Source Of Terracing Information

FARM TYPE	PARENTS	NEIGHBOR	EXT. WORKER	VILL. OFF.	MODEL FARM	REGREEN PROG.	OTHER PROG.	AG. OFF.
MF	10%	6%	52%	6%	11%	5%	6%	3%
DS	18%	8%	49%	3%	5%	3%	5%	10%
LP	13%	7%	47%	13%	7%	3%	0%	0%

Information about terracing is also spread through parents, neighbors, village officials, and others. It seems likely, however, that the sources of this information might also be the extension workers and the model farm itself.

6. POTENTIAL OFF-SITE RETURNS

Soil erosion on upland agricultural land may contribute to sedimentation problems downstream. The previous analysis has focused on the on-site returns from the model farm program. But the model farm program, through terracing, improving drop structures and other means, may also produce off-site benefits in the form of reduced costs caused by sedimentation.

The off-site costs of soil erosion are often difficult to identify, let alone to measure. Practically no data exist with which to assess these costs in the Citanduy area. The purpose of this section is to identify some of the potential off-site costs of soil erosion and the types of possible returns the model farm program may produce by reducing this erosion. The source of the data presented, though not necessarily the interpretation, is a study by Mr. Tampubolon.[10]

Sediment and other pollutants resulting from soil erosion that are carried to streams and rivers can cause a variety of in-stream and off-stream damages. In-stream damages include damages to aquatic organisms, water-storage facilities and navigation. Off-stream damages include flooding damages and damages to water-conveyance systems.

6.1 IN-STREAM DAMAGES

6.1.1 Aquatic Life

Sediment can directly damage fish, crustaceans and other aquatic life, and can indirectly affect them by destroying spawning

[10] Tampubolon, S.M.H. 1988. Unstructured Survey To Determine The Effects of Upstream Soil Erosion on Downstream Activities. Unpublished report to Cochrane and Huszar. January.

areas, food sources and habitat. Nutrients carried by sediment may cause algal bloom which reduces available oxygen to aquatic life. Pesticides carried off fields by sediment may be directly toxic to aquatic life. Finally, siltation of estuaries may reduce the stock of fish and shrimp due to the loss of their breeding grounds.

The effects of siltation on fisheries in the Citanduy watershed have not been investigated. The only data found on fish production are shown in Table 6.1 for the off-shore and Anakan Lagoon areas near Cilacap. The data do not indicate a decline in production over time. In addition to the possible negative impacts of sedimentation on production, methods used for harvesting the fish have been changed in response to government regulations, so that it is not possible to isolate the effects of sediment alone. The apparent decline in production in recent years may have been as likely caused

Table 6.1. Fish Production In Cilacap, 1969-1986

Year	Off-Shore (Metric Tons)	Anakan Lagoon (Metric Tons)
1969	3,603	Not Available
1970	2,432	"
1971	1,686	"
1972	5,578	"
1973	1,329	"
1974	7,260	"
1975	8,257	"
1976	10,521	664
1977	18,314	1,017
1978	15,974	622
1979	13,466	282
1980	6,022	199
1981	2,706	236
1982	3,363	248
1983	4,488	399
1984	3,841	362
1985	5,914	Not Available
1986	9,331	"

Source: Cilacap Office of Fishery.

by these changes in fishing methods, or even by over fishing, as by siltation.

6.1.2 Storage Facilities

Siltation of water storage facilities reduces the useful life of the structures. While no storage facilities exist on the Citanduy, this is a particularly important problem in the Jratunseluna and Brantis watersheds. And in the Citanduy watershed, high silt loads may reduce the feasibility of constructing water storage facilities.

6.1.3 Navigation

Sedimentation also affects navigation in diverse ways. The major costs appear to be lost access within harbors and waterways and dredging costs to reduce the negative impacts on access. The Cilacap Office of Land and Water Transportation feels that navigation is being reduced in the Anakan Lagoon by siltation. However, ferry traffic between Kalipucang and Majingklak, as indicated by the number of passengers shown in Table 6.2, has not obviously been impaired.

Table 6.2. Passenger Traffic Between Kalipucang And Majingklak, 1980-1986

Year	Number of Passengers
1980	50,086
1981	66,556
1982	81,429
1983	93,586
1984	100,132
1985	116,090
1986	123,217

Source: Cilacap Office of Land and Water Transportation.

6.2 OFF-STREAM DAMAGES

6.2.1 Flooding

Aggradation of streambeds caused by sediment may increase the frequency and depth of flooding. Moreover, damages associated with flooding are often caused by sediment, not the water itself. Flooding damages include the destruction of crops, damages to housing and other structures, increased instances of disease, injury or death of humans and livestock, and disruption of economic activities. Unfortunately, data are not available to assess these costs.

Table 6.3 shows the amount of land flooded in the Citanduy River Basin, the number of households in the Ciamis subdistrict (Kabupaten) affected by flooding, and the estimated value of flood losses by year. The data are from three different data sets and, as a consequence, are not complete for all years. The data show that since 1968 the annual area flooded has remained relatively constant, the number of households affected by flooding has tended to decline, and that the value of losses has tended to increase.

That flooded area has not increased and that the number of households affected by flooding has decreased contradicts the hypothesis that siltation is exacerbating the flooding hazard. Taken alone, the fact that the value of losses has increased would seem to support the hypothesis of more flooding. But taken with the data on flooded area and number of households affected, the fact that the value of losses is increasing may simply reflect increasing wealth rather than more flooding. That is, while a significant area is flooded annually, affecting hundreds of households and causing million of rupiah of losses, there is no evidence that siltation is causing these flooding damages to increase.

Table 6.3. Flooded Area In Citanduy River Basin, Number Of Households Affected In Ciamis Kabupaten, And Estimated Value Of Flood Losses

Year	Flooded Area (Hectares)	Households Affected (Number)	Estimated Value of Losses (1,000's of 1975Rp)
1968	20,700	677	33,381
1969	---	5,530	27,853
1970	---	---	34,820
1971	4,200	2,769	28,383
1972	4,500	1,326	23,413
1973	18,400	9,743	28,616
1974	6,450	1,393	31,513
1975	10,750	606	22,000
1976	---	---	40,656
1977	---	351	40,479
1978	12,384	72	53,533
1979	5,050	268	---
1980	---	582	55,887
1981	4,946	243	67,880
1982	1,950	314	83,369
1983	1,140	136	60,847
1984	5,615	227	127,780
1985	---	254	---
1986	6,923	156	236,872
1987	---	206	100,162

Source: Citanduy River Area Development Project and Ciamis Office of Social Welfare.

6.2.2 Irrigation Systems

Sedimentation may increase the operation and maintenance costs of irrigation systems. Three types of irrigation systems are identified in the Citanduy watershed: technical, semi-technical and simple. Technical irrigation systems are defined to consist of relatively sophisticated primary, secondary and tertiary canals, regulation structures, spillways and drainage structures which are

maintained and operated by the local Office of Irrigation Public Works. Semi-technical systems are less sophisticated and are generally only managed by the local Office of Irrigation Public Works up to the secondary level, with water users being responsible for the remainder of the system. Simple irrigation systems are designed, constructed and operated by local water user groups and are technically the simplest irrigation systems.

Table 6.4 shows the area irrigated by each type of irrigation system during 1972 and 1985. As can be seen, the area irrigated by technical systems has grown by 250 percent and the area irrigated by semi-technical systems has grown by 240 percent, while the area irrigated by simple systems has declined by nearly 40 percent since 1972. Moreover, the total area irrigated by all types of systems has increased by 147 percent. Since technical and semi-technical systems are more capital intensive and since more land is being irrigated, the implication is that the value of irrigation systems at risk from siltation is increasing.

Table 6.4. Area Under Technical, Semi-Technical And Simple Irrigation Systems In The Citanduy River Basin, 1972 & 1985

Kabuaten	Type of System					
	Technical		Semi-Technical		Simple	
	1972	1985	1972	1985	1972	1985
	(Hectares)					
Tasikmalaya	2,570	3,490	2,569	4,088	7,986	7,887
Ciamis	11,062	17,834	3,877	8,122	19,537	13,147
Cilacap	4,547	24,255	1,100	5,878	6,433	3,473
Total	18,179	45,579	7,546	18,088	33,956	24,507

Source: Citanduy River Area Development Project, Banjar.

But no evidence was found indicating that damages from sediment are increasing. Table 6.5 shows the operating and maintenance costs for the Kabupaten Ciamis Irrigation System. Within this irrigation system, the area irrigated has remained roughly constant at 17,834 hectares over the 11-year period shown in Table 6.5. As can be seen from the table, the level of funding for operation and maintenance costs has stayed relatively constant. It may be that funding levels for operation and maintenance have not kept pace with actual costs, but in the absence of any other evidence, there is no support for the contention that sediment is increasing the operation and maintenance costs of, at least, this irrigation system.

Table 6.5. Operation And Maintenance Funds In Kabupaten Ciamis Irrigation System, 1976-1988

Year	Operation & Maintenance Funds (1,000's of 1975 Rp)
1976/77	37,222
1977/78	32,367
1978/79	14,140
1979/80	32,172
1980/81	31,842
1981/82	20,773
1982/83	0
1983/84	36,310
1984/85	37,788
1985/86	35,776
1986/87	33,322
1987/88	28,978

Source: Office of Irrigation Public Works, Kabupaten Ciamis

7. CONCLUSIONS

The conclusions below regarding the success of the model farm technology, the success of the model farm program to spread that technology, the need for subsidies to promote adoption of the technology, and research needs follow from the analysis.

7.1 SUCCESS OF MODEL FARM TECHNOLOGY

The measure of success of the model farm technology is that it yields an increase in the value of production, measured in terms of farm incomes, greater than its cost and that it reduces soil erosion. No data are yet available on its effects on soil erosion. Furthermore, the available data do not show a strong and unambiguous relationship between bench terracing and farm incomes.

Average gross farm incomes increased over the span of time the model farm program has been in existence. It appears that both project and outside project farmers shared in these gains. The most important factor explaining the increase in farm incomes appears to be a shift in the cropping mix. During the early years of the project, the shift was into rice and out of cassava production and, more recently, the shift has been into cassava and out of rice production. This shifting cropping mix has been triggered by fluctuations in the relative prices of cassava and rice.

Farmers whose production is nearly exclusively cassava or rice producers are worse off than producers who grow a combination of both crops. Using 1985 prices, net incomes are highest for those farmers with a cropping mix that includes approximately 40 percent cassava by weight. This is approximately one half of a typical farm's cassava production prior to 1981. At 1987 prices, the optimum output mix rises to approximately 60 percent cassava by weight.

Bench terracing appears to facilitate a shift in the cropping mix towards rice production. During the early stages of the model farm program, when rice prices were rising relative to cassava prices, farm incomes rose both because of the rising prices and because bench terracing permitted the shift into rice production.

But as the relative price of cassava has risen in recent years, the benefits of weighing the cropping mix towards rice production and, thus, the benefits of bench terracing, have declined. Bench terracing appears more important for rice production than for cassava production. Because the relative contribution of rice production to farm income has declined with declining rice prices, there has been an associated decline in the income benefits attributable to bench terracing.

Put briefly, bench terraces yield the greatest income benefits when the optimum cropping mix is weighted heavily towards rice. Bench terraces benefit incomes least when the optimum share of cassava in the cropping mix can be obtained on non-bench terraced land. Since 1985, incomes have risen more because of rising cassava prices than because of bench terracing.

This finding helps explain why analyses of the Sinaga and USESE data sets yield conflicting results. Analysis of the Sinaga data set showed sizable net benefits for farmers who adopted the model farm technology, whereas analysis of the USESE data failed to show such significant net benefits. The Sinaga data were collected for the 1980 to 1981 period; the USESE data cover the 1981 to 1985 period. The Sinaga data set reflects a period when rice was a more economically attractive crop; the USESE data measure a period when the relative worth of rice was declining.

The USESE data sets were subjected to a wide range of statistical tests in order to examine alternative explanations proposed to us for the apparent lack of success of the model farm

technology. The results of these tests are based upon data for a relatively short time period, however, and should be treated with caution. The statistical tests indicate that we can rule out the learning process, soil degradation, source of income, diversion of subsidies to lowland rice fields, and differences in soils (i.e., volcanic versus sedimentary) as reasons for the apparent lack of success of the model farm technology to increase incomes.

The value of the model farm technology and, particularly, bench terracing, in terms of increasing farm incomes may be more of a long-run phenomenon than is observable with the available short-run data. Cyclical changes in rice and cassava prices induce changes in the cropping mix of farmers. Farmers with terraces are better able to take advantage of these price changes than farmers without terraces, especially when the shift is into rice production. Therefore, farmers with terraces are likely to have higher average incomes over the long run than farmers without terraces. But the present data are insufficient for testing this hypothesis.

7.2 SUCCESS OF THE MODEL FARM PROGRAM

Bench terracing, which is the major component of the model farm technology, spread rapidly during the 1981 to 1985 period. Not only is bench terracing within model farm projects nearly total, but bench terracing by nearby farms outside the project lags only slightly behind those in the project.

Extension workers are the primary source of information regarding bench terracing. This is the case not only for farmers in the project, but also for outside project farmers. The extension component of the model farm program for spreading the technology appears successful.

The need for many model farms for spreading the technology, however, is not obvious. Extension workers, not the visual presence

of the model farm, seem to be the catalysts for change. Moreover, the improved "before" condition of model farm sites since 1981 may be due to extension workers spreading the technology in advance of the model farms.

7.3 NEED FOR SUBSIDIES

Under certain conditions, bench terracing appears to pay for itself. Unsubsidized farmers outside the project are bench terracing using their own resources and their net incomes are increasing. The fact that the net incomes of the model farmers declined may be a function of input and output restrictions imposed upon them by the model farm program. If these mixes are somehow important to the demonstration function of the model farms, then subsidies are needed for these farmers. But neither subsidies for terracing nor program input subsidies are economically justified for other farmers.

There may be other purposes of the subsidies. For example, it has been argued that they contribute to the support of the extension workers. If this is the case, then there may be justification for subsidies beyond the model farms, but in terms of on-farm economics, they do not appear warranted. Credit may be needed more, but data are not sufficient to assess this need.

7.4 RESEARCH NEEDS

A number of questions have been raised by the preceding analysis. Some of these questions may have been answered in previous research with which we are not familiar, while other questions may require additional basic research. In order to complete the analysis of the model farm program and build confidence in the results reported here, the following questions need to be answered.

Flexibility to change the cropping mix in response to shifting relative prices is a prime determinant of the farmer's income. Terracing appears to enhance this flexibility, at least for some crops such as rice. The role of terracing in cassava production is less clear. Moreover, how the sustainability of cultivation on steep slopes is affected by terracing is not well defined. Research is needed to assess the physical relationships between terracing and changing cropping patterns and the sustainability of this type of agriculture over time.

Erosion from upland agriculture is thought to have negative downstream impacts. The model farm program may reduce these downstream costs, but in order to assess the magnitude of the benefits produced we need to know how much on-farm erosion is reduced by the model farm program, how much on-farm erosion contributes to downstream sediment problems, and what is the magnitude and cost of downstream sediment problems. The study being conducted by Dr. David Harper should contribute to answering the first question, but further research is needed to determine whether or not reductions in on-farm erosion have appreciable impacts on downstream sediment loads and what costs this sediment imposes.

The macroeconomics of the "uplands problem" have not yet been systematically explored. The limited success of the model farm program to increase net incomes appears due to the rise of cassava prices in recent years. At least in part, these rising cassava prices have resulted from a national policy seeking alternative exports to oil. Since cassava is not a terrace dependent crop and the effects of terracing on cassava production are not clear, the model farm program and national export policy may be working at cross purposes. Moreover, rising cassava prices may be encouraging further expansion of cropping on steep upland slopes. This expansion will likely justify more government programs and expenditures to control erosion. These issues merit further investigation.

Finally, the experience gained in the process of conducting this study provides insights into how data collection might be improved. The large data set utilized by this study was invaluable, but as was discovered, it is also inflexible. We recommend that in the future smaller, more directed data sets be collected. That is, well defined hypotheses should be formulated at the outset, data should then be collected to test these hypotheses, and the testing should lead to both conclusions and new hypotheses to be tested, perhaps with new data. Sequential testing and evaluation will shorten the time required to collect and analyze the data, while focusing attention on the most important issues. In addition, the use of carefully controlled experiments, although possibly more expensive than interview surveys, would contribute to the credibility and accuracy of the information. In our opinion, this strategy would contribute greatly to reducing the confusion and differences of opinion which inevitably arise when interpreting less structured surveys.

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ANNEX A

METHODOLOGICAL CONSIDERATIONS

Two methodological issues need to be clarified at the outset: (1) What are the appropriate experimental and control groups in the data set provided to us? (2) Is there a difference between evaluating the model farm technology and the model farm program?

A.1 ESTABLISHING EXPERIMENTAL AND CONTROL GROUPS

In order to assess the economic returns from the model farm program, it is necessary to determine benefits and costs of the program "with" and "without" the program. A simple "before" and "after" analysis may be erroneous if there have been changes other than those brought about by the program. That is, it is necessary to establish an experimental group "with" the program and a control group "without" the program.

In the data set provided us for this study, the model farmers and the expansion area farmers are supposed to represent the experimental group, while the outside project farmers are supposed to represent the control group. However, from our observations in the field and from the results of a mini-survey we conducted, we are relatively confident that the experimental and control groups have mixed over the period being investigated.

The ideal "before" situation for conducting the "with and without" evaluation of the model farm program is represented by Figure A.1, where it is shown that prior to adoption no farmer has undertaken measures similar to those in the model farm package (e.g., terracing). The ideal "after" situation is represented by Figure A.2, where the technology has diffused throughout the experimental group, but has not been adopted by the control or outside project group.

FIGURE A.1. IDEAL "BEFORE" ADOPTION

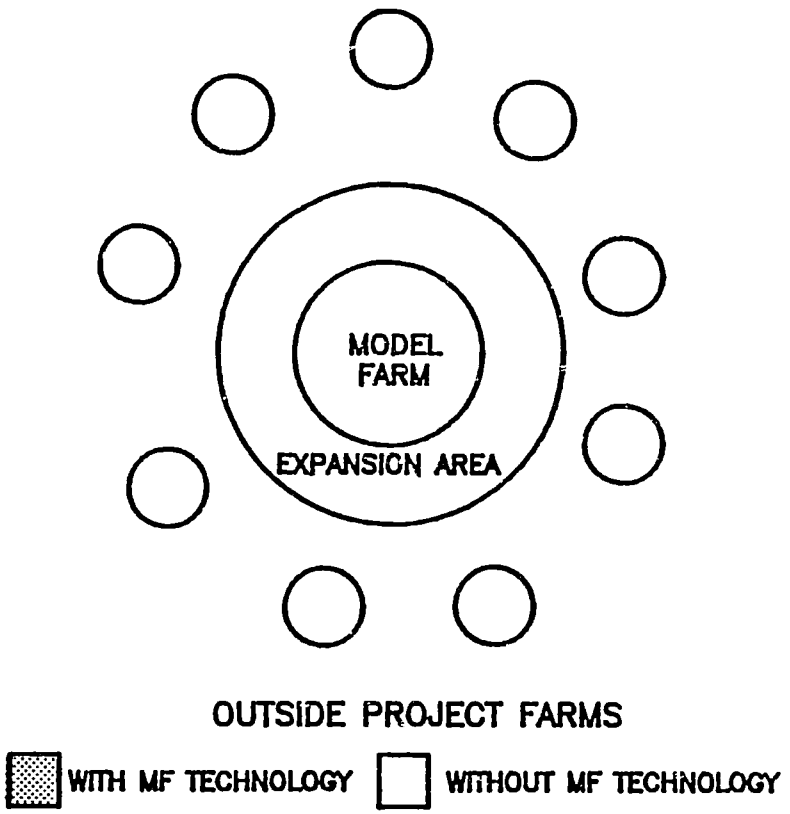
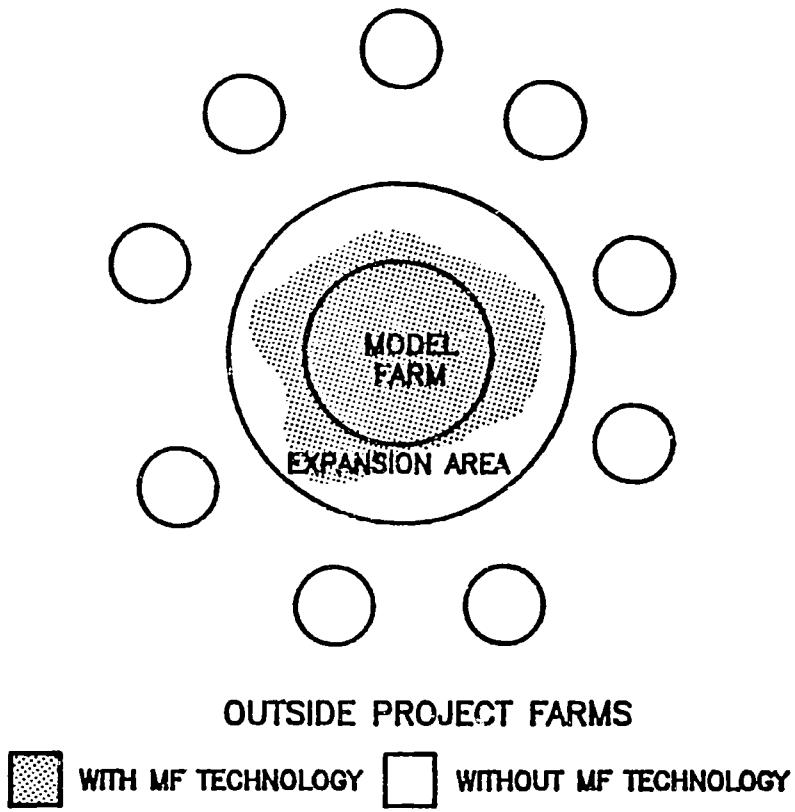


FIGURE A.2. IDEAL "AFTER" ADOPTION



For a variety of reasons, neither the ideal "before" or "after" conditions seem to be met. Earlier soil conservation programs or this program itself may have influenced both members of the experimental group and the control group to adopt practices similar to those of the model farm program prior to its "official" start, so that the actual "before" situation is represented by Figure A.3. Also, one might expect that (1) during the "after" period some of the progressive outside farmers may adopt the more profitable elements of the model farm package, or that (2) unrelated other factors, such as the introduction of drought resistent seeds and the promotion of water conservation practices by extension agents may alter the operations and profitability of the control group. That is, the actual "after" situation may look more like Figure A.4.

If the "before" and "after" groups cannot be accurately identified, the analysis will produce erroneous results. For example, if it is assumed that the ideal "before" and "after" situations hold and the analysis finds that the outside group performed as well as the inside group after the technology is introduced, then it might be concluded that the technology has no effect on net income and that what occurred within the project area would have happened anyway. This conclusion would be erroneous if the outside project farmers where influenced by and adopted some of the model farm practices. If this is the case, then the model farm program could claim a share of the benefits earned by the outside group.

A.2 ASSESSING THE TECHNOLOGY VS. THE PROGRAM

This brings up a very important point, namely, the difference between evaluating the technology vs. the program. The technology is defined as the package consisting of building bench terraces and utilizing new cropping and input mixes; the program is getting farmers to adopt the model farm technology.

Since the control group is effectively lost by the seemingly rapid spread of the model farm technology beyond the "project participants," it may be impossible to assess the technology fully. The control group or "without" condition selected is the "before" situation of the farmers in the 1981 model farm areas (the model farm program began in 1981); thus, these observations should not contain farmers who have already adopted the model farm technology. The "with" condition is the situation of all farmers after the model farm is begun in their village. Since the model farms are begun at different times, however, there may be some actors causing change, such as climate or pests, for which we can not account.

On the other hand, loss of the outside project "control" group may provide evidence of the success of the model farm program. If, indeed, it is the program which is responsible for the spread of the model farm technology beyond the "project" area, then the program is more successful than had been planned. That is, in order to assess the success of the model farm program, it is necessary to determine the extent to which the spread of the technology is attributable to the program.

Therefore, the evaluation of the model farm technology requires that we assess its benefits and costs; the evaluation of the model farm program requires that we determine the degree to which it spreads the model farm technology.

FIGURE A.3. ACTUAL "BEFORE" ADOPTION

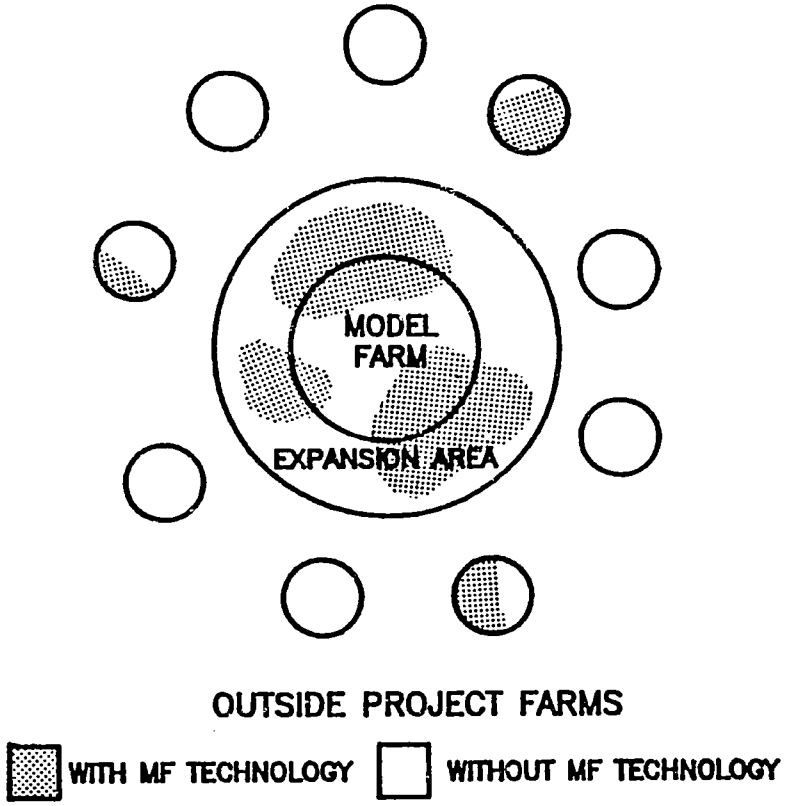
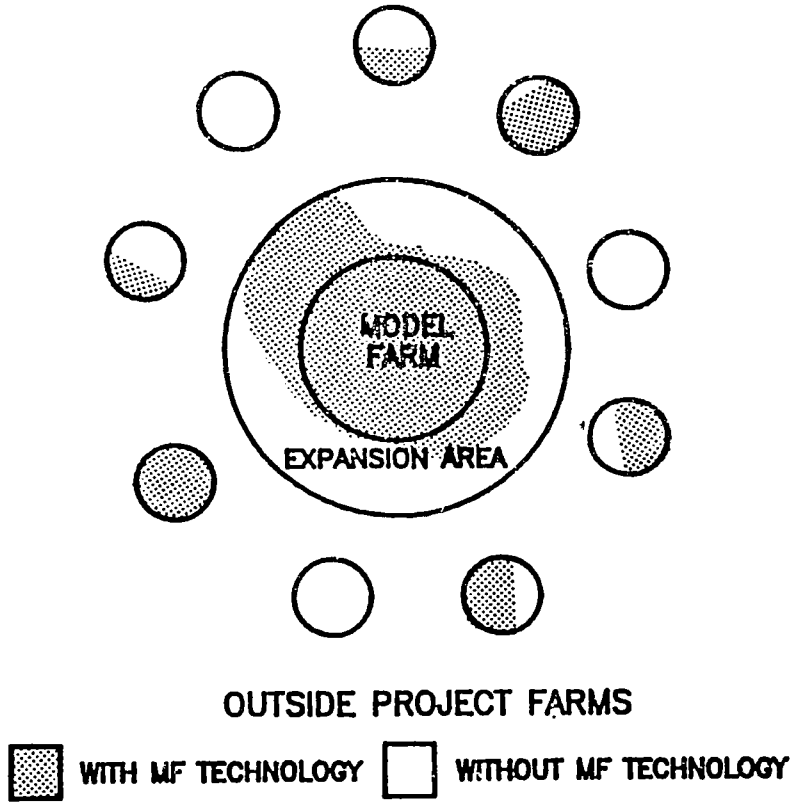


FIGURE A.4. ACTUAL "AFTER" ADOPTION



ANNEX B

A FRAMEWORK FOR MEASURING THE ECONOMIC EFFICIENCY OF THE MODEL FARM PROGRAM

The purpose of this annex is to present a framework for evaluating the model farm technology and program. In the course of analyzing the various facets of the problem, simple economic principles proved to be extremely helpful in disentangling the issues. This discovery gave rise to what is titled below "The Simple Analytics of the Evaluation Problem." In this section basic economic concepts are used to show how bench terracing might alter a farmer's options, how program subsidies might induce the use of new input mixes, how the relative prices of outputs could influence incomes (and, hence, project benefits), and how structural subsidies might affect the acceptance of the technology. The annex concludes with a set of hypotheses which are then tested in Annex C.

B.1 PROBLEM OVERVIEW

The accounting stance one takes plays an important role in shaping an evaluation. From the perspective of both the Government of Indonesia and donor agencies, an evaluation should focus on net social benefits. This means that all relevant costs and benefits are included, whether or not they accrue to or are incurred by the region affected. A public accounting stance is somewhat different from that of the farmer, who may be simply interested in how his net income responds to a new technology. Questions such as how downstream losses are affected, or who else might be absorbing project costs are of lesser importance. This does not imply that the two stances are unrelated. Private gains often comprise a significant part of the total social welfare. In some instances these gains, net of public expense, are so large that off-site benefits need not be considered.

The model farm package includes both bench terracing and a mix of crops thought to be less destructive to soil structure, and therefore less erosive. Whether the recommended mix is perceived by the farmer to be economically viable is key to the program's success. For without an acceptable economic return, it would be very difficult to ensure that recommended practices are continued once the program and the accompanying subsidies are terminated. Because of the importance of on-farm benefits in shaping farmer opinions regarding the acceptability of the technology, we begin with a detailed assessment of on-farm effects.

B.2 ANALYTICAL DETAILS

The private benefit derived from the construction of bench terraces is the difference in net incomes **with and without** the technology. The terms with and without are underscored to emphasize an important point mentioned above. That is, benefits can only be isolated by clearly establishing control and experimental groups. Ideally, the control group should include farmers not affected by the program and therefore should reflect what would have happened had the model farms never been established. For reasons pointed out in Annex A, in practice it is difficult to select and track a pure control group. There is no way of ensuring that the so called control group remains insulated from the experimental group. In the case of the Citanduy Project, this proved to be especially troublesome since both groups live in the same or in neighboring villages and information is freely exchanged among the different groups.

Frequently the with and without principle is confused with a related but incorrect standard of comparison which is based on events occurring before and after implementation. As will be explained below, farming practices "before" implementation may embody some aspects of the technology and therefore would not serve as an accurate benchmark for conducting the evaluation. In spite of

these difficulties, the with and without principle remains an indispensable tool in conducting benefit-cost studies. The economic framework presented in the following sections was developed with these concerns in mind.

B.3 THE SIMPLE ANALYTICS OF THE EVALUATION PROBLEM

The following analytical framework is provided to clarify the principle just described and to help lay the foundation for the econometric analyses which follow. It is highly simplified in order to capture the essential elements of the analysis without burdening the reader with unnecessary and complicating detail.

B.3.1 Background

The model farm program has been promoted primarily as a means of reducing upland soil erosion. There are also indications that the technology represents a cost-effective way of enhancing living standards and employment opportunities in the Citanduy region. The question of whether these changes have been prompted by the provision of subsidies, induced by a temporary shift in the price of cassava, or whether they represent a sustainable improvement in farming methods can be subjected to economic analysis. The models which follow are intended to sort out these issues.

Upland farmers can choose from a wide variety of cropping patterns, ranging from monoculture in either rice or cassava, to a highly diversified mix of cassava, rice, soy, peanuts, and maize. In addition, most farmers cultivate tree crops, primarily coconut. The wide diversification of cropping that can be observed in the Citanduy area is product of a number of forces, not the least of which is the protection it offers against potential crop failure. Cassava, although not a first choice as a food crop, is highly drought resistant and therefore serves as a form of insurance against loss due to unfavorable weather conditions or pest

infestations. More recently, cassava has gained favor as a cash crop as export market pressures have produced a rapid rise in its price.

B.3.2 A Simplified Mixed Farming Model

Mixed farming such as found in the Citanduy area is difficult to evaluate since it is nearly impossible to attribute the effects of purchased inputs, labor and land improvements to individual yields. To circumvent this problem researchers have resorted to indices such as output value (in rupiah or rice equivalents). However, such approaches introduce new sets of problems, which if not recognized and properly addressed could lead to erroneous conclusions.

The following highly simplified model is introduced to illustrate how a typical farmer might respond to the offer of both input and capital subsidies and how their termination might affect farming practices. The model is used to develop a set of hypotheses used in Annex C to test whether the introduction of bench terracing has proven to be economically beneficial.

Consider the simplest of mixed farming systems. A farmer tilling a fixed amount of land(X), applying a given amount of labor(L) and inputs(I) must decide how much cassava($Q_c$assava) and rice($Q_r$ice) to produce. A separate production relationship, shown as Eq. (1) and Eq. (2) in Table B.1, governs how labor and purchased inputs translate into yield.

The variables used in the model are defined in Table B.2. The responsiveness of each crop to inputs differs in two important ways. Rice production is assumed to be sensitive to the extent of terracing(z), whereas cassava is not. Second, purchased inputs are assumed to be most effective in stimulating rice yields only; in order to simplify the analysis, cassava production is shown to be

Table B.1. A Simplified Mixed Cropping Model

Eq.(1) $$\frac{Q_{rice}}{X} = z a_1 (1-k)^{b1} \left(\frac{I}{X}\right)^{c1} \left(\frac{L_{rice}}{X}\right)^{d1}$$

Eq.(2) $$\frac{Q_{cassava}}{X} = a_2 k^{b2} \left(\frac{L_{cassava}}{X}\right)^{d2}$$

Eq.(3) $$X = X_{cassava} + X_{rice}$$

Eq.(4) $$k = \frac{X_{cassava}}{(X_{cassava} + X_{rice})}$$

Eq.(5) $$L = L_{cassava} + L_{rice}$$

Eq.(6) $$\frac{GFI}{X} = P_{rice}\left(\frac{Q_{rice}}{X}\right) + P_{cassava}\left(\frac{Q_{cassava}}{X}\right)$$

Eq.(7) $$\frac{Cost}{X} = \left(\frac{I}{X}\right) P_I + \left(\frac{L}{X}\right) W$$

Eq.(8) $$Cost_{terrace} = f(z)$$

Eq.(9) $$\frac{NFI}{X} = \frac{GFI}{X} - \frac{Cost}{X}$$

Eq.(10) $$\frac{NSB}{X} = \frac{NFI}{X} - \frac{OFC}{X}$$

Eq.(11) $$\frac{OFC}{X} = f(z, k)$$

Table B.2. The Variables Defined

Qrice	rice yield measured in kilograms
Qcassava	cassava yield measured in kilograms
X	farmer's plot in hectares
Xcassava	area planted in cassava
Xrice	area planted in rice
k	percentage of the total area planted in cassava
1-k	percentage of the total area planted in rice
z	extent of terracing
I	units of purchased inputs(fertilizer, seeds, and pesticides) applied
PI	unit cost of purchased inputs
L	annual number of on and off-farm mandays of labor applied to the plot(preparation, cultivation, weeding, harvesting etc.)
W	wage rate per manday
Lrice	labor devoted to cultivation of rice
Lcassava	labor devoted to the cultivation of cassava
GFI	gross farm income(crop yields times market value)
NFI	net farm income(gross income less cost of on and off farm labor less cost of purchased inputs)
NSB	net social benefits(on farm benefits less off-farm costs of erosion)
OFC	off-farm costs of cultivation(siltation, damage to estuaries, flooding, etc.)
a1,b1,c1, d1,a2,b2, d2	are parameters of the rice and cassava production functions

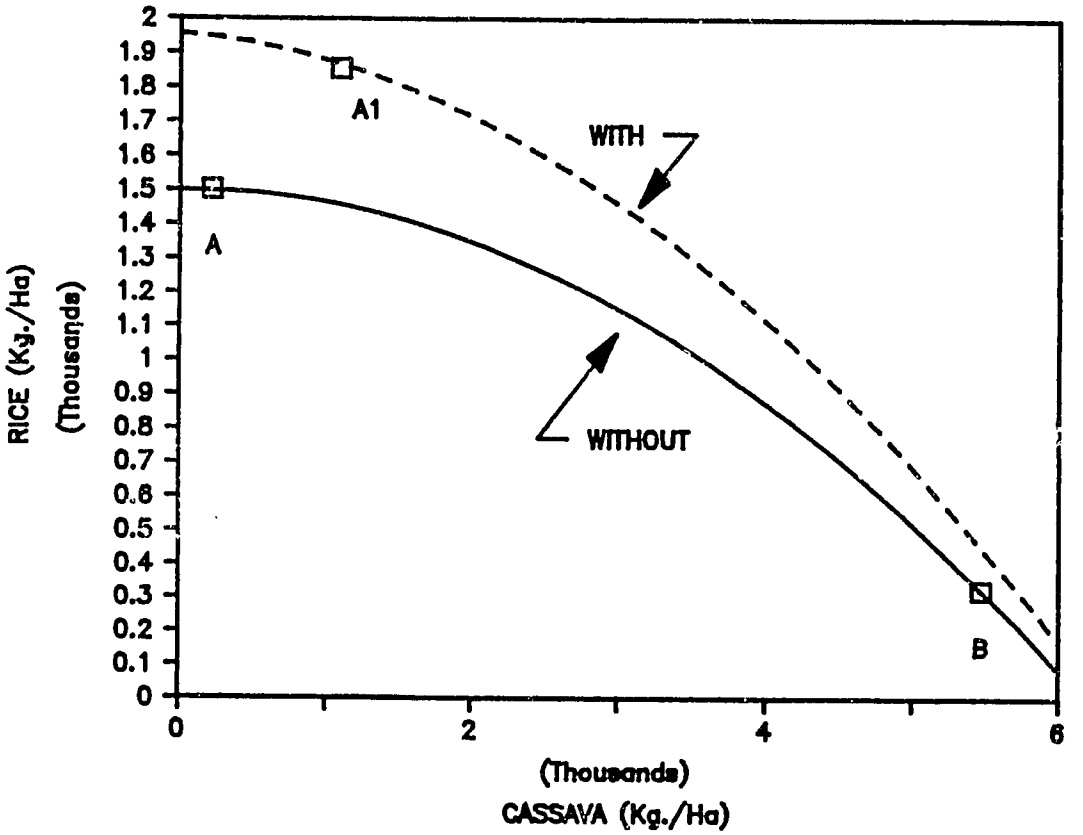
independent of the application of fertilizers and pesticides. The percentage(k) of the farmer's plot devoted to cassava is shown to depend on relative yields, the cost of inputs and the price each crop will fetch in the marketplace.

B.3.3 The Technology and Production Possibilities[1]

The net return to bench terracing hinges on how the technology alters the mix of crops a farmer can produce on a fixed plot of land. Figure B.1 illustrates the influence of the production relationships shown in Table B.1 (Eq. (1) through Eq. (5)) on rice and cassava harvests. The solid line shows the various combinations

[1] We use the term production possibilities loosely, since the curves shown in Figure 4.1 are based on different input levels. They therefore represent an "envelope" of possibilities.

FIGURE B.1. PRODUCTION POSSIBILITIES



that could be produced on a hectare of ground given a fixed amount of labor and other inputs. The word fixed is emphasized since in reality the production of rice will require resources not necessary to produce cassava. At the extremes, points A and B, the farmer need sacrifice very little of his primary crop to produce small amounts of the alternate. But, foregone production rises as more of the alternate is cultivated.

The slope of this curve reflects the tradeoff the farmer faces. Should he use limited resources to produce cassava or rice, or some combination of both? The answer to this question depends on the relative price of the two commodities. When the relative price of cassava vis a vis rice is high, he should be more willing to sacrifice rice harvests by planting more cassava. A combination closer to point B may appear more attractive than one nearer point A.

The introduction of bench terracing and recommended cropping patterns should alter production possibilities in two ways. One, it should shift the feasible range of options, shown as the dashed line in Figure B.1. This implies that $z>1$ in Eq. (1). Given the assumption made earlier that terracing exerts a disproportionate influence on rice yields, the production possibilities curve will rotate clockwise as shown. Two, the model farm package includes subsidized inputs. Fertilizers, seeds and pesticides are provided to participating farmers (model farmers and subsidized expansion area farmers, or dampak). In exchange, the farmers are required, or strongly encouraged, to adopt recommended practices which deemphasize the cultivation of cassava. This is reflected in Figure B.1 as point A1. Technically, once the subsidy is terminated the farmer is free to adopt any production possibility made feasible by the technology.[2]

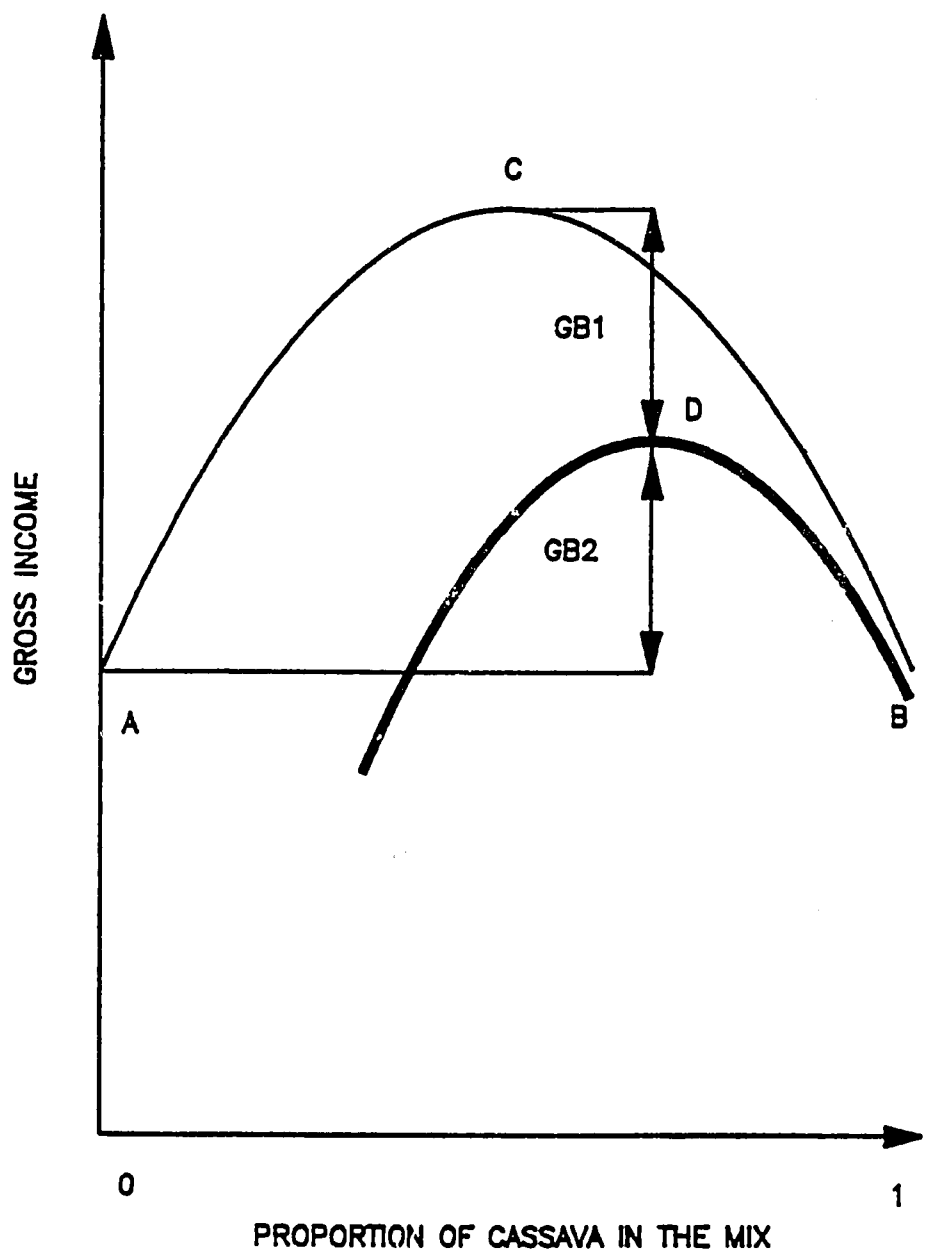
B.3.4 Cropping Mix and Farmer Income

The production possibilities concept is a useful tool for showing how the technology could increase on-farm income. In the case of the two-crop example portrayed in Figure B.1, it would be unwise for the farmer to produce solely rice or cassava. The opportunity cost of the alternate may be prohibitively high. At either extreme, gross farm income (GFI) would rise by introducing some of the alternate crop. Gross farm income is maximized when 1000 Rp of additional rice is produced per 1000 Rp of cassava sacrificed. That is, the value gained as a result of shifting the cropping pattern equals what is lost.

[2] When analyzing cropping mixes, it is important to consider limitations such as access to credit needed to purchase required inputs, and social pressure to continue the recommended practices. However, the framework employed in this study emphasizes the importance of economic forces, and these potentially important factors had to be omitted from consideration.

Figure B.2 illustrates this concept formally. The cropping mix, now represented as a ratio of production (cassava to rice, k), is related to gross income. The darkened curve reflects the income changes previously described. Gross income rises with the first kilogram of rice (Point A) or cassava (Point B) produced, peaking at a ratio in between the extremes of 0 and 1. The introduction of bench terracing and subsidized inputs raises income for each cropping mix, less so for cassava and more so for rice intensive plots.

FIGURE B.2 INFLUENCE OF TECHNOLOGY ON GROSS INCOME



Ignoring costs of production for the moment, the gross benefit is shown as GB1, if the farmer is allowed to elect the cropping mix which yields the highest reward. In the event that cassava is discouraged or prohibited, gross benefits decline to GB2, which in this illustrative case proves to be negative. In general, GB2 could be positive or negative, but will always be less than GB1. In summary, GB1 is the gross benefit when cropping is unregulated; the introduction of restrictions will reduce the technology's benefits to a minus GB2 in this extreme example.

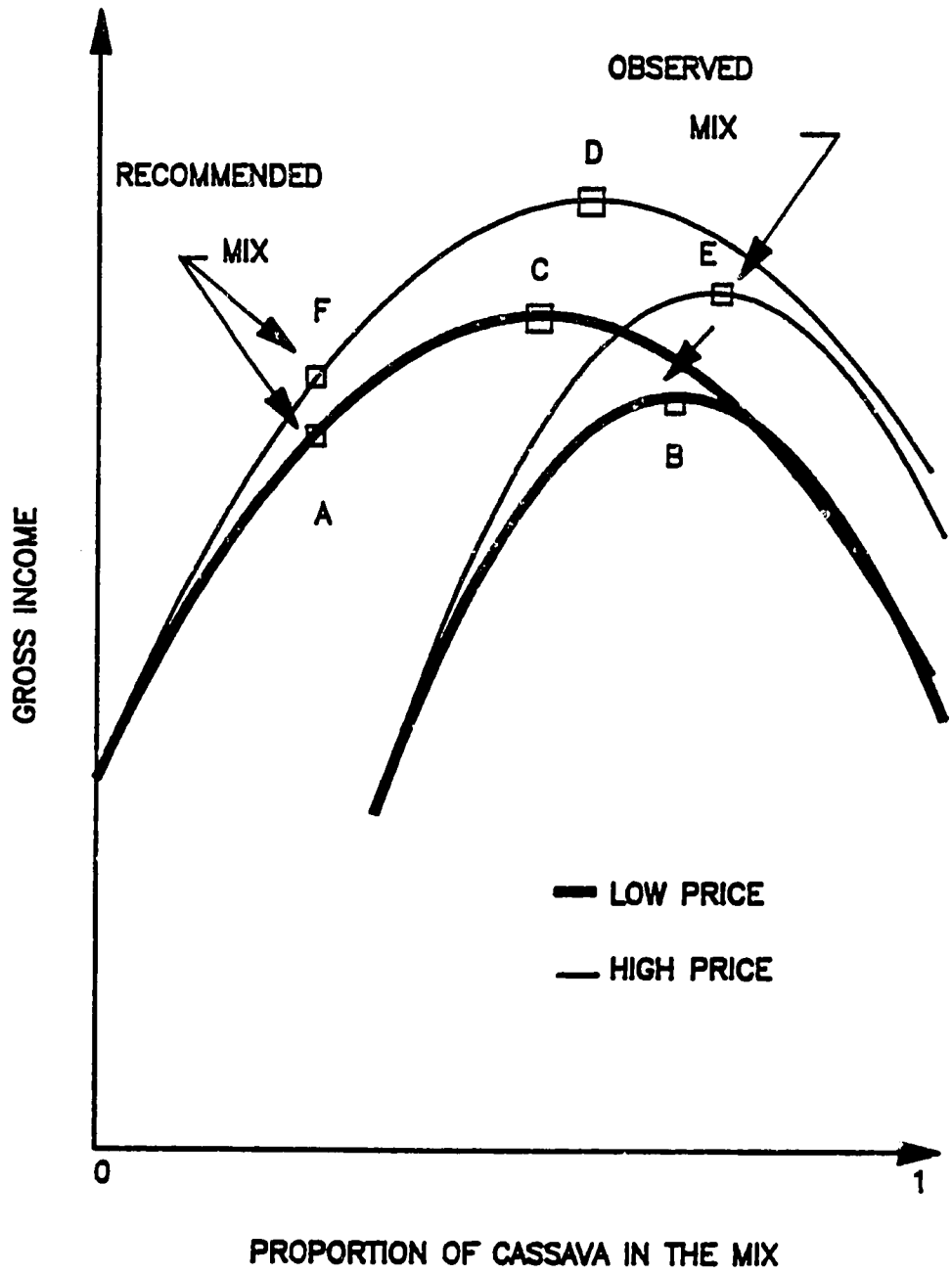
This highly simplified analysis suggests important considerations regarding management strategies. Once input subsidies are terminated there will be little incentive for the farmer to remain at the regulated cropping mix, barring the factors mentioned above. It is most likely that if the perceived loss of benefits is substantial, the farmer will increase cassava production (to point C), but not so much as to return to the pre-terrace cropping mix (point D). The attractiveness of cassava, and the potential benefit of the technology, are highly sensitive to the relative price of cassava and rice, a point to which we now turn.

B.3.5 The Impact of Output Price Changes on Gross Farm Income

For reasons partly tied to European demand for Indonesian cassava, the price of cassava has risen dramatically since 1981. At that time the market price was approximately Rp. 25 per kg. or .1 times the price of rice. By 1985 the price had climbed to Rp. 42 (.15 times the price of rice) and by 1987, it had almost doubled again (Rp. 75 per kg. or .25 times the rice price). It is clear from the framework just developed that this set of events is making it increasingly difficult to convince farmers to adopt the transition recommended by the model farm technology, and to sustain it once adopted.

Figure B.3 demonstrates how gross farm income and subsequently model farm benefits could be altered by changed market conditions.

FIGURE B.3 INFLUENCE OF CASSAVA PRICE ON GROSS BENEFITS



The lower (darkened) curves were explained above. The upper curves reflect the influence of cassava price changes on farm income. In order to simplify the presentation and focus attention on output prices, production costs have been temporarily ignored. As a result, a change in gross income is equivalent to a change in gross benefits. A more formal and complete treatment of production costs is presented in the following section. There, the optimum mix of inputs and outputs will be addressed.

Assume that points A and B represent the initial starting points for those adopting the package and those who have not. B, the optimum mix of cassava without terraces, is shown to be greater than for mix C, the optimum with terraces. This reflects the assumption that cassava production is not greatly enhanced by the presence of a terrace, at least relative to other crops such as soy, maize and rice which require greater amounts of soil moisture. As a result of the technology, the productivity and hence the cassava ratio declines Note, however, that mix C exceeds the recommended level of production, identified as A. Hence, A and B represent the initial starting points.

Escalating cassava prices boost incomes for non adopters (to point E) by more than those for adopters (point F). It is important to note that the price change has also diminished the gross benefits of implementing the technology. Rather than comparing incomes earned at B and A to determine whether the technology is economically feasible, prospective adopters must now compare incomes earned at E and F. For the example provided, it is clearly in the farmer's best interest to shun the package: the incomes at E exceed those the farmer would earn at the regulated mix F. Gross incomes would improve if allowed to move to D.[3]

[3] For those who have previously invested in bench terracing, the associated excavation costs are sunk. As a result, they too benefit from the price changes, albeit by a lesser amount than those whose cropping options are unrestricted. The new price does, however, increase the opportunity cost of adhering to the recommendations, rising in this case from A-C to F-D.

Note that this particular conclusion is not generalizable but is simply a result of how the curves are positioned. However, it is true that rising cassava prices diminish gross benefits. Whether this reduction is sufficiently large to warrant attention is testable.

B.3.6 Optimum Cropping Mix and Input Usage

The model presented in Table B.1 can be solved to obtain the mix of inputs and outputs which maximizes net farm income. Table B.3 shows the first order conditions derived by differentiating Eq. (9), Table B.1, with respect to k, $L_r$ice, L and z, and setting the resultant expressions equal to zero. According to the model, farmers could maximize their net return by:

1) adjusting the amount of land devoted to cassava production so that the additional gain just equals the income lost as a result of sacrificing rice yields, Eq.(2);

2) applying purchased inputs in amounts that enhance farm income by at least as much as the costs incurred, Eq.(3);

3) expanding the use of on- and off-farm labor by an amount which yields additional product justifying the wage (both implicit and explicit) paid Eq.(15);

4) allocating labor to the cultivation of rice and cassava in proportion to the respective returns each crop earns Eq.(14);

5) employing bench terraces if the increase in farm income warrants the costs of construction, Eq.(16).

6) increasing the proportion of land devoted to cassava production (k) when the price of cassava rises relative to rice;

Table B.3 First Order Conditions for Maximizing Net Farm Income

Eq.(12) $$\delta\frac{\frac{NFI}{X}}{\delta k} = P_{cassava} b_2 a_2 k^{b_2-1}\left(\frac{L_{cassava}}{X}\right)^{d2} - P_{rice} b_1 z a_1 k^{b1-1}\left(\frac{I}{X}\right)^{c1}\left(\frac{L}{X}\right)^{d1}_{rice} = 0$$

Eq.(13) $$\frac{\delta\frac{NFI}{X}}{\delta I} = P_{rice} c_1 z a_1 (1-k)^{b_1}\left(\frac{I}{X}\right)^{c1-1} - P_I = 0$$

Eq.(14) $$\frac{\delta\frac{NFI}{X}}{\delta L_{rice}} = P_{rice} d_1 z a_1 (1-k)^{b_1}\left(\frac{I}{X}\right)^{c_1}\left(\frac{L_{rice}}{X}\right)^{d_1-1} - P_{cassava} d_2 a_2 (L - L_{rice})^{d_2-1} = 0$$

Eq.(15) $$\frac{\delta\frac{NFI}{X}}{\delta L} = P_{rice} d_1 z a_1 (1-k)^{b_1}\left(\frac{I}{X}\right)^{c1}\left(\frac{L_{rice}}{X}\right)^{d_1-1} - W = 0$$

Eq.(16) $$\frac{\delta\frac{NFI}{X}}{\delta z} = P_{rice} a_1 (1-k)^{b_1}\left(\frac{I}{X}\right)^{c_1}\left(\frac{L_{rice}}{X}\right)^{d_1} - f'(z) = 0$$

7) terracing additional land and increasing the application of purchased inputs as the price of rice rises;

8) increasing the use of labor as the proportion of cassava to total yield diminishes.

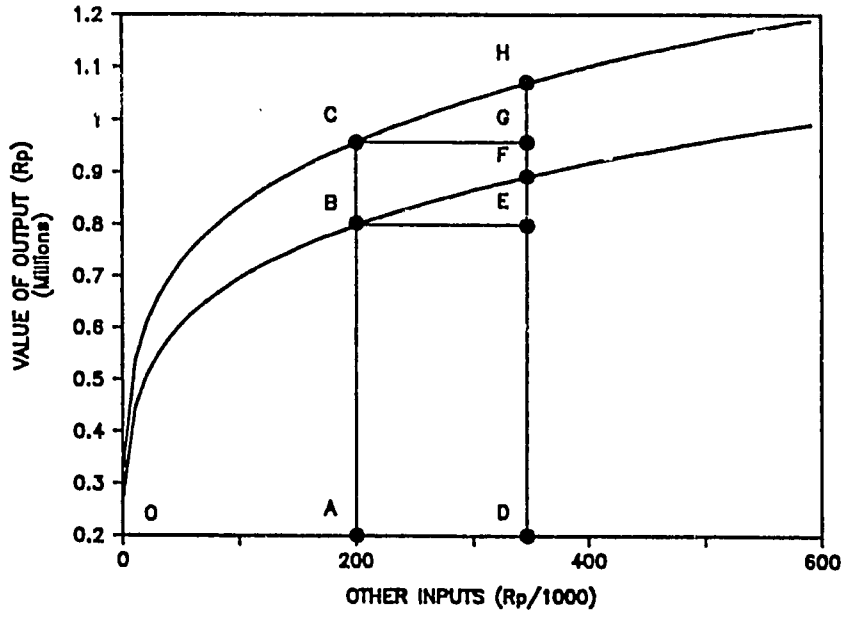
These principles focus attention on how net farm income might respond to a variety of factors, some of which are tied to the model farm program and some of which are external to it. They also provide the basis for isolating on-farm benefits derived from terraces in contrast to the enhanced yields resulting from the provision of input subsidies.

B.4 ISOLATING THE ON FARM BENEFITS OF BENCH TERRACING

As mentioned above, the model and dampak farmers of the project received two types of subsidies, one to defray expenses incurred in the process of excavating the terrace and the other in the form of seed and chemicals. Although lumped together as simply "subsidies," they are quite different. The aid provided to prepare the land can be viewed as a capital investment, one which could, or should, lead to a stream of additional income over the life of the terrace. Chemical and seed subsidies, however, are entirely different. Under normal circumstances increased use of inputs yields some return to the farmer. Whether this return is sufficient to cover their cost is open to question. However, incomes will rise. This point is emphasized to avoid confusion. It has been argued by some that since post-project farm incomes have been observed to increase, the program must be succeeding and therefore terracing is economically viable. This may be true, but in order to substantiate such a claim, the effects of terracing would first have to be separated from the effects produced by increased use of fertilizers and pesticides. A priori, it is impossible to determine which of the two is responsible for the changes observed.

The extensions to the model discussed above focus attention on how net farm income is influenced by labor, and particularly the use of purchased inputs. Under certain conditions, the outward shift in the envelope of production possibilities (shown in Figure B.1) results in increased farm income. However, Figure B.2 masks the effects of bench terracing. Since the model farm package provides for the distribution of subsidized chemical inputs, it is impossible to conclude how much of the shift portrayed is attributable to terraces. By desegregating the effects in Figure B.4, the two types of benefits can be clearly isolated.

FIGURE B.4. VALUE OF OUTPUT RELATED TO INPUTS



Gross income is shown to rise by an amount equivalent to H-E, E-F of which can be attributed to the increased availability of inputs (A-D). The gain identified as E-F would have been observed had the terrace not been built. Therefore, the gain H-F is traceable to the terrace.

Given the way the diagram is drawn, the farmer should continue buying inputs amounting to O-A and supplementing them with the subsidized quantity A-D. The reason for this is best explained with

reference to the demand for inputs and their associated costs, Figure B.5. When viewed at the margin, the subsidy induces the farmer to utilize input levels which, in this illustrative example, appear uneconomical. That is, at rate of application O-D, the marginal value produced by the last unit applied to the plot is less than the cost of purchasing that unit. The shaded area portrayed in Figure B.6 is equivalent to the increased gross farm income produced by the combined effects of terracing and chemical inputs. Whether the inputs supplied by the government increase farm income by at least enough to cover their costs depends on the productivity of the chemicals. In terms of the illustrative example chosen, the cost of subsides exceeds the combined benefits of terracing and the application of additional fertilizer. This is apparent since the region to the right of I and above the new demand for inputs represents costs incurred but not compensated by a commensurate change in farm income.

B.4.1 What the Model Suggests about the Time Pattern of Input Use and Output Value

If the farmer initially applies O-A units of purchased inputs costing A-C,[4] and then receives a supplement from the government amounting to A-D, output value should rise by an amount equivalent to the shaded area shown in Figure B.6, or the vertical distance B-H in Figure B.4. However, at the A-D rate of application, fertilizers are costing the government more than they increase gross farm income. As a result, it is to be expected that the rate of usage would decline to O-I once subsidies are terminated, while the value of farm output should decline accordingly.

[4] The farmer is assumed to purchase inputs, i.e., seeds, fertilizers and pesticides, so as to maximize net economic return according to (Eq.(13), Table B.2).

FIGURE B.5. MARGINAL VALUE OF INPUTS

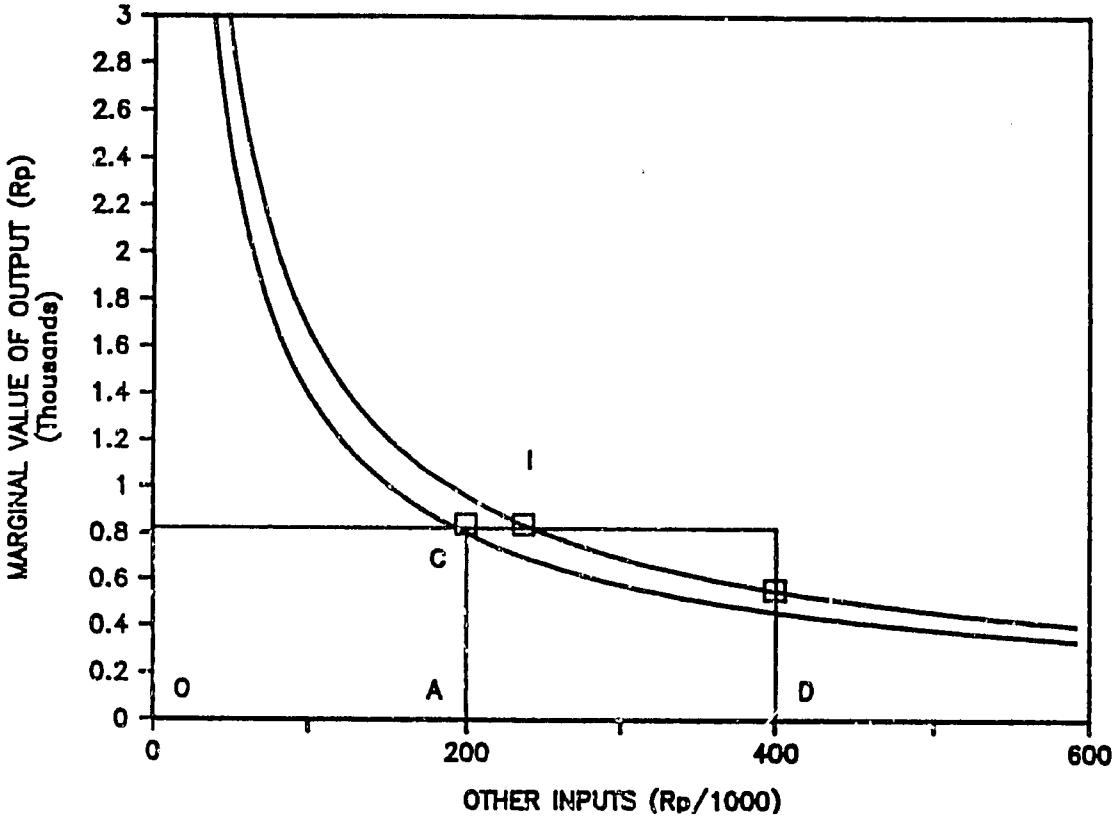
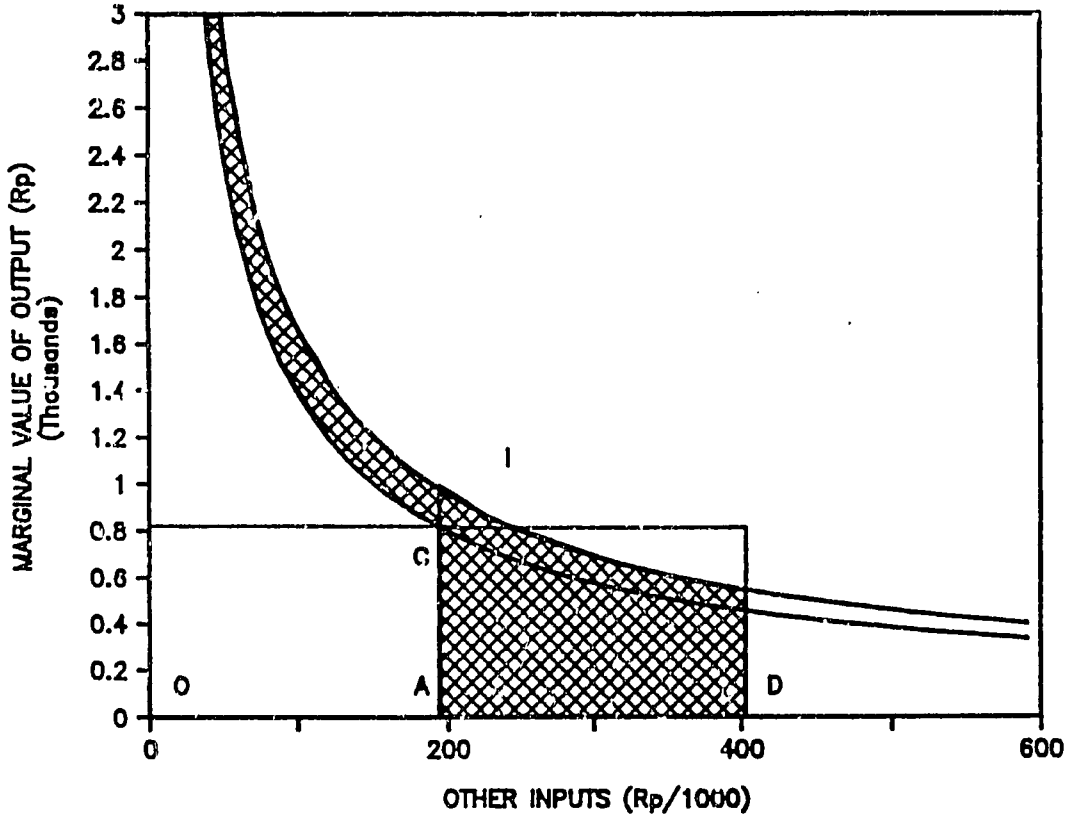


FIGURE B.6. CHANGE IN GROSS FARM INCOME



In the event that the initial level of subsidized inputs is less than O-I, the farmer should supplement it until O-I is achieved. In this case the withdrawal of the subsidy would leave both input use and outputs unchanged. It is impossible to know whether subsidies have been excessive; however, it is safe to conclude that amounts deemed to be "insufficient" would be supplemented. Therefore, the withdrawal of subsidies should result in either no change in input use (and value) or lead to a decline. On average, both the rate of application and production should fall.

The recent escalation in cassava prices should also influence input use and yield by crop. Based on the theoretical framework developed above, rising cassava prices should trigger a shift in production which deemphasizes rice and therefore reduces reliance on purchased inputs.

B.4.2 The Cost Effectiveness of Terraces

The net benefit of terracing is isolated in Figure B.7. The shaded areas representing the increased return to inputs (shown) and labor (not shown) can be attributed to the terrace. The net return to terraces is then the discounted sum of these increases. This raises the possibility of over estimating the benefit of terracing. If input output data are collected during a period when subsidies are provided, the shaded area shown in Figure B.7 could be larger than that observed after the subsidies are withdrawn.

B.4.3 The Cost Effectiveness of Input Subsidies

Analysis of input demand also indicates whether the benefits received by the farmer are at least equivalent to the amount of subsidy paid. Technically, shifts in labor and input demand, such as shown in Figure B.5, reflect the enhanced productivity of the land due to the construction of terraces. So increases in gross farm income stemming from additional use of inputs should be linked to the terrace and not to the chemicals. Figure B.8 is a magnified

FIGURE B.7. BENEFITS OF TERRACING AFTER SUBSIDY IS ENDED

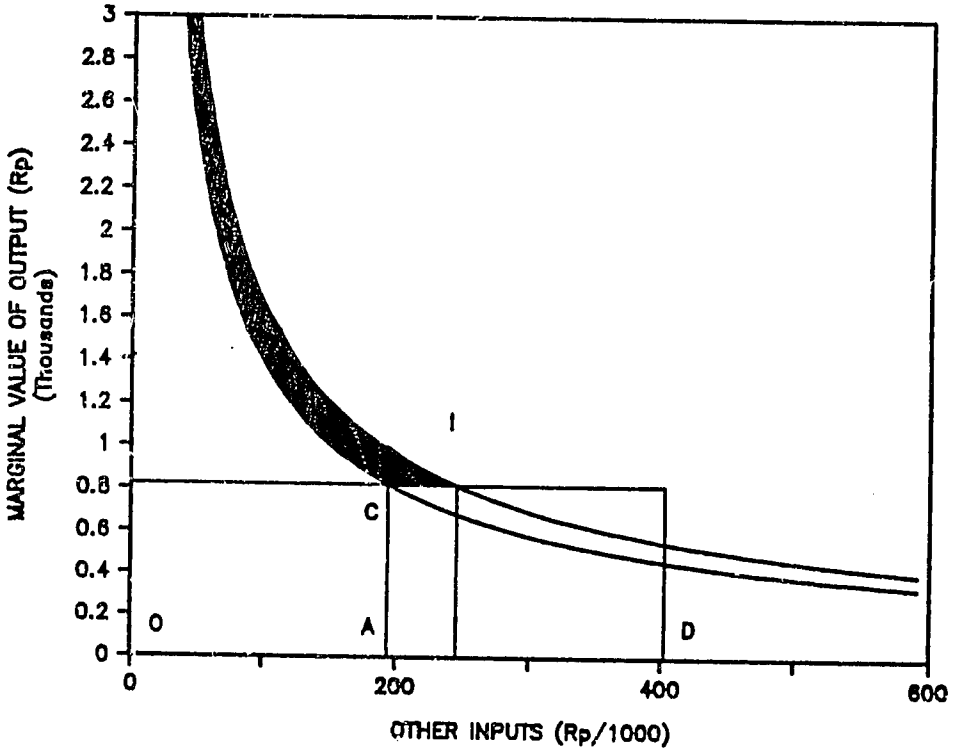
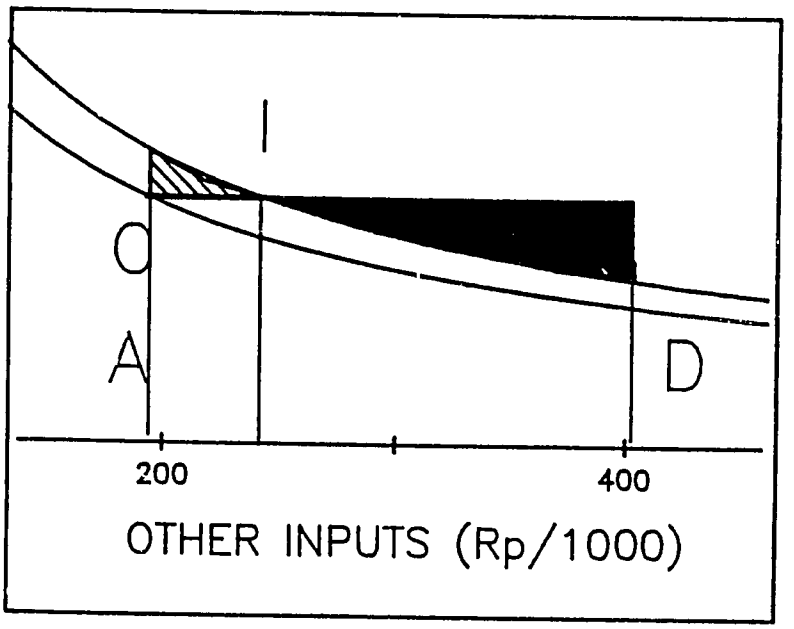


FIGURE B.8. MAGNIFIED VIEW AROUND POINT I



view of the region near point I shown in Figure B.5. The shaded area to the left of I represents the value added as the rate of chemical usage rises from O-A to O-I. This area represents an addition to terracing benefits which is traceable to the new level of input use. If the subsidy totals to A-D, gross farm income increases by an amount which is less than the cost of purchasing the inputs. This loss to the Government of Indonesia is represented by the shaded area in Figure B.8. In the example portrayed, the farmer pays only for O-A; the remaining amount, A-D, is provided by the government.

B.5 INCORPORATING EXTERNALITIES AND PRICE SUPPORTS

The orientation taken above was heavily weighted toward the measurement of private benefits. This is in part due to the fact that on-farm benefits comprise a significant component of total social gain. In addition, it reflects our judgment regarding the accuracy and availability of off-site damage data. At least conceptually, the simplified model just developed is readily expanded to incorporate off-site erosion costs. If it could be demonstrated that flood damages, siltation of hydroelectric reservoirs and increased irrigation system maintenance costs are all attributable to the cultivation of steep unterraced slopes, then the argument for continuing subsidization of bench terraces might be warranted, regardless of on-farm benefits. The inclusion of off-site losses is readily appended to the model. Although lack of data prevents the inclusion of off-site costs, they can at least be addressed conceptually.

The net social gain from terracing, NSB of Eq. (10), Table B.1, is the private gain less off-site costs. Erosion costs are assumed to be a function of terracing and the proportion of cassava in the cropping mix, Eq. (11). The more of the former and the less of the latter, the lower erosion costs are likely to be. However, it is unlikely that farmers acting on their own behalf would take these

effects into account in selecting the most efficient mix of crops (k) or land improvements (z). Therefore, the levels of k and z (derived from the first order conditions shown in Table B.3) that maximize net income will not necessarily maximize net social benefits.

Publicly financed programs to manage rice prices and maintain fertilizer costs at an affordable level alter the incentives to terrace. According to the model, lowering the cost of chemicals and seeds and increasing the market price for rice should induce farmers to construct terraces on their existing plots, thereby permitting a production shift, out of cassava and into rice. However, at the same time, high cassava prices might prove to be a powerful incentive for expanding the cultivation of cassava on virgin and more steeply sloped lands.

Since the Government of Indonesia's policy regarding subsidies is currently in a state of flux, these macro level issues were not incorporated into quantitative measurements of net social benefits. However, it is important to note that GOI macro level policies do impact the acceptability of upland soil conservation programs.

B.6 A NUMERICAL EXAMPLE

The following numerical example is provided to illustrate the issues discussed above. It is based on the model shown in Tables B.1 and B.3[5] and the parameter values provided in the upper part of Table B.4. Experiments labeled 1 through 6 were performed. These are summarized in Table B.5. Experiment 1 represents what the program's formulators might have believed to be the "without" case:

[5] The influence of labor was omitted from the production functions in order to simplify the calculations.

Table B.4. Parameter Values and Solutions to the Numerical Model

VARIABLE	EXPERIMENT 1	2	3	4	5	6
X	100	100	100	100	100	100
z	1.0	1.0	1.5	1.5	1.5	1.5
a1	250	250	250	250	250	250
b1	0.3	0.3	0.3	0.3	0.3	0.3
c1	0.1	0.1	0.1	0.1	0.1	0.1
a2	500	500	500	500	500	500
b2	0.4	0.4	0.4	0.4	0.4	0.4
I					10000	10000
pI	10	10	10	10	10	10
p rice	200	200	200	200	200	200
p cass.	50	100	50	100	50	100
I	4284	3807	6984	6512		
X rice	79	56	89	72	89	73
X cass.	21	44	11	28	11	27
k	0.44	0.55	0.27	0.37	0.26	0.35
Q rice	2142	1903	3492	3256	3627	3418
Q cass.	1681	2280	1310	1895	1283	1857
deltQ1	8	10	12	14	12	14
deltQ2	-32	-21	-47	-27	-49	-28
MVX rice	1622	2054	2357	2711	2433	2794
MVX cass.	-1622	-2054	-2357	-2711	-2433	-2794
MVI	10.0	10.0	10.0	10.0	7.3	6.8
GFI	512498	608662	763938	840677	789486	869297
NFI	469656	570596	694095	775555	689486	769297

Key

deltQ rice	the marginal product of an additional unit of land devoted to rice production
deltQ cass.	the marginal product of an additional unit of land devoted to cassava production
MVX rice	the marginal value of an additional unit of land devoted to rice production
MVX cass.	the marginal value of an additional unit of land devoted to cassava production
MVI	the marginal value of an additional unit of inputs
GFI	gross farm income
NFI	net farm income

Table B.5. Interpretation of the Experiments

Experiment	Before/After Model Farm	Terrace	Input Subsidy	Cassava Price
1	Before	No	No	Low
2	After	No	No	High
3	After	Yes	No	Low
4	After	Yes	No	High
5	After	Yes	Yes	Low
6	After	Yes	Yes	High

that is, the income level and cropping mix observed on a typical unterraced plot. Experiment number 5 depicts a terraced farm, the owner of which is still receiving input subsidies. Experiment 3 illustrates how the same farmer might respond to the termination of subsidies.

B.6.1 Interpreting the Results

The results of experiments 1 through 4 were derived by solving the first order conditions, Eq. (12) through Eq. (15) in Table B.3 with the parameters shown. The land area was assumed fixed at 100 units. The decision variables are X rice and X cass., the land/area devoted to the production of the two crops, I, the level of input use, and L, labor. Crop yields (Q), the marginal value of additional inputs (MVI), the ratio of cassava to other crops (k), and the change in productivity resulting from a shift in cropping patterns (delt Qrice, delt Qcass.) gross farm income and net farm income are derived from the final solution.

Solutions for experiments 5 and 6 were derived by setting inputs equal to 10,000 units, a level of application in excess of what the farmer would elect if forced to pay the market price. The value of the last input unit drops to 7.3 and 6.8., yielding a return which is less than its assumed cost of 10.

B.6.2 Conclusions Drawn from the Example

As noted in Table B.5, experiment number 1 reflects the condition that might have been observed prior to implementation of the model farm package. Cassava prices were low relative to that of rice and few farmers had adopted bench terracing practices. Accordingly, net (469,655 Rp) and gross farm income (512,498 Rp) is the lowest of the experiments investigated. Experiment number 2 points out that the escalating price of cassava improves net income substantially, in this case by 18.7 percent. This is shown to occur without constructing bench terraces. Note also that input usage declines as a result of the price induced change in cropping mix. Experiment number 2 may be thought of as representing a farm plot "after" the technology but under the new price regime.

Bench terracing is first introduced in experiment number 3. Here, the twin effects of low priced cassava and the advantage terraces offer the farmer, in terms of enhancing rice yields, result in a significant swing toward rice. At the same time input usage rises from 4,284 to 6,984 units per hectare. If cassava prices had not changed, the technology would have increased net incomes by the difference between that earned originally and that observed in the third experiment, which is approximately 252,000 Rp per hectare, or a 49.1 percent increase.

Experiment number 4 shows the impact of increasing cassava prices on rice production and the use of inputs. Both decline as was previously suggested. Note that both gross and net farm incomes rise but this is due entirely to the increased profitability of cassava. Although not explicitly shown, the benefits attributable to terraces must be falling. This follows from the assumption that cassava will grow equally well on terraced or unterraced land. If this assumption proves to be true, we can conclude that the benefits of terracing are inversely related to the price of cassava. The practical implication is that the viability of the upland soil

conservation program is tied to the price of cassava. If Indonesia continues to experience difficulties meeting export quotas, the price of cassava will remain relatively high and the benefits of bench terracing will continue to erode. In short, a price structure advantageous to cassava is disadvantageous to the technology.

Experiments 5 and 6 show how input subsidies alter the picture. In both cases, it is assumed that the government is providing inputs which exceed the amount the farmer would choose if charged the true market price. The only difference between the two tests is the cassava price. Since the farmer is not charged for the 100,000 Rp of inputs, his net income is 789,486 Rp and 869,297 Rp, respectively. From a social standpoint, the net gain is 100,000 Rp less than this.

From these experiments it is possible to formulate and emphasize several principles for conducting a benefit cost analysis of the technology. The correct measure of annual benefit is the difference between net income with and without the technology and without the input subsidy (for either high priced or low priced cassava). If the current price structure is anticipated to prevail then the former comparison most accurately reflects the technology's worth. It is incorrect to make pure "before" and "after" comparisons. Some of the farm plots may have been terraced before the program's implementation. The before case also reflects a different set of prices. Lastly, it is incorrect to compare gross returns, since input subsidies are likely to alter cropping mix and production. Since the subsidies are temporary, the change in gross farm income is likely to be temporary as well. The correct measure of annual benefits for the example provided is 204,959 Rp/Ha (assuming that cassava prices will remain at their current level).[6]

[6] This is the difference between the net incomes shown for Experiments 2 and 4.

A number of additional experiments were performed to illustrate the principles discussed earlier. The simulated impact of cassava on farm incomes (gross and net) is shown in Figure B.9. The pattern is similar to that discussed earlier and shown in Figure B.2. Figures B.10 and B.11 demonstrate how increased cassava prices and bench terracing alter incomes. In both cases the optimum ratio of cassava to total production changes as previously predicted and portrayed, Figure B.3. Figure B.12 illustrates the effect of both terracing and subsidized inputs on the benefits farmers can anticipate. In the example provided, benefits equal the difference between net income without the terrace and sum of net income plus the subsidy with the terrace. Figure B.13 indicates how the cassava ratio and incomes will respond to the termination of subsidies. Income is maximized at points B and D during the period when subsidies are received. Points A and C reflect the optimum cassava mix after subsidies are withdrawn.

FIGURE B.9. GROSS AND NET INCOME

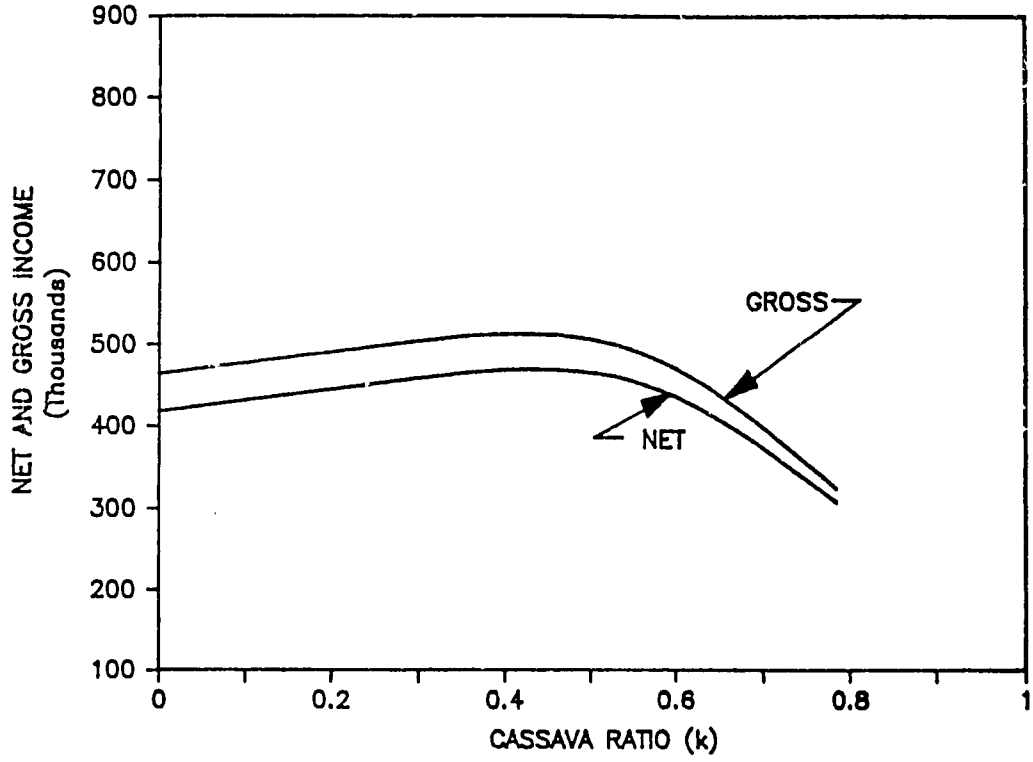


FIGURE B.10. IMPACT OF INCREASING CASSAVA PRICES

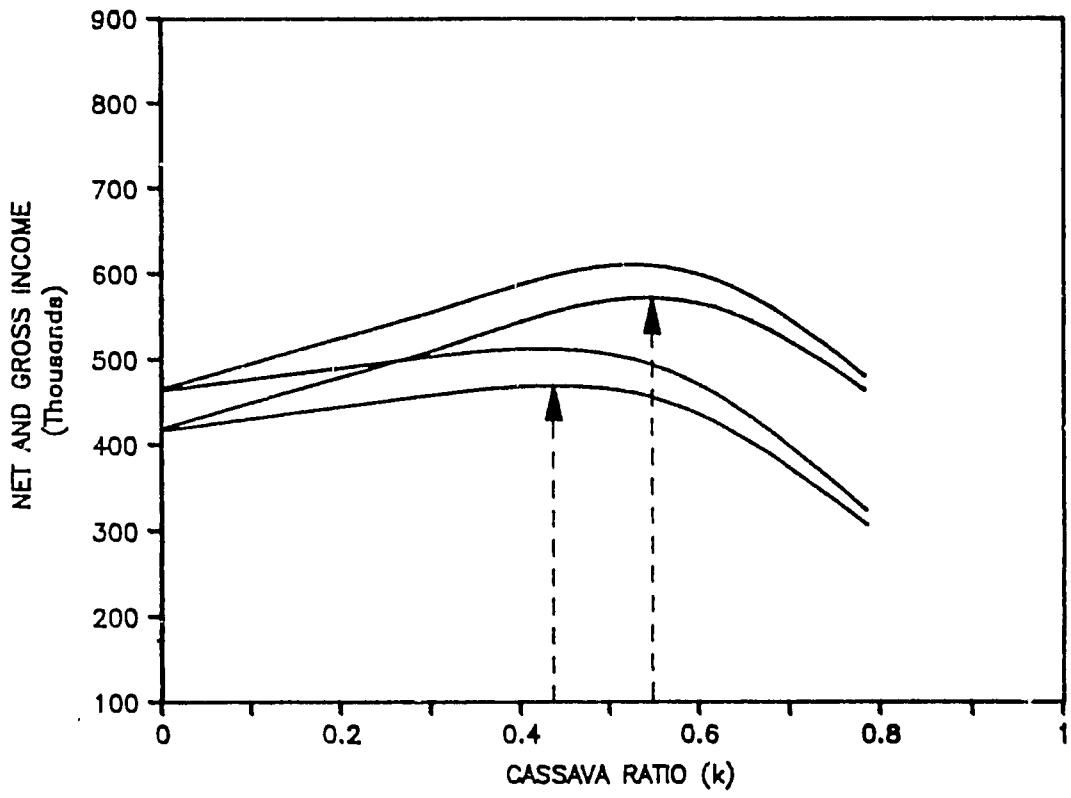


FIGURE B.11. IMPACT OF TECHNOLOGY

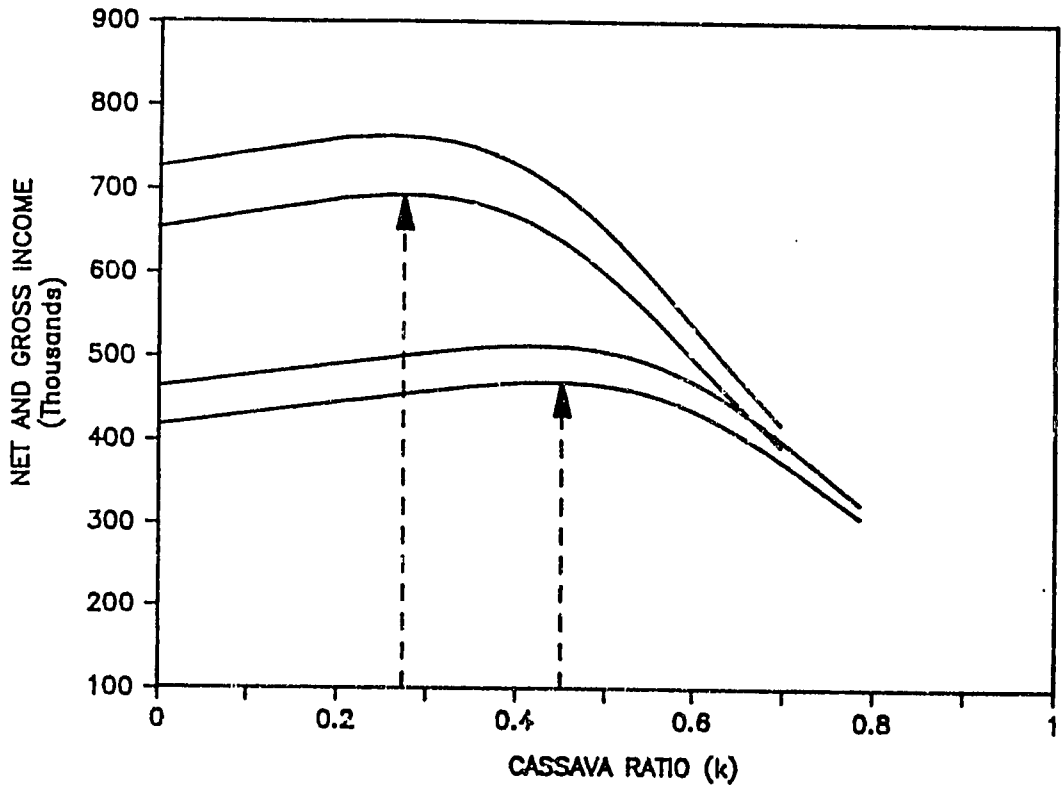
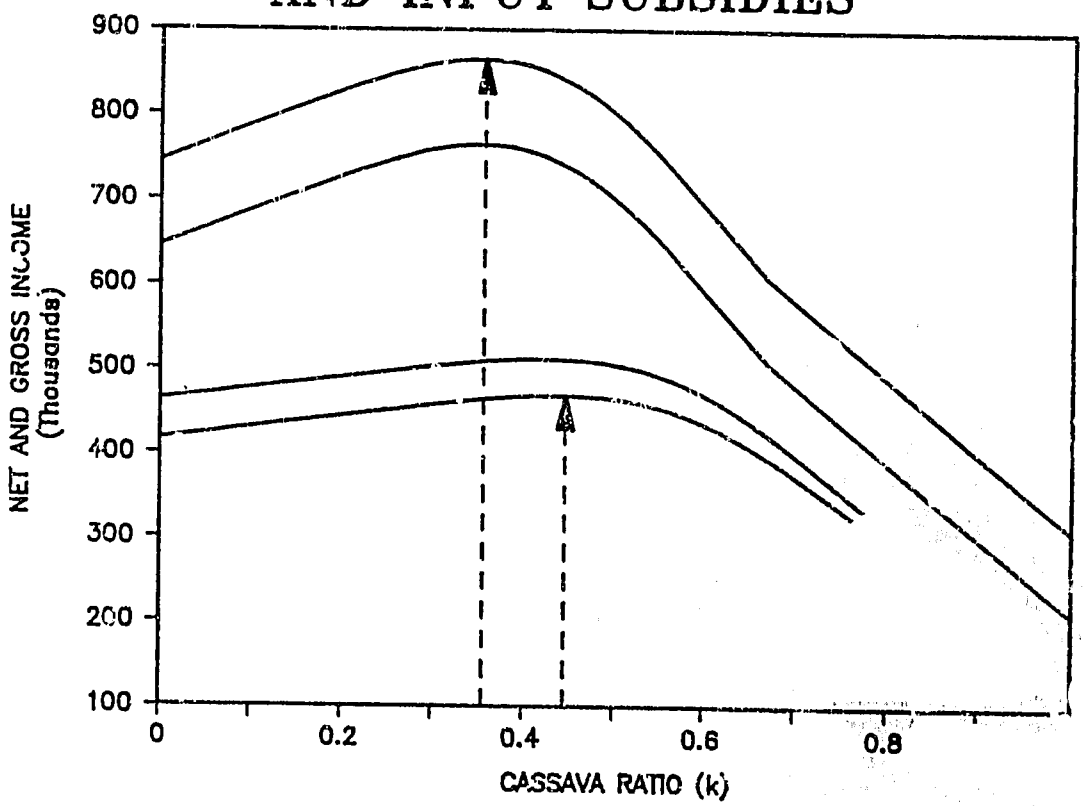


FIGURE B.12. IMPACT OF TECHNOLOGY AND INPUT SUBSIDIES



B.7 TESTABLE HYPOTHESES

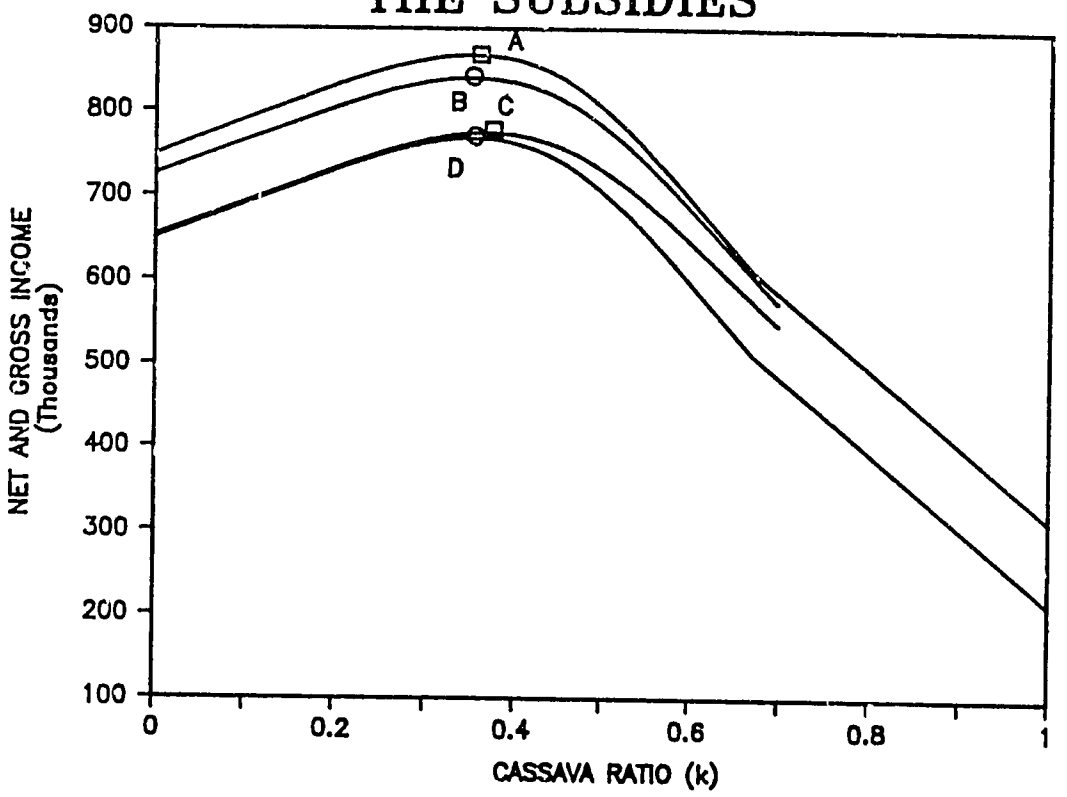
This framework offers a set of hypotheses that are testable and directly related to the evaluation. The first and most important concerns the effect of the technology on gross income. A case has been made that if the technology is beneficial to the farmers of the region, its impact should be observable. After normalizing for input and labor usage, those who have adopted the technology should earn higher incomes than those who have not. Two different tests of this hypothesis follow directly from the conceptual framework. They are stated in a positive way, which is more understandable to policy makers, if not statisticians.

Hypothesis (1)--The technology causes the value function to shift upwards. Hypothesis (2)--Farmers who specialize in either cassava or rice will earn lower incomes than those who employ a combination of both. If the technology is perceived to be truly productive, some or all of the package would be adopted by outsiders. Hypothesis (3)--The pace at which outside project farmers adopt terracing lags only slightly the conversions made by project participants. The rapid rise in the price of cassava since 1984 should prove to be a potent incentive for emphasizing cassava in the cropping mix. We expect that since outside project farmers are not constrained in their choice of crops, they will rely more heavily on cassava as a source of income. Hypothesis (4)--The (k) value observed on nonproject farms will be significantly higher than that for the project participants. However, once subsidies end, even model farmers and dampaks may find it difficult to withstand the economic pressure to continue growing the "recommended" mix (which deemphasizes cassava).

Last, the model suggests that if the government provides too few inputs, farmers would supplement them at their own expense. If, however, the government provides economically excessive amou ts of

inputs, the farmer would apply the amount distributed, but would reduce the rate of usage once subsidies are withdrawn. Hypotheses (5) and (6)--Gross farm income will rise during the period when model farmers and dampaks are participating in the program; the increased use of chemicals and improved seeds should alter both yields and cropping mix. However, once the program is terminated, both the application of purchased inputs and yields should decline.

FIGURE B.13. OUTCOMES WITH AND WITHOUT THE SUBSIDIES



ANNEX C

STATISTICAL TESTS OF THE TECHNOLOGY

This section serves a three-fold purpose. First it, develops a statistical test of the main hypotheses, which is consistent with the theoretical framework formulated in Annex B. Second, the USESE (1 and 2)[1] and Sinaga[2] data sets are analyzed and the resultant estimates reported. And third, the statistical results are evaluated and interpreted.

C.1 A DEFENSIBLE ECONOMETRIC MODEL

The summary statistics reported in Chapter 4 suggest the possibility that bench terracing technology has proven to be economically beneficial to the farmers of Citanduy. The purpose of this section is to subject the data to econometric testing in order to determine the statistical significance of the findings.

The input-output data collected by USESE were used to estimate the influence of labor, purchased inputs, and bench terracing on farm income. Eq. (C1) is a simplified example of a large number of relationships tested.

$$\text{Eq.(C1)} \quad GFI/X = a_1 + a_2 z + c\ (I/X) + d\ (L/X)$$

[1] USESE-1 and USESE-2 data sets refer to Phase II and Phase III, respectively.

[2] Sinaga, Rudol S., et al. 1985. Beneficiary Impact Study Citanduy Watershed Area: A Case of Three Model Farm Sites. Survey Report No. 02/SR/85. Bogor, Indonesia: Agroeconomic Survey Foundation.

GFI is the value produced, X is the plot area, L is the number of man days, and I is the amount of inputs (seed, fertilizer, etc.) purchased, all normalized for the size of the farmer's plot (measured in hectares). z, the dummy variable, is used to isolate the effects of bench terracing. It can take a value of either 0 or 1, those farmers employing the technology being identified with a 1, all others with a 0. a_1 is the constant term and a_2, c and d are coefficients.

In this simplest of models, a_2 represents the value of the technology. It indicates in monetary units how much farmer income would change as a result of adopting the package. Terms c and d have intuitive explanations. They are the marginal (and average) value of each man day of labor and unit of purchased input applied to the plot. For example, if d equalled Rp 1,500, this would mean that the farmer's income rises Rp 1,500 for each additional man day spent. Coefficient c is interpreted similarly, but for inputs.

Although a useful starting point, Eq. (C1) is unrealistic in that it represents a production relationship which is not subject to diminishing returns. That is, either labor or inputs can be applied in any amount without affecting income per hectare. This problem is corrected in Eq. (C2).

$$\text{Eq. (C2)} \quad GFI/X = a_1 \, (a_2 \, z) \, (I/X)^c \, (L/X)^d$$

This functional form does exhibit diminishing returns to both inputs. a_2 is no longer the absolute change in value brought about by the bench terrace. It is now the ratio of values produced with and without the technology. For example, if a_2 was observed to be 1.3, farm incomes could be expected to rise by 30 percent for adopters regardless of input use. Terms c and d are interpreted differently than in the linear model. The additional value realized through the employment of either factor is given in Eq. (C3) and Eq. (C4).

Eq. (C3) Additional Value(Labor) = d (GFI/L)

Eq. (C4) Additional Value(Inputs)= c (GFI/I)

Eq. (C3) and Eq. (C4) show the changes in farm income which result from the employment of one more man day of labor, or one more unit of purchased inputs. Eq. (C4) is particularly useful since it indicates whether input subsidies raise farm income by at least as much as they cost the government.

Using a single dummy variable as shown in Eq. (C2) implies that the technology affects labor and purchased inputs similarly. A more general model, not shown here, allows for the possibility that the technology influences labor and inputs differently. This is accomplished by attaching a dummy term to the exponents of Eq. (C2).

C.2 A DISCUSSION OF THE THEORETICAL AND ECONOMETRIC MODELS

The simplified mixed cropping model developed in Annex B showed the relationship between gross farm income and inputs employed in the cultivation of cassava and other crops. Because the USESE farm survey data do not differentiate input use by crop, the econometric models depicted above are reduced form equations. As a result, care must be exercised to interpret the coefficients properly. This point is the subject of the discussion which follows.

In the highly simplified model developed in Annex B, gross farm income was related to the sum of rice and cassava sales. Separate production relationships were assumed for each crop; Eq. (1), Eq. (2) and Eq. (6) from Table B.1 are repeated in Table C.1 for the reader's convenience. It is difficult to test this model directly since the USESE data set does not disaggregate input use by crop. Instead, it contains one set of inputs per farm plot. As a result,

Table C.1. The Linkage Between the Theoretical and Economic Models

Eq.(1) $$\frac{Q_{rice}}{X} = z a_1 (1-k)^{b1} \left(\frac{I}{X}\right)^{c1} \left(\frac{L_{rice}}{X}\right)^{d1}$$

Eq.(2) $$\frac{Q_{cassava}}{X} = a_2 k^{b2} \left(\frac{L_{cassava}}{X}\right)^{d2}$$

Eq.(6) $$\frac{GFI}{X} = P_{rice}\left(\frac{Q_{rice}}{X}\right) + P_{cassava}\left(\frac{Q_{cassava}}{X}\right)$$

Eq.(17) $$\frac{GFI}{X} = P_{rice}\left(z a_1 (1-k)^{b1} \left(\frac{I}{X}\right)^{c1} \left(\frac{L_{rice}}{X}\right)^{d1}\right) + P_{cassava}\left(a_2 k^{b2} \left(\frac{L_{cassava}}{X}\right)^{d2}\right)$$

if k=1

Eq.(18) $$\frac{GFI}{X} = P_{cassava}\left(a_2 \left(\frac{L_{cassava}}{X}\right)^{d2}\right)$$

if k=0

Eq.(19) $$\frac{GFI}{X} = P_{rice}\left(z a_1 \left(\frac{I}{X}\right)^{c1} \left(\frac{L_{rice}}{X}\right)^{d1}\right)$$

it is virtually impossible to isolate how much land, labor and purchased inputs are employed in the cultivation of each crop.

It is only when all (k=1) or no (k=0) cassava is grown that the econometric and the theoretical models converge, and the estimate for a_2 can be clearly interpreted. For instance, if k=1, then Eq.(17) in Table C.1 reduces to Eq. (18). Providing that terracing does not significantly influence cassava yields, a "with" and "without" test would fail to detect a significant difference in farm income. The opposite holds if k=0, as is shown by Eq. (19), Table C.1. In this case, Eq. (19) and the econometric model are essentially the same. Here it is legitimate to interpret a_2 as a measure of terracing benefits.

These cases represent the extremes. It is more difficult to interpret a_2 in the event the cassava ratio is observed to be between 0 and 1.

This point is important, particularly for the Citanduy evaluation, where with and without observations are separated in time by a number of years. If, as in the case of the USESE-1 survey, the data are collected over a period when prices are fluctuating and cropping patterns are in a state of flux, the estimated value for a_2 will reflect more than the technology. It also captures market induced shifts in k which, for the period in question, tends to diminish the influence of bench terracing on farm income.

The USESE-1 data set is use to further illustrate this important point. The "before terracing" observations reflect planting decisions made over the period 1980 to 1984, whereas the "after" decisions were made in 1985. Since the price of cassava relative to that of rice rose dramatically over the intervening five

years, it is highly likely that the optimum cassava ratio had changed as well. As a result, the effect of terracing could have been masked by an increase in land area(k) devoted to the production of cassava.[3]

To accomodate the effect of shifting cropping patterns, Eq. (C3) was revised. The influence of cropping mix was incorporated into the econometrics by introducing the cassava ratio (k) and "rice" ratio (1-k) explicitly into the reduced form model. See Eq. (C5).

$$\text{Eq. (C5)} \quad GFI/X = a_1 \, (a_2 \, z) \, (L/X)^{d3} \, (I/X)^{c3} \, k^{b3} \, (1-k)^{b4}$$

Because Eq. (C5) is a close approximation to the theoretical model developed in Annex B, it was chosen as the basic form for conducting the econometric studies. It is important to note that the term k was slightly revised, since the proportion of the plot devoted to the production of cassava is unknown. To adjust for this, the ratio of cassava yields to total yield was used as a proxy for k.

After considering the likelihood that the effectiveness of terracing would be enhanced by the presence of crops other than cassava, Eq. (C5) was amended to reflect the interaction of z and (1-k). See Eq. (C6). This new dummy reflects a critical assumption utilized in the theoretical model, that the existence of a terrace would exert a disproportionate effect on the production of rice, soy, maize and groundnuts.

$$\text{Eq. (C6)} \quad GFI/X = a_1 \, a_2 \, z(1-k) \, (L/X)^{d3} \, (I/X)^{c3} \, k^{b3} \, (1-k)^{b4}$$

[3] This masking is due to the simultaneous influence of z and k. If the value of z is not too large, relative to the shift in output prices, those "without" the technology stand to gain more than those "with" it.

The meaning of a_2 is similar to that described earlier, except it now reflects the effect of (1-k). According to Eq. (C6), the presence of a terrace does not affect gross farm income when cassava is the sole crop. The influence of terracing is magnified as k drops, that is, the proportion of the plot devoted to the cultivation of crops other than cassava rises.

C.3 TESTS OF ANNEX B HYPOTHESES

C.3.1 Basic Tests

All tests of the USESE input-output data were based on these models or slight variations thereof. The results of the econometric tests of Eq. (C6) using the USESE-1 data set are shown in Table C.2.

Several important conclusions can be drawn from these statistics. While the R^2's are low, the t-values are highly significant, and the explanatory power of the model is as high as can be expected from the data. Second, it appears that the technology does not shift the value function but induces a new mix of outputs. The variable reflecting the existence of a bench terrace, z(1-k), does not appear to influence gross farm incomes. a_2 is not significant, whereas the ratio of cassava to other mixed crops, k and (1-k), contribute to nearly half of the equation's explanatory power. It is more disturbing to note the value of a_2 estimated for the model farms. Although not highly significant, it appears negative. There are two possible reasons for this curious result. One is that the model farms were designed as demonstration plots and, therefore, the input and output mixes may not be representative of what unconstrained farmers might achieve. Two, the model farms were to some extent experimental. Participants were asked to adopt practices which tended to run counter to their short-run economic interests. Possibly, over a longer time horizon, the productivity of unterraced plots will suffer. However, such is not observable at this stage.

Table C.2. Economic Results--Equation (C.6)

Model Farms					
Constant		-0.21			
Std Err of Y Est		0.66			
R Squared		0.33			
No. of Observations		201			
Degrees of Freedom		195			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.12	0.32	4.45	5.32	-0.45
Std Err of Coef.	0.05	0.08	1.15	1.11	0.30
t value	2.35	4.20	3.87	4.81	-1.52
Dampak Farms					
Constant		-1.33			
Std Err of Y Est		0.73			
R Squared		0.29			
No. of Observations		114			
Degrees of Freedom		108			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.01	0.31	6.57	7.30	0.10
Std Err of Coef.	0.08	0.11	1.58	1.64	0.35
t value	0.13	2.81	4.16	4.45	0.29
Outside Project Farms					
Constant		0.13			
Std Err of Y Est		0.90			
R Squared		0.20			
No. of Observations		303			
Degrees of Freedom		297			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.15	0.03	5.36	6.59	-0.23
Std Err of Coef.	0.05	0.09	1.15	1.17	0.30
t value	3.11	0.40	4.67	5.64	-0.79
All Farms					
Constant		0.18			
Std Err of Y Est		0.83			
R Squared		0.19			
No. of Observations		798			
Degrees of Freedom		792			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.15	0.14	4.94	5.72	-0.06
Std Err of Coef.	0.03	0.04	0.65	0.67	0.15
t value	4.83	2.88	7.59	8.50	-0.37

Lastly, terraces are but a single component of the model farm technology. It may take a longer span of time before the effects of adopting new input-output mixes and revising farming practices are observed. Such is the case for the agroforestry element of the program. It is possible that instead of shifting the value function as first thought, the technology permits farmers to deemphasize cassava in their cropping decisions. That is, terracing enables farmers to move along a single value function, such as shown in Annex B. This, of course, is wortwhile so long as the technology facilitates the achievement of the optimum mix. Clearly not all mixes require the technology. As cassava prices rise, the optimum mix shifts toward that which is achievable without the technology.

The estimated coefficients for inputs and labor indicate that each of their marginal returns are less than their respective costs. According to the estimates shown, farmers are earning approximately 50 percent of the cost of an additional input applied.[4] Based on these estimates, it appears that input subsidies could be cut without loss of economic efficiency.

C.3.2 Testing the Impact of Cassava Price Changes

The collection of input-output data in the upper Citanduy dates back at least eight years, over which time the relative prices of farm outputs have swung substantially. In addition to the two USESE surveys (1985 and 1987), a third survey was conducted in 1980 by Sinaga. Of the three surveys, Sinaga's most closely reflects the conditions which prevailed at the time the model farm program was in the design stages. As has been mentioned repeatedly, economic

[4] This was determined from Eq. (13) in Table B.2. Plugging the values of c, GFI and I (.15, 550, 100, respectively) into Eq. (13) results in a marginal value of inputs of .82, which is 82 percent of its cost.

conditions and the state of knowledge regarding bench terraces have been altered by the passage of time. As a result, the input-output choices recorded in the USESE-1 and USESE-2 surveys may not be directly comparable to those measured by Sinaga. For the purpose of comparison, all three data sets were subjected to the same statistical test, Eq. (C6).

The only change made was the exclusion of the dummy (z) from the Sinaga and USESE-2 test. The Sinaga data set did not contain sufficient information to include terracing, and all of the USESE-2 sample plots were terraced. The same output prices (1985) were used to compute gross farm income, with the exception of cassava prices, which were adjusted to reflect the year the survey was conducted.[5] Cassava was singled out because of its importance in the region's cropping pattern and because of the significant fluctuations in price which have occurred over the 1980 to 1987 time period.

The regression results displayed in Table B.3 are in a form comparable to that of Table B.2. Several observations can be drawn from the comparison. First, the optimum mix of cassava rises with its price. See Figure C.1. This should not be too surprising given the price adjustments made to obtain gross farm income. However, it is interesting to note that the mix (k) which maximizes gross income reflects what is observed to be occurring on the upland plots.

Analysis of the survey data shows that early early adopters (i.e., the 1981 model farms) employed a cassava mix amounting to 25 percent of total yields, which is the proportion indicated in Figure C.1 as maximizing gross income. By 1987, the commonly employed mix

[5] The following cassava prices were used--Sinaga (1980, 20 Rp/Ha), USESE (1985, 45 Rp/Ha) and USESE (1987, 72 Rp/Ha).

Table C.3. Impact of Cassava Prices on Gross Farm Income

USESE with 85 price of cassava(42 Rp/Kg) See Table C.2

Sinaga Survey with 1981 Price of Cassava(20 Rp/Kg)

Constant		4.153			
Std Err of Y Est		0.855			
R Squared		0.425			
No. of Observations		299			
Degrees of Freedom		294			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.005	0.392	6.425	8.226	none
Std Err of Coef.	0.015	0.078	1.084	1.133	
t value	0.359	5.045	5.927	7.263	

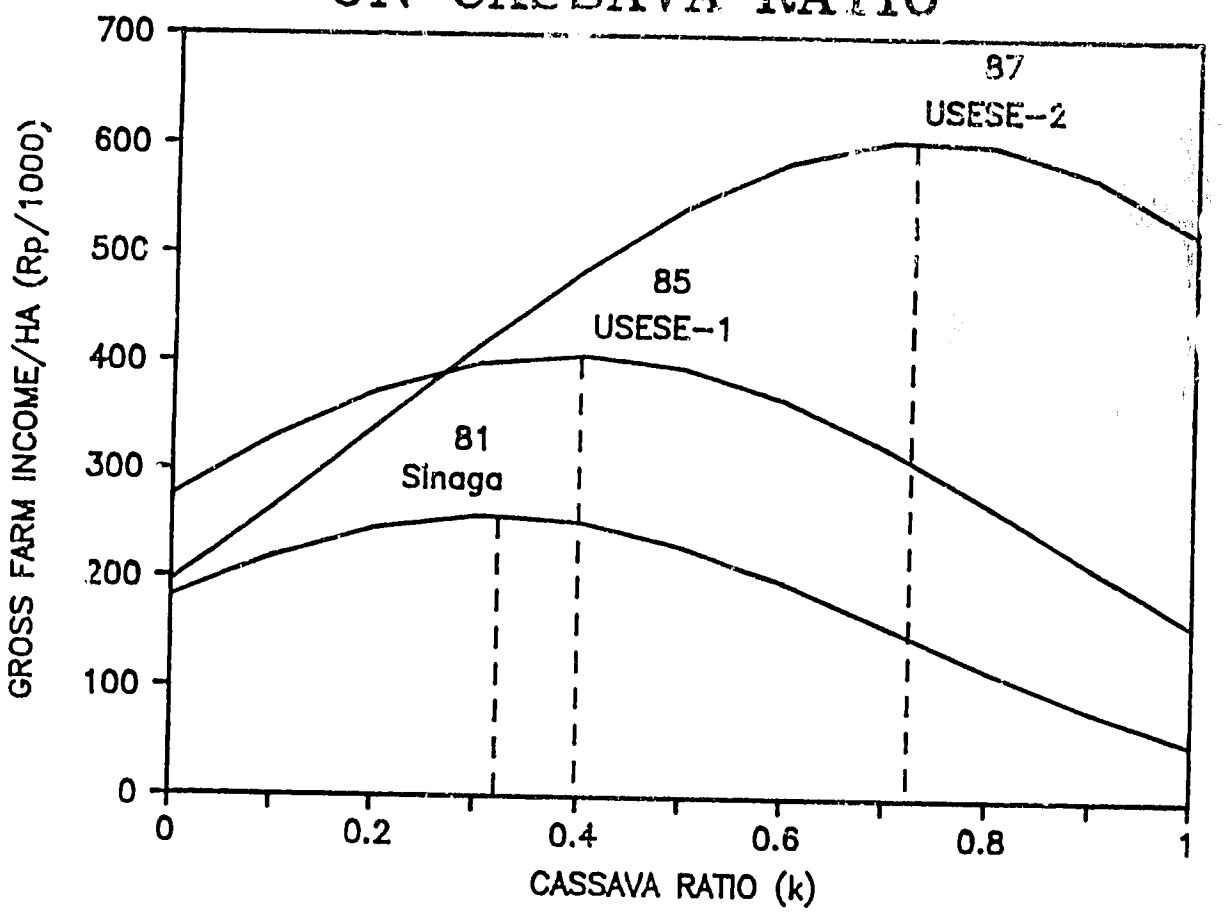
USESE-2 Survey with 1987 Price of Cassava (70 Rp/Kg)

Constant		0.699			
Std Err of Y Est		0.747			
R Squared		0.169			
No. of Observations		278			
Degrees of Freedom		273			
	Inputs	Labor	k	(1-k)	z(1-k)
X Coefficient(s)	0.098	0.263	5.201	3.790	none
Std Err of Coef.	0.037	0.085	1.295	1.251	
t value	2.624	3.089	4.016	3.030	

Note

Information about terracing was not available in the Sinaga Survey. All plots in the USESE-2 survey were terraced. Therefore, the dummy reflecting terracing was excluded from the model.

FIGURE C.1. INFLUENCES OF PRICES ON CASSAVA RATIO



had climbed to 65 percent, matching the model's prediction.[6] It is also interesting to note that this ratio has been adopted by both project participants and outside project farmers alike. Furthermore, it appears to be insensitive to both the slope of the land and the existence of terraces. Whether such a practice is sustainable is an extremely important question, but unfortunately one which cannot be currently answered.

C.3.3 The Other Hypotheses

The time pattern of input use and output value conform to the predictions made in Annex B. Generally, both peak the first year subsidies are received and decline thereafter. It has been argued by some that declining outputs are a result of pest infestations or the overuse of chemicals, which is adversely affecting soil fertility. As will become evident in succeeding sections, there is no clear evidence supporting such explanations. It appears instead that declining rice yields are a product of 1) economic forces inducing a switch in cropping, and 2) the termination of subsidized inputs which is curtailing their use.

C.3.4 Other Experiments

A number of ad-hoc experiments were conducted during the early stages of the research to test a variety of relationships and functional forms. See Table C.4. None, however, proved to enhance the fits already shown, but all yielded results consistent with the framework developed above.

[6] The optimum mix of cassava is one which maximizes net income. However, the greater the significance of cassava in the cropping mix, the more closely gross and net incomes correspond. Therefore, the statement is justifiable.

Table C.4. Summary of Preliminary Experiments Performed

Variables Added

Village
Whether the farmer owned lowland or other dry land plots
Outside income
Time
Type of terrace
Soils
Slope
Subsidies received
Farm gate price of outputs
Variation in the price of cassava

Disaggregation

By farm type
By year
Individual inputs and labor(on farm/of farm)

Other Functional Forms

Quadratic and cubic
Log-linear
Linear

The preliminary experiments are described here for one very important reason. Legitimate differences over both the nature of the model used and the interpretation of the results are bound to surface. Because of these differences, some researchers and/or policy makers will in all likelihood take exception to the methodology utilized in this study, perhaps offering alternatives. In order to build confidence in the findings we have reported, several of the major concerns expressed over the course of the study were investigated and the appropriate experiments conducted.

In our opinion, it is imperative that some form of agreement be achieved regarding the interpretations offered above. Without this the debate over the effect of soils, climate, markets, or some hidden and unaccounted for socioeconomic factor will most likely continue unabated. With this in mind we briefly report the results of other experiments.

Village--Do the socioeconomic conditions of the village alter outputs? Dummy variables were added to the model to determine whether certain villages outperformed others. In the event that this were observed to occur, the source of the difference would have been investigated. The results do not support the existence of significant differences before the program is introduced. After the model farms where established, five villages (Gunasari, Cibahayu, Sadabumi, Tanjaunjaya, and Cimenga) appeared to exhibit gross farm incomes less than the average village in the sample. These villages were generally the early adopters, which tended to be situated on the worst land. Therefore, these results appear to be more indicative of geographic location than anything inherent in village structure, management or marketing. The relationship between the variables village and year made it appear that certain villages were outperforming others. Instead it reflects differences in time of adoption, where later adopters tended to outperform their predecessors.

Soils--The problem of multicollinearity created problems in isolating the effects of soil type as well. Since each village was situated on some variant of either volcanic or sedimentary soils, failure to detect a difference in productivity by village indirectly implied that soil type did not influence gross incomes. This conclusion was checked by contrasting the performance of Mekarsari (volcanic) with Andrapraja (volcanic) and Margajaya (sedimentary). The results of the test are reported in Table C.5. Note that the village situated on sedimentary soils outperformed that on volcanic.

Table C.5. Impact of Soils on Gross Farm Income

USESE-2 With Cassava priced at 70 Rp/Kg

Constant		0.209		
Std Err of Y Est		0.696		
R Squared		0.285		
No. of Observations		278		
Degrees of Freedom		270		
	Inputs	Labor	k	(1-k)
X Coefficient(s)	0.076	0.313	5.899	4.693
Std Err of Coef.	0.036	0.082	1.216	1.180
t value	2.129	3.826	4.852	3.978

ANDRA	MARG	ID
-0.661	-0.315	0.114
0.104	0.109	0.095
-6.362	-2.882	1.195

Key

ANDRA is Andrapraja
MARG is Margajaya
ID is a dummy for model farms and dampaks (1 = model farm and 0 = outside project farms)

Admittedly these results are not conclusive; other factors might have played a role in shaping the outcomes. However, at least the short-term effects of soils have yet to be demonstrated.

Time--It has been argued that the passage of time is an important factor influencing the success of the program. The following are representative of the theories as to how time might alter farm productivity.

"It takes time before the soils stabilize." "It takes time for the farmers to learn how to fully utilize the technology." "Farmers are using too much fertilizer. Over time the soil/will be poisoned." "Pests are affecting the type of crops which the model farm package emphasizes."

No doubt over the course of the last eight years, each of these have been observed at one time or another. However, whether they have had a systematic and measurable influence on farm income is another question, but one which is testable. To do so the basic model was reformulated to include time as a separate variable, specifically, the length of time since the model farm was introduced. The results indicate that the time variable does not affect income. The coefficient proved to be small and statistically insignificant, implying that the observations made above may not be generalizable and most likely reflect isolated instances.

Socioeconomic Considerations--Farmers seldom rely solely on their upland holdings for their livelihood. Production from the more steeply sloped plots tends to be supplemented by non-farm income and yields from lowland *sawah*. Diversification such as this introduces several complications which might explain some of the variation in farm income observed. For example, it had been rumored that the fertilizer subsidies targeted for the upland plots were being diverted to lowland *sawah*. Such a decision might make economic sense, particularly if the farmer believed that the return possible from the upland plot is *relatively* unattractive. In such cases the incentive to divert inputs might prove compelling.

This theory is readily testable since the USESE data sets provide information on *sawah* holdings. If fertilizer was indeed being diverted then those who own *sawah* should exhibit different returns to inputs than those that do not. The regressions show that the variable reflecting ownership of lowland irrigated plots does not explain changes in farm incomes. One must conclude that this theory is not supported by the data.

This same conclusion was reached in July 1987 as a result of resurveying a sample of the USESE-1 respondents. Farmers were asked to indicate the amount of fertilizer subsidy received and rice yields on their *sawah*. A statistical test of the responses failed

to show a relationship between receipt of the government supplied inputs and sawah rice production.

Lastly, the existence of non-farm income was thought to be a distracting influence, possibly affecting on-farm decisions and efficiency. It was hypothesized that upland yields would suffer in proportion to the amount of such income earned. A statistical test of this possibility proved negative. No relationship was detected.

Methodological Considerations--The earliest statistical tests of the USESE data sets utilized a dummy variable which was designed to detect a neutral shift in the value function. It was initially believed that the "with" technology group consisted of all model farmers and dampak after the model farm was instituted. All plots before plus all outside project farmers after were believed to comprise the "without" group. This assumption, although entirely logical, eventually proved to be false. It was learned that many of the outside project farmers had constructed bench terraces similar in design to those observable on the model farm.

A variety of experiments were performed refining the "with technology" dummy variable. Separate equations were estimated for the with and without plots. A new dummy was introduced to capture changes in the function's slope instead of its intercept. However, none of the variants significantly improved the explanatory power of the model, nor did the estimates alter the conclusions reached above.

C.3.5 Interpreting the Results

All the tests performed point to the importance of cropping as the key variable driving gross farm income, more so than inputs, labor or whether the farmer is participating in the model farm program. The models show that farm incomes are lower for those who rely exclusively on cassava and those who exclude it from their mix altogether. To the extent the model farm program assists farmers in

seeking out more optimal mixes, it could be judged to be highly beneficial.

These results help resolve a puzzle. When analyzing the 1981 model farms and dampak, it was discovered that output values rose significantly from before adoption to after. However, the performance of project farms which came later did not keep pace. In attempting to explain this phenomenon, some have argued that this was due to the time required for farmers to learn and soils to adjust. From the data and the econometric results just discussed, it appears that the chief reason for the observed change in performance is a shift in the mix of crops farmers employ. Figures C.2 and C.3 show this to be the case.

The solid line (derived from the USESE data) shows the envelope of production possibilities available to the farmer before and after the technology is introduced. Each point plotted represents the mix of crops adopted by farm type. M refers to model farm, D for dampak and L for luar projek. The numbers to the right indicate year, with 1 representing 1981, etc. The two numbers shown in Figure C.3 are identified as 1985(5) which is the "after" date and the "before" year. Figure C.2 makes clear that the 1981 model farms and dampak are an anomaly. Their cassava to rice ratio is extremely high. Therefore, their pre-adoption incomes are abnormally low. Subsequent model farms proved to be more productive in terms of rice, and are shown to have shifted away from cassava to other crops (even before they are officially participating). Whether this represents a trend or reflects the anomalous nature of the 1981 farms remains an open question.

Figures C.2 and C.3 show the pattern of transition which has been unfolding since 1981. Almost without exception each farm type has moved along the envelope shown. The extent to which this reflects a diffusion of the technology prompted by the program is still a matter for debate. These diagrams do show why simple "with" and "without" tests of efficiency have not produced significant results. The standard of comparison is shifting.

FIGURE C.2. PRODUCTION POSSIBILITIES BEFORE

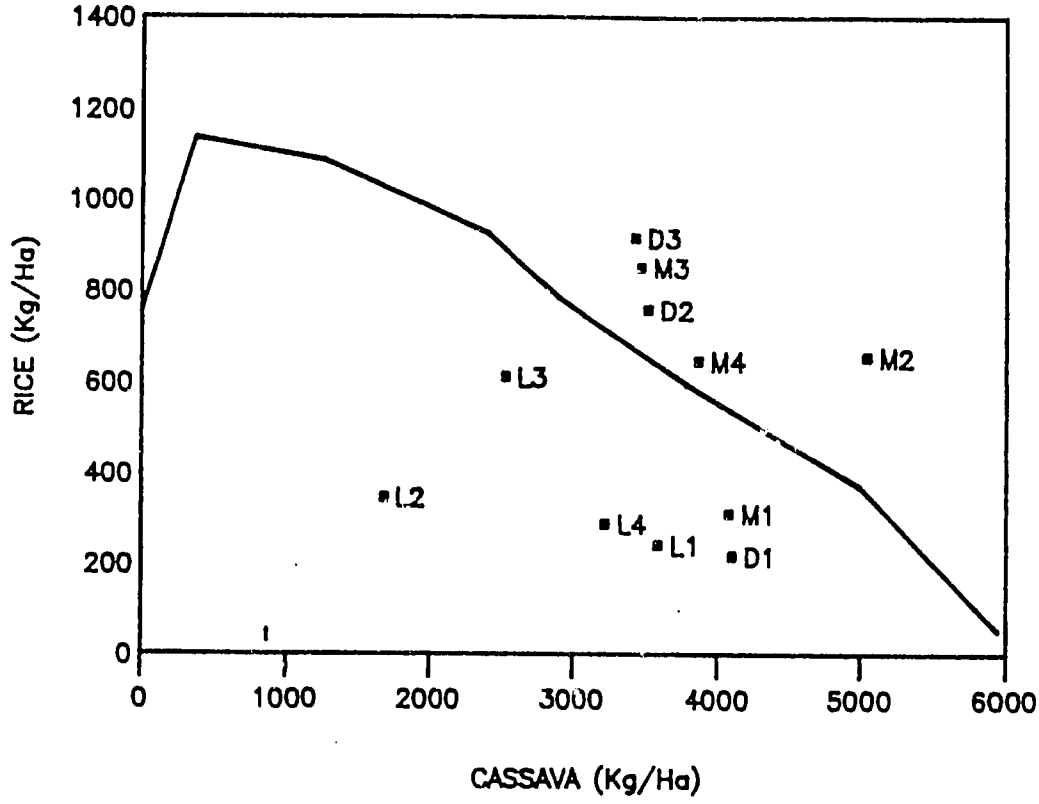
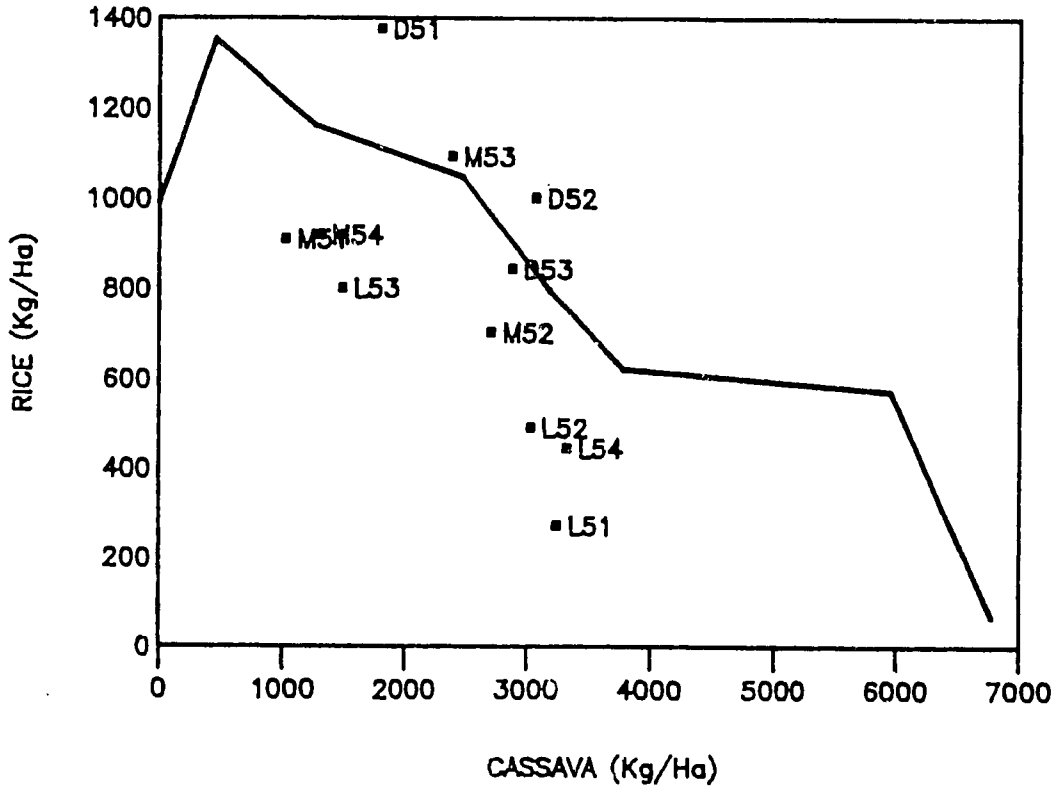


FIGURE C.3. PRODUCTION POSSIBILITIES AFTER



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8. The Sederhana Assessment Study for West Java, West Sumatra, North Sumatra and South Sulawesi Provinces, Indonesia, by P.T. EXSA International Co. Ltd., May 1988.

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