PN-AAV-918
47257

# MODEL FARM PROGRAM BENEFITS: THE CITANDUY WATERSHED

By:

Bungaran Saragih
Director, USESE

Paul C. Huszar
Colorado State University

and

Harold C. Cochrane
Colorado State University

July 1986

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

# EXECUTIVE SUMMARY

The Citanduy II project, which began in 1981/82 is intended to increase the incomes of farmers, reduce erosion, and increase employment opportunities in the upland areas of the Citanduy River basin in West and Central Java. The project established 48 model farm units and expansion areas (areas surrounding the model farms) and introduced a variety of erosion control and other agricultural innovations including bench terraces, back-sloping, grassing terrace risers, channeling runoff, new cropping patterns and systems, and new input (e.g., seed, fertilizer, insecticide) mixes. Farmers were also given limited subsidies and credit to buy new inputs and construct their own terraces. To date, these improved agricultural practices have been introduced in over 10,000 hectares of critical land in the Citanduy upland areas.

USESE, the Project Socio-Economic Evaluation Unit working with the Yayasan Agro-Ekonomi, and with assistance from faculty of the Department of Agricultural and Resource Economics at Colorado State University, conducted this study to determine the impact of the improved agricultural practices on the project's beneficiaries. The study provides data on the performance of the model farm/expansion area component of the project and contributes to the growing body of empirical data that can be used to improve our understanding of upland farming. The study's results will assist project decision makers in determining the appropriateness of the package of agricultural technology now being applied.

The study's main conclusions are:

1. The actual value of production (crop yields x market price) averaged for the model farm and expansion areas increased from 136,000 rp/ha before terracing to 446,000 rp/ha after terracing. This increased value of farm production is largely due to changing cropping patterns (for example, cassava production fell by 30% while rice and peanut production rose by 23.7% and 14.4%, respectively).

2. Labor use (employment) within the model farm and expansion areas increased from an average of 860 hr/ha before terracing to 1,774 hr/ha after terracing. The majority of increased labor use came from within the farmers' households.

3. Labor productivity (the value of production divided by labor use) increased from an average of 158 rp/hr before terracing to 216 rp/hr after terracing.

4. The actual input mix of labor use and such purchased inputs as fertilizer, insecticide and seeds was suboptimal before terracing and rose to nearly optimal after terracing. This resulted in a significant increase in the marginal value of both labor and purchased inputs.

These findings demonstrate that with the adoption of appropriate agriculture and conservation technologies, there is a significant potential for improving both farm incomes and rural employment opportunities in the upland areas of Indonesia. However, before this program's practices and technologies can be applied on a wider scale, three main issues need to be investigated further:

1. Because the present study was conducted on sites with relatively homogeneous agro-climatic data, little can be said about the relationship between agro-climatic conditions and production increases. A larger sample with more diversity of agro-climatic conditions is necessary in order to assess this relationship.

2. The present study does not include sufficient data to determine the full costs of the project. Understanding and measuring these costs is necessary to assess the need for and effectiveness of the Government of Indonesia offering incentives to terrace.

3. A complete analysis requires an examination of alternative methods of achieving the goals of upland agricultural development. Thus, the costs and benefits of agro-forestry and other methods of cropping on different slopes, soil types, and terracing methods, in addition to bench terraces, must be investigated to determine the optimum program mix.

Draft Translation

RINGKASAN PELAKSANAAN PROGRAM

(EXECUTIVE SUMMARY)

Proyek Citanduy II, yang dimulai pada tahun 1981/1982, dimaksudkan untuk meningkatkan pendapatan para petani, mengurangi erosi tanah, dan meningkatkan kesempatan kerja di daerah dataran tinggi lembah sungai Citanduy di Jawa Barat dan Jawa Tengah. Proyek ini telah membentuk 48 unit pertanian percontohan (model farms) masing-masing dengan daerah perluasan (daerah-daerah disekitar unit pertanian percontohan tersebut) dan memperkenalkan bermacam-macam cara pengendalian erosi tanah dan pembaharuan-pembaharuan dalam bidang pertanian termasuk terasering (bench terraces), pemiringan ke tengah (backsloping), perumputan tampingan teras (grassing terrace risers), kanalisasi aliran air (channeling runoff), pola dan sistim penanaman baru, dan pola masukan baru seperti bibit, pupuk, dan pestisida. Para petani juga telah diberikan subsidi dan kredit dalam jumlah yang terbatas untuk membeli masukan baru dan membangun teras milik mereka sendiri. Hingga saat ini teknologi baru pertanian tersebut telah diperkenalkan di atas tanah seluas 10,000 hektar yang keadaannya kritis di daerah dataran tinggi Citanduy.

USESE (Unit Studi dan Evaluasi Sosial Ekonomi) telah bekerja sama dengan Yayasan Agro-Ekonomi dan dengan bantuan staf pengajar dari Department of Agricultural and Resource Economics di Universitas Colorado untuk mengadakan penelitian guna menentukan dampak dari teknologi pertanian yang baru pada penerima manfaat proyek.

Penelitian ini memberikan data-data mengenai hasil-hasil dari pertanian percontohan atau daerah perluasan dan ikut menunjang berkembangnya data empiris yang nyata dan yang dapat dipergunakan untuk meningkatkan pengetahuan kita mengenai pertanian dataran

tinggi. Hasil-hasil penelitian ini akan membantu para pengambil keputusan dalam penentuan ketepatan dari paket teknologi pertanian yang kini sedang dipergunakan.

Kesimpulan utama dari penelitian tersebut adalah sebagai berikut:

1. Nilai konkrit dari produksi (hasil tani x harga pasar) pertanian percontohan dan daerah perluasan meningkat dari 136,000 rp/hektar sebelum adanya terasering menjadi 446,000 rp/hektar. Meningkatnya nilai hasil pertanian sebagian besar disebabkan oleh adanya perubahan pola penanaman (misalnya, hasil ubi kayu turun sebanyak 30% sementara hasil beras dan kacang tanah masing-masing meningkat 23.7% dan 14.4%).

2. Penggunaan tenaga kerja dalam pertanian percontohan dan daerah perluasan meningkat dari rata-rata 860 jam/hektar sebelum terasering menjadi 1,774 jam/hektar. Meningkatnya penggunaan tenaga kerja sebagian besar berasal dari keluarga petani.

3. Produktivitas tenaga kerja (nilai produksi dibagi pemakaian tenaga kerja) meningkat dari rata-rata 158 rp/jam sebelum terasering menjadi 216 rp/jam.

4. Campuran masukan yang sebenarnya (actual input mix) antara pemakaian tenaga kerja dan masukan yang dibeli seperti pupuk, pestisida dan bibit-bibit adalah dibawah optimal sebelum terasering dan hampir mencapai titik optimal setelah terasering. Hal ini menimbulkan peningkatan yang berarti dalam nilai marginal dari tenaga kerja dan masukan yang dibeli.

Kesimpulan-kesimpulan ini menunjukkan bahwa dengan pengunaan teknologi yang tepat untuk bidang pertanian dan pengawetan, ada potensi yang tinggi untuk meningkatkan pendapatan pertanian dan kesempatan kerja di daerah dipedesaan dataran tinggi di Indonesia. bagaimanapun juga, sebelum pelaksanaan program dan teknologi ini dapat diterapkan lebih luas, tiga masalah pokok perlu ditinjau lebih lanjut, yaitu:

1. Oleh karena penelitian ini diadakan di daerah-daerah yang mempunyai data iklim pertanian yang relatif homogen, tidak banyak yang bisa diutarakan mengenai hubungan antara keadaan iklim pertanian dan peningkatan produksi. Contoh yang lebih luas dengan perbedaan iklim yang lebih menyolok diperlukan untuk menilai hubungan tersebut.

2. Penelitian yang sekarang ini tidak mencakup data yang cukup untuk menetapkan seluruh biaya proyek. Biaya tersebut perlu diperhitungkan untuk dapat menilai kebutuhan dan keerektipan dari tawaran perangsang (untuk terasering) yang hendak diberikan oleh pemerintah Indonesia.

3. Untuk analisa yang lebih lengkap diperlukan adanya pengujian terhadap metode-metode pilihan demi tercapainya tujuan pengembangan pertanian daerah dataran tinggi. Dengan demikian, biaya dan keuntungan-keuntungan dari pertanian hutan (agro-forestry) dan metode-metode penanaman lain pada lereng dan tanah yang berbeda-beda jenisnya serta metode terasering harus diteliti terlebih dahulu untuk menetapkan pola campuran program yang optimal.

CONTENTS


| | Page |
|---|---|
| EXECUTIVE SUMMARY (ENGLISH) | i |
| EXECUTIVE SUMMARY (BAHASA INDONESIA) | iv |
| 1. INTRODUCTION | 1 |
| 1.1 Project History | 1 |
| 1.2 Studies of the Citanduy II Project | 2 |
| 1.3 Purpose of the Study | 3 |
| 2. DESCRIPTION OF THE SINAGA STUDY | 5 |
| 2.1 Purpose | 5 |
| 2.2 Overview of the Study Area | 5 |
| 2.3 Methodology | 6 |
| 2.4 Findings | 7 |
| 3. FINDINGS | 8 |
| 3.1 Total Value of Production | 10 |
| 3.2 Labor Use | 10 |
| 3.3 Labor Productivity | 11 |
| 4. CONCLUSIONS | 12 |
| 4.1 Causes of Productivity Increases | 12 |
| 4.2 The Contribution of Terracing to Increased Production Values | 12 |
| 4.3 Increased Marginal Values of Labor and Purchased Inputs | 13 |
| 4.4 The Optimal Mixes of Labor Use and Purchased Inputs Use | 13 |
| 4.5 Labor Productivity | 14 |
| 4.6 Changing Cropping Patterns | 14 |
| 5. RECOMMENDATIONS | 17 |
| REFERENCES | 19 |
| APPENDIX A. ADDITIONAL SINAGA STUDY FINDINGS | 20 |
| APPENDIX B. PRODUCTION FUNCTION ANALYSIS | 23 |
| APPENDIX C. REGRESSION RESULTS: VALUE FUNCTIONS | 32 |
| PUBLICATIONS OF GENERAL INTEREST AVAILABLE FROM USAID/INDONESIA | 34 |

# 1. INTRODUCTION

## 1.1 Project History

The problems caused by the intensive cultivation of steep land slopes in Java (erosion in the upper watersheds, flooding, and the siltation of irrigation systems in the lower plains of most of the island's major river basins) have long been of national concern. To address these problems, the Government of Indonesia (GOI) launched the Citanduy I project in 1976. Citanduy I was mainly directed toward providing flood control, rehabilitating old irrigation systems, and constructing new irrigation systems in the lowlands of the Citanduy River Basin in West Java.

In addition, the GOI initiated a pilot project under Citanduy I (called the Panawangan Pilot Project) to examine new solutions to the root cause of lowland flooding and soil erosion resulting from the intensive cultivation of steep slopes. In this project, the problems of steep slope farming were approached from both an agricultural and a soil conservation point of view, where efforts were made to develop farming systems that increase production and income as well as incorporate soil conservation techniques.

Based on the results of the Panawangan Pilot Project, the Citanduy II project was begun in 1981/1982. The objectives of this project are to increase the incomes of farmers, reduce soil erosion, and increase employment opportunities in the upland areas of the Citanduy River Basin.

The core activities of Citanduy II are the establishment of 48 model farm units and expansion areas over a five-year period. The model farm concept is an extension model which attempts to introduce a package of

upland agricultural technologies to farmer groups in contiguous areas of approximately 10 hectares. The package consists of bench terraces, new cropping patterns and systems, and new input mixes (e.g., seeds, chemical fertilizers, and insecticides) for land with slopes of less than 45 percent. Land with slopes of more than 45 percent receive an agro-forestry package. In addition to this relatively intensive set of extension activities, the project provides subsidies and credit to model-farm farmers over the five-year period in order to allow them to construct bench terraces themselves, adopt new cropping patterns, and to buy new inputs.

Expansion areas are lands surrounding the model farms where land conditions are similar to those of the model farms. It was hoped that during the project, expansion area farmers would imitate the practices of the model farms. If this was done successfully, these extension area farmers were incorporated into the program and received input subsidies for three years and financial credit for their activities.

## 1.2 Studies of the Citanduy II Project

Several studies have been conducted to determine the success of the model farm program and the factors that contributed to this success. Sinaga et al. (1985) measured the project's impacts on three model farms that were built in 1981/82 and their extension areas. A similar study, with a larger coverage in terms of the number and age of model farms, was conducted by USESE (1986). Other studies of the Citanduy II model farm program include a study by Irawan (1986), which examines the marketing of selected products of the model farms and their expansion areas, and a study by Tatuh (1986), which investigates credit for soil conservation and farm practices.

All of the above studies investigate only the socio-economic aspects of the model farms and expansion areas. An important study of the agro-climatic conditions of land resources in the model farms area has been conducted by Kucera (1985). Kucera's study is intended to compliment the Sinaga and USESE studies.

## 1.3 Purpose of the Study

The original intention of the present study was to combine the Sinaga and Kucera studies in a unified analysis of soil characteristics and to determine the project's beneficial impacts on the model farms and expansion areas. However, only a small subset of the data from the Kucera study can be associated with farmers' data from the Sinaga study. In addition, the soil characteristics data that can be matched are relatively homogeneous. Therefore, only a limited analysis was possible.* But the Sinaga data are rich in information and provide a basis for further investigation of the beneficial impacts of the model farms program.

---

* A preliminary analysis of the relation between production and agro-climatic conditions found that the only significant relationships to the value of production are present land use and drainage. Land use has a positive relationship, but drainage appears to be negatively correlated. This negative relationship, however, may represent multicollinearity with some other unknown factor. The lack of a sufficiently large data base and the homogeneity of the data available are the likely causes of the failure to find a significant relationship between other agro-climatic variables and production.

This report contains the findings of a study conducted during a one-month visit by Dr. Bungaran Saragih, Director of the Unit Studi and Evaluasi Sosial Ekonomi (USESE), to the International School for Agricultural and Resource Development (ISARD) of Colorado State University. Given the data limitations noted above and the short period provided to conduct the study, this analysis provides: (1) a verification of the analysis conducted by Sinaga, (2) an investigation of the causal relationships of the impacts observed by Sinaga, and (3) the identification of future research needs. The next section of this paper provides a brief description of the Sinaga analysis.

# 2. DESCRIPTION OF THE SINAGA STUDY

## 2.1 Purpose

The primary purpose of this study was to assess the socio-economic impact of the Citanduy II project on model farm and extension area farmers. The focus of the study was limited to an examination of land and labor productivity and their related factors. Special attention was also paid to the factors that may motivate farmers to participate in the project.

## 2.2 Overview of the Study Area

### Site Selection

To ensure the most thorough assessment possible, three sites were chosen using the criteria of selecting the project's oldest model farms and selecting farms located in different subwatersheds (it was presumed that sites located in different subwatersheds would also have different agroclimatic conditions). The sites selected were: (1) Mekasari village in the Cimuntur watershed area of West Java, (2) Cibahayu village in the Citanduy Basin in West Java, and (3) Sadabumi village in the Cikawung basin in Central Java.

### Physical Conditions

The average elevations of the three sites range from 330 meters to 575 meters above sea level. Except in Cibahayu, where there are considerable areas of flat land, the sites are characterized by moderate to steep slopes. Although detailed information on soils was lacking, it appears that these areas generally consist of volcanically-derived brown latosols which are vulnerable to erosion. The sites' rainfall ranges from 2150 to 2320 mm per year.

### Socio-economic Conditions

Statistical data on socio-economic conditions at these sites were incomplete or lacking altogether. Available data indicated that Cibahayu's population density is 1063 people per square kilometer and its agricultural density is 16.4 persons per square hectare. Comparable figures for Sadabumi are 302 and 6.3, and for Mekasari, 510 and 5.2, respectively.

The primary cash crops grown at the sites are coffee and clove trees in Sadabumi, and coconut in Mekasari, while much of the Cibahayu area is planted in bamboo. In addition, rice, maize, cassava, peanuts, various annual vegetables, and bananas are the next-most prominent crops, although manioc and squash are also grown. Land ownership is highly fragmented, with farmers' plots located on as many as five different blocks of land.

## 2.3 Methodology

### Selection of Sample Land Parcels and Farmers

Field blocks belonging to the project were randomly selected. Then, because the owners of each field block consisted of members of one farmer group (Kelompok Tani), the sample plots were chosen through a random selection of farmers, using membership lists of the selected field block farmer groups. Village membership lists were used to sample non-adopters (see below).

### Data Collection

Two basic techniques were used to collect data: the measurement of fields or plots, and interviews with farmers. These two types of data collection were conducted simultaneously.

Number of Sample and Grouping*

The population was divided into three groups: model farmers, expansion area farmers (those who adopted the project's technologies within the expansion areas) and non-adopters. (because land ownership is fragmented into several plots in different blocks, non-adopters may have participated in the program in blocks other than those for which they were surveyed. Thus, non-adopters here are farmers who elected not to participate in the project in the blocks surveyed.) A total of 195 farmers comprised the sample. Ten model farmers in each of the three villages, 40 extension area farmers in each of the villages, and fifteen non-adopters in each village were selected.

## 2.4 Findings

The main findings and conclusions of the Sinaga study are discussed in Section 3. Additional details on Sinaga's findings are presented in Appendix A.

* The original report used a slightly different terminology for these farmer divisions, although their definitions have not changed here. For clarity, the terms model farmers, expansion area farmers, and non-adopters are used consistently throughout this analysis.

## 3. FINDINGS

The results reported in the Sinaga (1985) study are based upon hand-calculations of preliminary data. Using micro-computers, we were able to verify these results using a complete data set. In general, the results of the Sinaga study agree with the computer-calculated values.

A table from the Sinaga study of particular interest to this study is his Table 11; the recalculated version of this table is shown here as Table 1. The original and recalculated tables differ in two ways: (1) Sinaga deflated his values by coverting rupiah values into rice equivalents, but the recalculated values are left in nominal terms; and (2) in addition to computing productivity values for the model farm and expansion areas, we also computed these values for non-adopters.

Table 1. Land and Labor Productivity

| | Model Farm | | | Expansion Area Farm | | | Non-Adopter Farm |
|---|---|---|---|---|---|---|---|
| | Before | After | Ratio of After to Before | Before | After | Ratio of After to Before | Before |
| **MEKASARI** | | | | | | | |
| 1. Total Value per Hectare (rp/ha) | 221,445 | 755,777 | 3.41 | 177,277 | 598,964 | 5.11 | 67,440 |
| 2. Labor Use (hr/ha) | 781 | 1,960 | 2.51 | 551 | 1,352 | 2.45 | 104 |
| 3. Labor Productivity (rp/hr) | 283 | 385 | 1.36 | 212 | 442 | 2.08 | 647 |
| **SADABUMI** | | | | | | | |
| 1. Total Value per Hectare (rp/ha) | 166,349 | 398,385 | 2.39 | 99,222 | 251,195 | 2.53 | 206,705 |
| 2. Labor Use (hr/ha) | 743 | 2,911 | 3.92 | 902 | 1,496 | 1.66 | 963 |
| 3. Labor Productivity (rp/ha) | 223 | 136 | 0.61 | 109 | 167 | 1.53 | 214 |
| **CIBAHAYU** | | | | | | | |
| 1. Total Value per Hectare (rp/ha) | 110,543 | 391,095 | 3.54 | 129,559 | 397,699 | 3.07 | 398,300 |
| 2. Labor Use (hr/ha) | 1,004 | 2,434 | 2.42 | 1,320 | 2,668 | 2.02 | 1,399 |
| 3. Labor Productivity (rp/ha) | 110 | 160 | 1.45 | 98 | 149 | 1.52 | 284 |
| **TOTAL SAMPLE** | | | | | | | |
| 1. Total Value per Hectare (rp/ha) | 160,293 | 510,868 | 3.19 | 111,942 | 380,414 | 3.40 | 282,684 |
| 2. Labor Use (hr/ha) | 832 | 2,483 | 2.98 | 891 | 1,664 | 1.87 | 1,077 |
| 3. Labor Productivity (rp/hr) | 192 | 205 | 1.07 | 125 | 228 | 1.82 | 262 |

### 3.1 Total Value of Production

For both the model farms and expansion area farms in all villages, the project resulted in an increase in the total value of production (crop yields multiplied by market price): from an average of 136,000 rp/ha before terracing to 446,000 rp/ha after terracing. That is, farm incomes increased by an average of 310,000 rp/ha/yr because of the project.

On average, the increase in the total value of production was 219 percent in the model farm areas and 240 percent in the expansion areas. However, non-adopters in Sadabumi and Cibahayu had greater returns per hectare than either the model farm areas or the expansion areas before terracing began (see Table 1), and non-adopters' total value of production in Cibahayu before terracing exceeded that of both model and expansion area farmers after terracing. Because of the non-adopters' high initial value of production, their non-adoption of the model farm technology would thus appear to be economically rational. Mekasari's far higher adoption rate of project technologies appears to correspond to its relatively low value of production before terracing was introduced.

### 3.2 Labor Use

Labor use (employment) within both the model farm and expansion areas increased from an average of 860 hr/ha before terracing to 1,774 hr/ha after terracing.

On average, the use of labor at model farms increased by 198 percent, and in the expansion areas it increased by 87 percent. After terracing, the model farm areas were found to use over twice as much labor per hectare and the expansion areas about one-and-one-half times as much labor as the non-adopters. The largest increase in labor use was a

292 percent increase in the model farm area of Sadabumi and the smallest increase in labor use was the 66 percent increase in the expansion area of Sadabumi.

### 3.3 Labor Productivity

Labor productivity (the value of production divided by labor use) showed an overall increase, from an average of 158 rp/hr to 216 rp/hr before and after terracing, respectively.

Labor productivity increased within both the model farm and the expansion areas of Mekasari and Cibahayu. It decreased in the model farm area and increased in the expansion area of Sadabumi. The largest changes in productivity occurred in Mekasari. On the average for all of the villages, labor productivity in the model farms remained relatively constant at approximately 200 rp/hr, but increased by 82 percent in the expansion areas, from 125 rp/hr to 228 rp/hr. However, labor productivity for the non-adopters is, on the average, 262 rp/hr, thus providing another reason why these farmers are non-adopters.

# 4. CONCLUSIONS

The verification of the Sinaga study (see Section 3) indicates that the total value of production (rp/ha), labor use (hr/ha) and labor productivity (rp/hr) all increased as a function of the model farm program. The purpose of this section is to examine the causes of these increases. The results of this examination are presented here; Appendix B delineates the hypotheses and methodology used, and elaborates further upon the results.

## 4.1 Causes of Productivity Increases

Changes in the input (labor use and purchased inputs) and output (crop) mixes account for the largest part of the increased value of productivity experienced in the project after terracing was introduced. While terracing accounts for only a part of this increase, it must be given credit for facilitating some of the changes in input and output mixes. Last, the Citanduy II model farms program itself likely provided farmers with the information that was necessary to make these input and output changes.

## 4.2 The Contribution of Terracing to Increased Production Values

After the optimum mixes of labor and purchased inputs were computed (see Appendix B), they were used to calculate the maximum value of production per hectare. These inputs were then subtracted to comprise an on-farm income that combines both rents and on-farm wages.

Terracing was found to boost on-farm income for the average farmer by approximately 80,000 rp/ha/yr. Because this benefit does not include purchased input costs, which are subsidized under the program, the farmer

would receive an additional gain of 51,000 rp in subsidized purchased input expenses under the project. This result was derived assuming optimal before- and after-terracing input mixes, so that the increased returns are solely due to terracing.

Using a 12 percent discount rate over a 15-year period, the present worth of these gains was calculated: 544,880 rp/ha without subsidies and 892,241 rp/ha with subsidies. Thus, to the extent that terracing costs are less than 544,880 rp, it could be expected that farmers would voluntarily adopt terracing and that subsidies should not be required, but credit may become very important.

## 4.3 Increased Marginal Values of Labor and Purchased Inputs

The marginal values of both labor and purchased inputs increased significantly with terracing. For example, the marginal value of the 1,400th hour of labor increased from approximately 25 rp before terracing to 75 rp after terracing, assuming 10,000 rp of purchased inputs. Likewise, the marginal value of the 10,000th rp of purchased inputs increased from approximately 0.7 rp before terracing to 4 rp after terracing, assuming 1,400 hr of labor inputs.

## 4.4 The Optimal Mixes of Labor Use and Purchased Inputs Use

After calculating the marginal costs of these inputs it was determined that before terracing, 286 labor hours per hectare would produce an economically efficient solution for the farmer, and that 4,900 rp/ha was the efficient level of application for purchased inputs. However, using a weighted average, it was found that model and expansion area farmers actually employed 860 hours of labor per hectare and that the value they received from the application of purchased inputs was only 25 percent of their costs.

The optimal after-terracing levels of these inputs were then calculated: 1,450 hours per hectare for labor use, and 51,100 rp of purchased inputs per hectare. After terracing, farmers were found to have achieved a near-optimal combination of labor and purchased inputs use: Their actual labor use was 1,774 hr/ha and their actual purchased inputs use was 57,400 rp/ha.

## 4.5 Labor Productivity

The productivity of labor increased from 1.43 hr/kg before terracing to 0.66 hr/kg after terracing for rice production, and from 2.5 hr/kg to 1.2 hr/kg for peanut production. For cassava production, labor productivity remained relatively constant at 0.15 hr/kg.

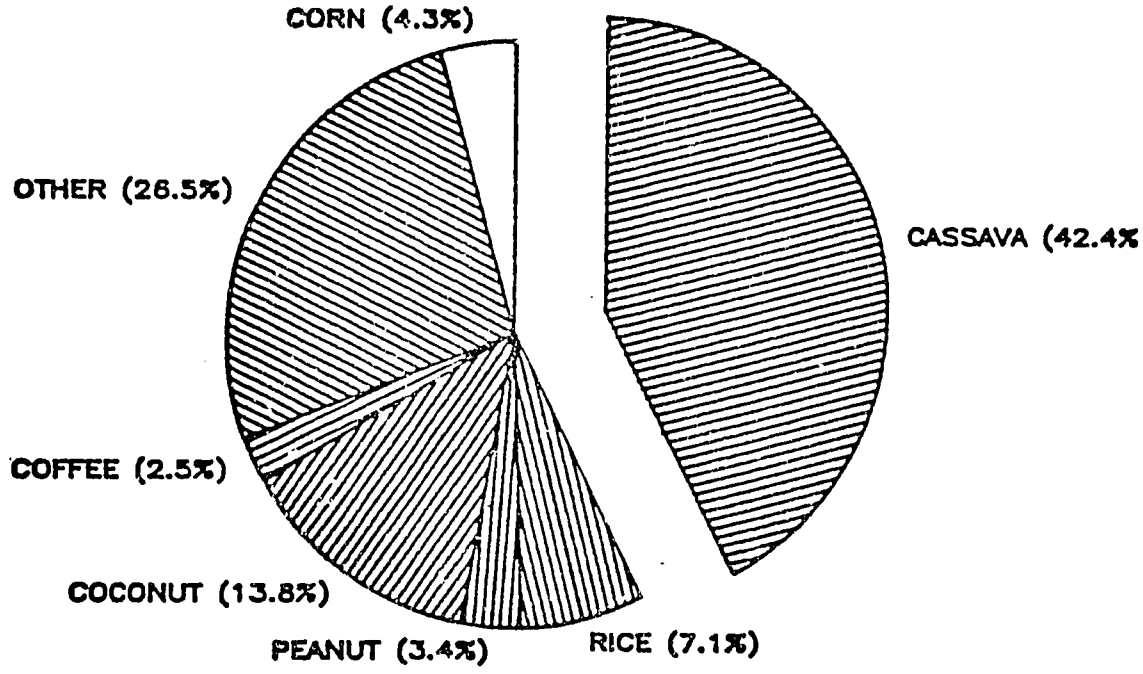
## 4.6 Changed Cropping Patterns

The price of each crop grown in the model and expansion farm areas was obtained by regressing physical and farm revenue before and after the project's technologies were introduced. Applying these estimated prices to the levels of production reported provided a breakdown of farm income by crop, and revealed that terracing has significantly altered the source of incomes at these farms: Conservation measures like terracing have induced farmers to shift from low-value crops such as cassava to crops that earn three to five times more per kilogram (see Figure 1).

For example, cassava production fell from 42.4 percent to 12.4 percent of the average value per plot, while rice production increased from 7.1 percent to 26.8 percent, and peanut production rose from 3.4 percent to 17.8 percent. (One of the functions of terracing is to conserve moisture in the soil. The fact that terracing increased rice production by nearly 400 percent shows that this objective of the project has been achieved.)

The most dramatic shifts occurred on slopes greater than 20 percent, where rice production increased from 193 to 46,427 rp per plot, peanut production increased from 0 to 22,374 rp per plot, and cassava production fell from 35,050 to 20,703 rp per plot.

BEFORE TERRACING




AVERAGE VALUE PER PLOT

AFTER TERRACING

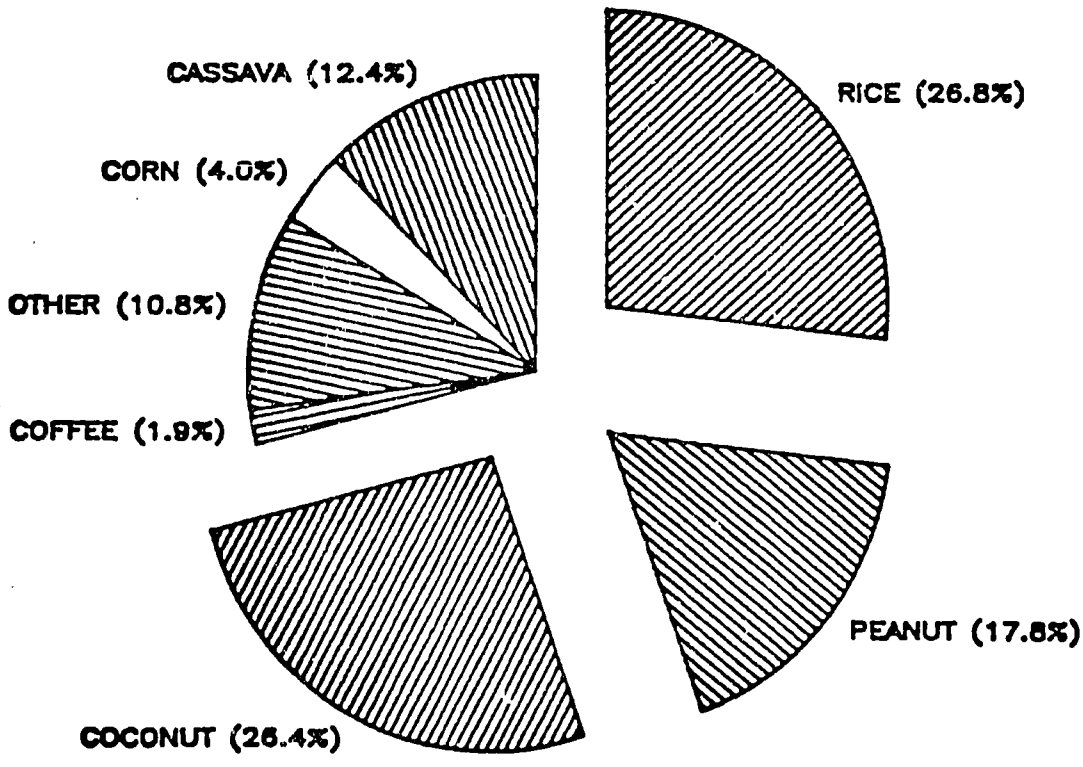



Figure 1. Average Value per Plot

## 5. RECOMMENDATIONS

A number of important questions remain that cannot be answered by this study. The questions and the necessary steps to answer them include:

1. Data for the model farm program cover only three years. This is too short a period to project whether benefits will increase, decrease or remain constant in the future. Therefore, further monitoring is needed in order to assess the long-run potential of terracing.

2. The observed changes in cropping patterns contributed to the economic viability of terracing. However, there may exist other cropping patterns and perhaps even new crops that would result in even larger gains from terracing. Research is needed to assess these possibilities.

3. This study was only able to identify agro-climatic data with relatively homogeneous characteristics for the model farms. As a consequence, little can be said about the relationship between agro-climatic conditions and productivity changes. A larger sample with more diversity of agro-climatic conditions must be collected in order to assess the importance of these conditions to the benefits realized by the project.

4. The present study is confined to the on-farm benefits of terracing, but there may also be significant off-farm benefits downstream from reduced soil erosion (including reduced sediment volume, improved water quality, reduced flooding, etc.) Thus, both the quantification of these off-farm benefits and an examination of the role of extension activities in influencing farmers' decisions to adopt conservation methods are necessary to evaluate the model farm program fully and are critical to policy decisions regarding subsidies for the adoption of the program.

5. On the cost side, no data are available to assess the construction costs of terracing. Such information is necessary in order to determine the feasible range for private terracing costs, to evaluate government subsidy programs to induce terracing, and to assess the economic viability of the project. Actual cost data need to be collected for the model farms and expansion areas.

6. Also on the cost side, there may be hidden costs of management associated with the operation and maintenance of the terraces and waterways. Understanding and measuring these costs is necessary for determining the feasibility of private terracing and for assessing the need for and success of government incentives to terrace.

7. The present study is confined to an assessment of bench terraces, but a complete analysis requires an examination of alternative methods of achieving the goals of increased productivity and reduced erosion. Investigation of the benefits and costs of agro-forestry and of other methods of cropping in different slopes and soil types is needed in order to determine the optimum program mix.

8. This study found that the observed mix of inputs (i.e., labor and purchased inputs such as chemical fertilizers) was suboptimal prior to terracing, but that after terracing the actual mix approached the optimal mix. Moreover, the output (crop) mix of farmers changed with terracing. One possible explanation of these changes is that the extension activities of the model farms provided improved information to farmers on optimum input and output mixes.

However, the available data are not sufficient to test this hypothesis. Further research is needed to assess the role of extension activities in the production decisions of farmers.

## REFERENCES


Irawan, Bambang. (1986). Pemasaran Untuk Pengembangan Usahatani Lahan Kering di DAS Citanduy. Ciamis, Indonesia: USESE.

Kucera, Karl P. et al. (1985). Micro-Model Farm Assessment of Land Resources. Ciamis, Indonesia: RMI Inc.

Sinaga, Rudolph 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: Agro-Economic Survey Foundation.

Tatuh, Jen. (1986). Kredit Untuk Conservasi Tanah dan Pengembangan Usahatani Lahan Kering di Bagian Hulu DAS Citanduy. Ciamis, Indonesia: USESE.

USESE Tim. (1986). Studi Impak Sosial Ekonomi Model Farm di Wilayah DAS Citanduy. Ciamis, Indonesia: USESE.

## APPENDIX A
## ADDITIONAL SINAGA STUDY FINDINGS

### A.1 Cropping Contributions to Total Return per Hectare

Before the model farm technology was introduced, cassava contributed between 54 and 62 percent of the total per-hectare yield in the three villages. Because of cassava's negative effect on soil conservation, however, growing this crop was not recommended, and sometimes prohibited, in the project. Instead, farmers were encouraged to cultivate rice, corn, peanuts, vegetables, grass for livestock, perennials such as fruit trees, and other trees which could be used for firewoods and industrial materials.

After the model farm technology was applied, the role of cassava decreased drastically and increased return per hectare and an improved quality of agricultural produce resulted. In the Mekasari model farms, rice became the dominant crop and coconut ranked second. In the expansion area, coconut remained dominant. In the Sadabumi model farms, rice, peanut and coffee production increased, while rice became dominant in the expansion area, with cassava second in rank. In the Cibahayu model farm and expansion areas, corn remained the most important crop.

### A.2 Input Use

Before the model farm technology was introduced, none of the farmers in the three villages used high-yield variety seeds or pesticides. After the project, however, these purchased inputs were used by the model and expansion area farmers in all three villages.

Fertilizer use also increased under the project. Except in Sadabumi, where animal fertilizer was seldom used and chemical fertilizers were not used before the project, farmers increased the amount of both types of fertilizer used.

## A.3. Employment Opportunities

During the project, labor use in all categories of farms increased, although the rate of increase varied considerably. In general, the rate of increase was higher in the model farms than the expansion farms. The overall proportion of family and hired laborers to labor use increase in the model farms was 68 percent and 32 percent, respectively; in the expansion farms, it was 85 percent and 15 percent, respectively.

In Mekasari, however, the greatest increase in labor use was for hired laborers. This was partly due to the type of perennial crop grown (coconut), which requires skill in harvesting.

Overall, increased labor use benefitted both males and females, with female laborers experiencing a slightly larger increase.

## A.4 Comparison of Model, Expansion Area and Non-Adopters' Farms

Except in Cibahayu, the value of production for the model and expansion area farms was higher after terracing than for the non-adopter farms. Labor productivity, on the other hand, was lower than the non-adopters productivity for all villages. Thus, it can be concluded that despite the increased value of production experienced under the project, the model farm program increased employment opportunities but with little increase in marginal productivity. One possible reason for the lower value of production in Cibahayu is that non-adopters were already employing cropping patterns similar to those recommended by the program before terracing. In addition, Cibahayu non-adopters were using chemical fertilizers before the project began.

## APPENDIX B

## PRODUCTION FUNCTION ANALYSIS

### B.1 Framework of the Analysis

The central problem defined here is one of optimizing the application of terracing to the upland regions. This optimization, of course, will depend upon the benefits and costs of terracing. The benefits are realized both on-farm, in the form of increased productivity, and off-farm, in the form of reduced downstream sedimentation from erosion. Because data have not yet been collected on the off-farm benefits, this analysis was confined to the on-farm benefits and costs.

A hypothetical set of costs and benefit functions are shown in Figure B-1. The total private costs (TPC) of terracing are likely to be a function of topography, because the steeper the slope, the greater the volume of soil that must be moved and thus the greater the loss of cultivatable land. That is, costs are likely to increase at an increasing rate with steepening slopes.*

The total private benefits (TPB) of terracing can be expressed in terms of additional net farm revenues stemming from changes in the productivity of land, labor and/or purchased inputs, and from changes in cropping patterns. Net farm revenues are simply the revenues earned minus the cost of hired labor and purchased inputs, net of any subsidies. Unlike the cost curve, there is no a priori reason to expect that the benefit curve will take any particular shape. The benefit curve in Figure B-1 assumes diminishing marginal returns from terracing as the slope gets very steep, but increasing marginal returns for more gradual slopes.

---

* A simulation model of terracing costs demonstrates increasing and diminishing marginal returns with increasing volumes of soil terraced. No actual cost data are available. The simulated cost function cannot be compared with the benefit function at this time.

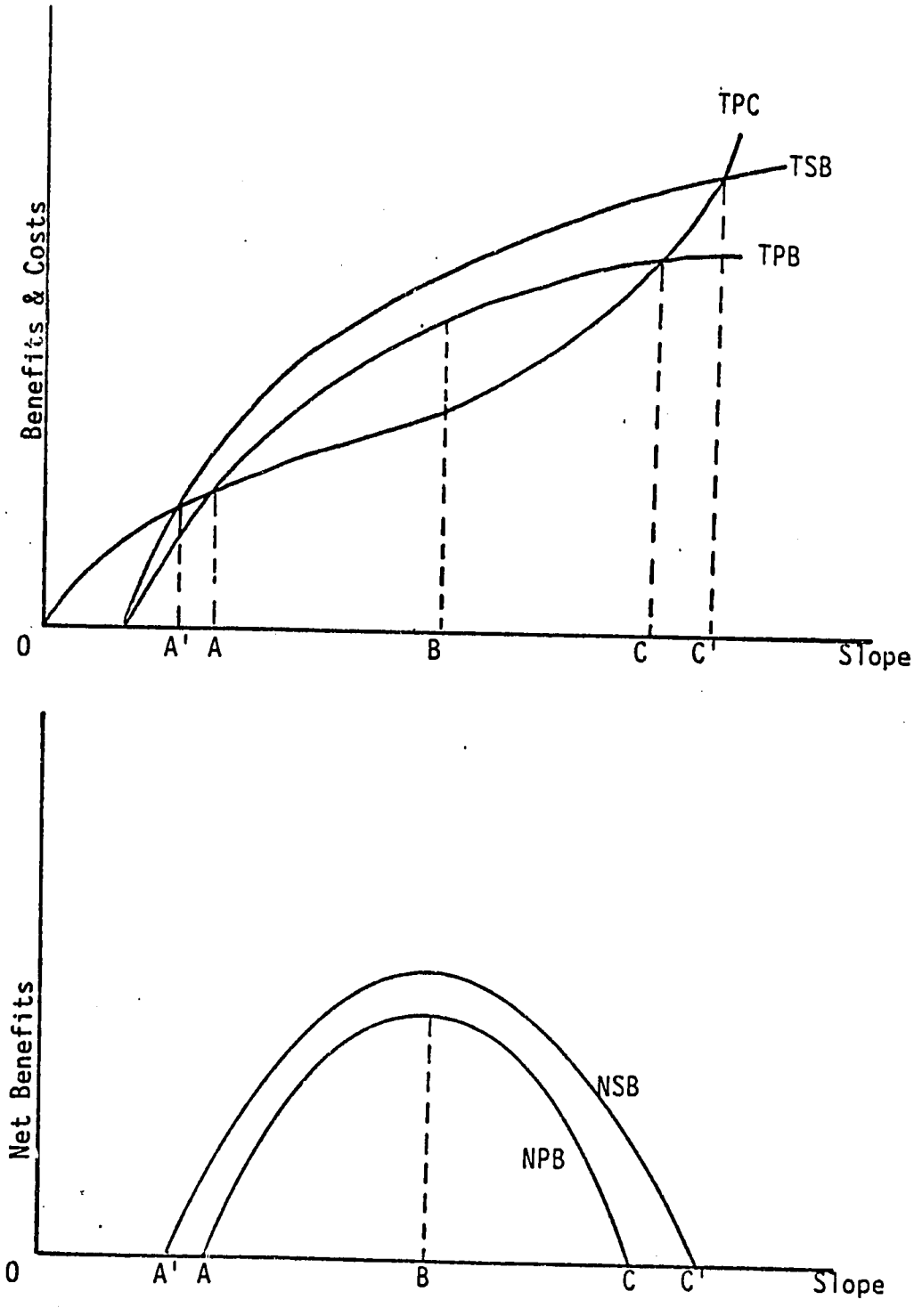



Figure B.1. Benefits and Costs of Terracing

Figure B-1 indicates that terracing is optimized for slopes equal to b. However, farmers cultivating land with slopes ranging from A to C would likely also terrace because the private benefits exceed the total private costs (TPC).

Summing off-farm erosion control benefits with the on-farm benefits of terracing yields the total social benefit (TSB) curve shown in Figure B-1. When off-farm benefits are included, the socially optimum range of slopes that should be terraced is expanded by AA' on lower slopes and CC' on higher slopes. Farmers on these slopes, however, will not terrace on their own because the private benefits are less than the private costs. Terracing on these slopes will require subsidies in order to make the private net returns from terracing positive.

## B.2 Estimation Methodology

### Private Benefits

The methodology employed to estimate private benefits was shaped to a large extent by the data available. It would have been ideal if production functions could have been estimated for the individual crops, and a model constructed to optimize the mix of labor, chemical, fertilizers, and insecticides, seeds, and land before and after terracing. The data provided only the value of production by sample plot, the labor hours, and the value of purchased inputs. At best, only before and after revenue functions could be estimated from this information. Given these limitations, the optimum mix of purchased and labor inputs were computed before and after terracing.

### Value Functions

A Cobb-Douglass form of value function was utilized to estimate the value functions, as shown in equation (1):

$$VALUE = \exp(C)\ L^{a1}\ IN^{a2} \qquad (1)$$

where: VALUE = the value of production in rp per ha;

C = the constant from the regression equation;

L = labor hours divided by ha;

a1 = the coefficient attached to labor;

IN = the purchased inputs measured in rp per ha; and

a2 = the coefficient attached to the purchased inputs.

Value, and the labor and inputs were divided by plot area. This implies constant returns to scale for all three factors, a restriction that was tolerated because the sample plot areas proved to be less than a hectare in almost all instances. Generalizing from these data in order to extrapolate to larger farms was considered too risky. Several supporting studies were conducted to determine whether the constant returns argument could be justified. The results strongly suggest that such an assumption is warranted.

Ordinary least square regressions were performed on the log transformations of value, and the labor and purchased inputs for both the periods before and after the terraces were constructed. The resulting two revenue functions were then utilized to determine the optimal combination of inputs and output (value of production) before and after implementing the technology. The difference in output value, given an economically efficient mix of labor and purchased inputs, should provide a consistent measure of the effect of terracing on upland agricultural regions. This strategy is superior to simply comparing the before and after yields per hectare, because productivity might have changed for reasons unrelated to the terracing. Other reasons for increases in productivity might include increases in the efficiency with which factor inputs are used and employing new cropping patterns. The likelihood of mistaking these and similar enhancements to production for the effects of terracing is diminished when the most efficient approaches, before and after terracing, are used as benchmarks for the purpose of comparison.

## Efficient Levels of Inputs

The functions represented by equation (1) provided the basis for determining how each additional labor hour per hectare or rupiah of purchased input per hectare influences the value of production. This is, of course, simply the first derivative of equation (1) with respect to L and IN, as shown in equations (2) and (3). The optimum combination of these ingredients is one which equates these marginal values to the resource costs.

$$VMP_L = a1 \exp(C)\ L^{(a1-1)}\ IN^{a2} \qquad (2)$$

where: $VMP_L$ is the additional value (in rp) of an additional hour of labor.

$$VMP_{IN} = a2 \exp(C)\ L^{a1}\ IN^{(a2-1)} \qquad (3)$$

where: $VMP_{IN}$ is the additional value (in rp) of an additional unit of purchased inputs (in rp).

The wages for female and male workers were obtained by regressing the hired wage bill against the hired worker hours. The resulting wage rates and the marginal resource cost of purchased inputs of 1 rp were used to solve equations (2) and (3) for the optimal mix of inputs. These solutions were then used in conjunction with equation (1) to determine the optimum revenue for the average farm.

One problem inherent in this approach is which marginal resource cost to charge for family labor. Men, women, and children all have different chores which are likely to differ from those assigned to off-farm laborers. The wage bills included in the data provided information about payments to off-farm help. It is questionable whether these rates should be applied to family members. No doubt the shadow price of on-farm labor should be tied to what one could earn off the farm. But the analysis is

never that simple. In the absence of any better information, we assumed that this shadow price was equivalent to that which a hired female worker would earn. It was thought that the wages of hired males would reflect heavy work which might not conform to the activities of the farm family.

The private benefits received by both the farm families and hired labor were computed by multiplying the optimal labor hours on- and off-farm by the marginal wage rate. Rents to the land owner were derived by computing the value of production using equation (1) and subtracting the wage bill and purchased inputs. We assumed that subsidies were not necessary and that farmers could pay for fertilizers, seeds, and insecticides. The benefits received by the land owners are, therefore, understated by the amount of subsidy the government wishes to offer. In structuring the problem in this way, we were able to determine whether such subsidies could be phased out, that is, whether terracing was worthwhile even without government involvement.

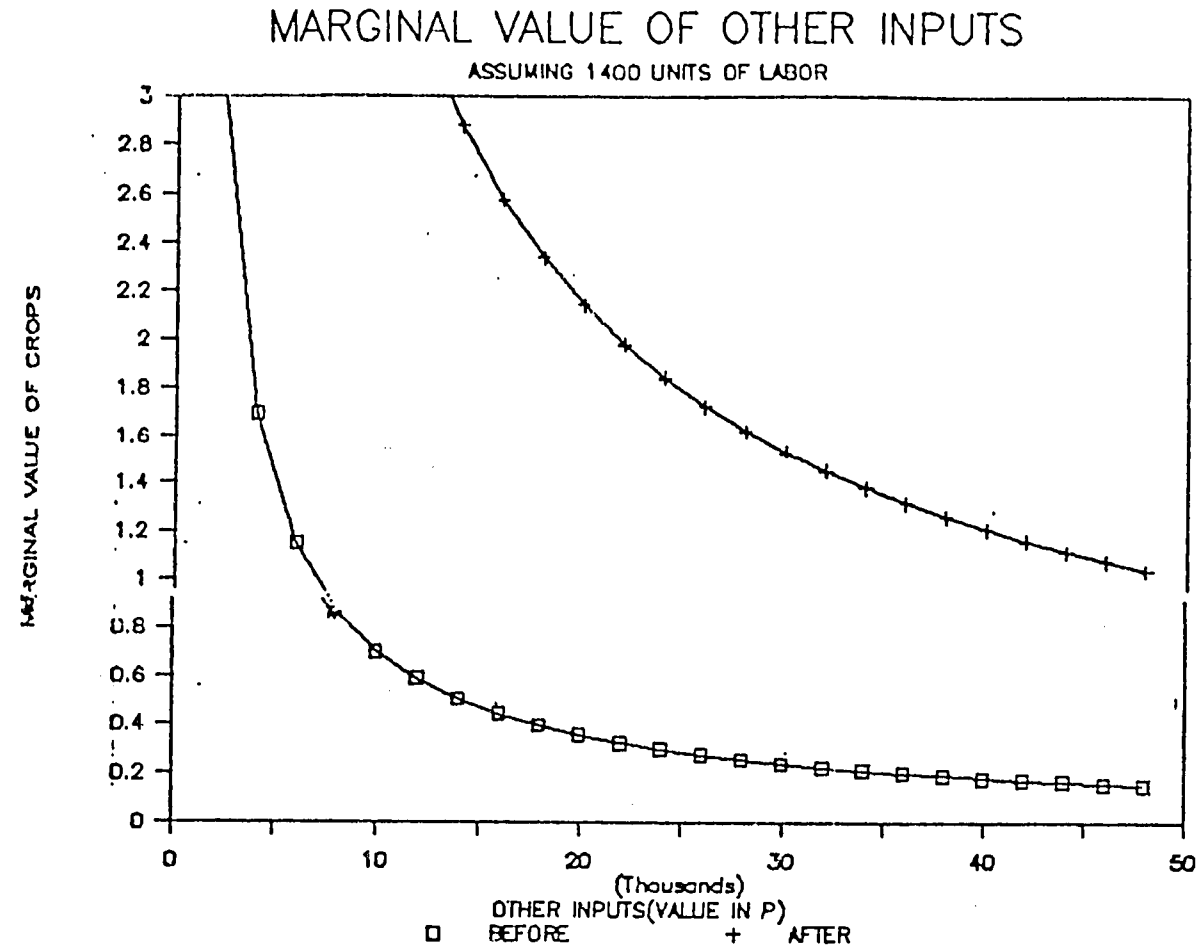
## B.3 Results

### Optimal and Actual Input Mix for All Plots

Prior to terracing, farmers employed labor up to the point where the value of an additional hour was 37.5 rp. This implies significant over-employment of labor, because the costs of an additional hired female and male worker are estimated to be 79 and 206 rp per hour, respectively. Assuming that the weighted averaged marginal cost of labor prior to terracing is 100 rp/hr, then 286 labor hours per hectare would produce an economically efficient solution. This is admittedly a small number and we know that on average model and expansion area farmers actually employed 806 hours per hectare before terracing. The reason for this discrepancy between what is considered economically optimal and actual practice may lie in the shadow price attached to family labor: 100 rp/hr is likely too high. It is thus probable that significant under employment or unemployment exists, there by decreasing opportunity costs.

It also appears that prior to terracing, the value received from the application of purchased inputs is only 25 percent of their cost, with the subsidy. The efficient level of application is only 4,900 rp/ha. One can only speculate as to why this might be the case. The additional analyses reported below provide at least a partial explanation.

After terracing, the situation appears to have improved significantly. Figure B-2 shows the extent to which terracing has shifted the factor demand curves. Farmers achieved close to an optimum input combination after terracing. According to the estimated value function, the value-maximizing levels of labor use and purchased inputs use are 1,450 labor hours/ha and 51,000 rp/ha, respectively. The average farmer employed 1,774 hours and 57,400 rp/ha, respectively. This is somewhat surprising because chemical inputs were subsidized. Under such conditions, one would have expected that these inputs would have been over-utilized. Perhaps the government limited the amount of subsidies to a level which either by accident or design produced an economically efficient solution.



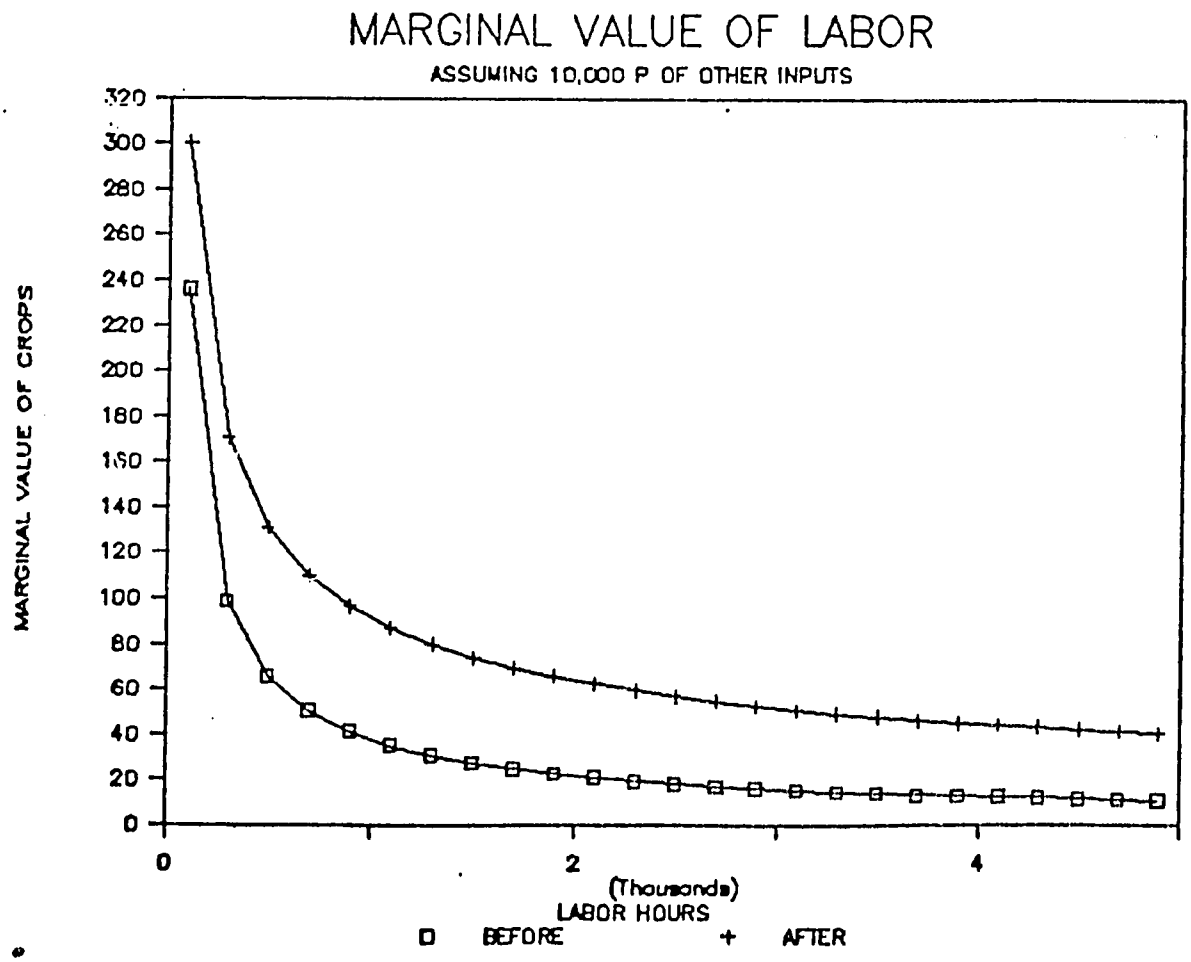




Figure B.2. Marginal Values

## Optimum Farm Income Before and After Terracing

Given the efficient mixes of labor and purchased inputs reported above, it was possible to compute the "best practice" solutions before and after terracing. The private benefits to the farmer were computed as follows. The optimum mixes were used to attain the maximum value of production per hectare. Hired labor and purchased input costs were then subtracted. The remainder comprised on-farm income that combines both rents and on-farm wages.

Terracing boosts on-farm income (both rents and implicit wages) by 79,983 rp/ha/yr. This benefit does not include purchased input costs, which are subsidized under the program. The gain an average farmer perceives would thus be approximately 80,000 rp plus 51,000 rp in subsidized purchased input expenses. The present worth of these gains, using a 12 percent discount rate for 15 years, is 544,880 rp/ha without subsidies and 892,241 rp/ha with subsidies. To the extent terracing costs are less than 544,880 rp/ha, one would expect farmers to voluntarily adopt the practice and subsidies should not be required, but credit may become very important.

## Other Benefits

The magnitude of the potential gains attributable to terracing led us to examine whether this practice was enhancing the productivity of farm inputs given the same cropping patterns or whether it facilitated a change in the mix of outputs. By regressing physical production against farm revenue, we were able to obtain the price of each crop, before and after the project's technologies were introduced. Applying these estimated prices to the levels of production reported provided a breakdown of farm income by crop. Figure I in Section 4 reveals that the program has significantly altered the source of incomes. It has induced farmers to shift from low valued crops such as cassava to those which earn three to five times more per kilogram, particularly rice, peanuts and coconuts.

## APPENDIX C

## REGRESSION RESULTS: VALUE FUNCTIONS

| Description | Constant | Coefficients LN (L/HA) | LN (IM/HA) | R 2 | Sample |
|---|---|---|---|---|---|
| 1 All Before | 10.359 | 0.207<br>0.096 | 0.035<br>0.022 | 0.07 | 148 |
| 2 All After | 7.232 | 0.484<br>0.137 | 0.171<br>0.051 | 0.23 | 148 |
| 3 Before Low Slope ( 10) | 8.603 | 0.454<br>0.182 | 0.007<br>0.031 | 0.18 | 40 |
| 4 After Low Slope ( 10) | 8.775 | 0.147<br>0.183 | 0.264<br>0.194 | 0.17 | 36 |
| 5 Before Int. ( 10, 20) | 9.528 | 0.286<br>0.113 | 0.033<br>0.027 | 0.11 | 90 |
| 6 After Int. ( 10, 20) | 7.025 | 0.529<br>0.207 | 0.158<br>0.066 | 0.18 | 97 |
| 7 Before High Slope ( 20) | 8.216 | 0.524<br>0.264 | 0.011<br>0.099 | 0.15 | 26 |
| 8 After High Slope ( 20) | 5.666 | 0.666<br>0.213 | 0.215<br>0.081 | 0.48 | 32 |
| 9 Mekasari Before | 8.611 | 0.524<br>0.129 | 0.074<br>0.056 | 0.29 | 53 |
| 10 Mekasari After | 5.741 | [illegible] | [illegible] | [illegible] | [illegible] |

| Description | Constant | LN (L/HA) | LN (IM/HA) | R 2 | |
|---|---|---|---|---|---|
| 13 Cibahayu Before | 10.105 | 0.085<br>0.128 | 0.153<br>0.023 | 0.56 | |
| 14 Cibahayu After | 5.477 | 0.112<br>0.149 | 0.565<br>0.145 | 0.26 | |
| 15 After Adoption 81 | 7.336 | 0.101<br>0.211 | 0.455<br>0.198 | 0.13 | |
| 16 After Adoption 82 | 5.998 | 0.701<br>0.175 | 0.107<br>0.053 | 0.32 | |
| 17 1 Revised--New Areas | 9.005 | 0.378<br>0.092 | 0.018<br>0.021 | -.15 | ] |
| 18 2 Revised--New Areas | 7.156 | 0.496<br>0.136 | 0.169<br>0.051 | 0.23 | ] |
| 19 Small Farms Before | 10.427 | 0.186<br>0.167 | 0.051<br>0.031 | 0.08 | |
| 20 Small Farms After | 8.928 | 0.241<br>0.167 | 0.189<br>0.056 | 0.23 | |
| 21 Large Farms Before | 8.817 | 0.469<br>0.137 | -0.051<br>0.046 | 0.19 | |
| 22 Large Farms After | 3.909 | 0.869<br>0.251 | 0.202<br>0.107 | 0.34 | |

PUBLICATIONS OF GENERAL INTEREST
AVAILABLE FROM USAID/INDONESIA

1. A Preliminary View of Indonesia's Employment Problem and Some Options for Solving It, by Robert L. Rucker, September 1985.

2. Demographic Background and Births Averted: Indonesian Family Planning, 1980-1984, by John A. Ross, Terry Hull, Lulu D. Cost, and David L. Piet, October 1985.

3. Public Expenditure Impact: Education and Health, Indonesian Family Planning, by Dennis N.W. Chao, John A. Ross, and David L. Piet, October 1985.

4. A Survey of Private Sector Training in Indonesia, by Grant Cox, November 1985.

5. An Epidemiological Approach to Health Planning and Problem Solving: A Case Study from Aceh Province, Indonesia, by Steven L. Solter, Ali Azir Hasibuan, and Burhanuddin Yusuf, February 1986.

6. Developing Manpower for Indonesia's National Family Planning Program: BKKBN's Experience with Overseas Graduate Training 1983-1985, by Santoso S. Hamijoyo, Thomas R. D'Agnes, and Slamet Sudarman, April 1986.

7. The High Performance Sederhana Irrigation Systems Project, by David M. Robinson, May 1986.

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 1986.

9. Model Farm Program benefits: The Citanduy Watershed, by Bungaran Saragih, Paul C. Haszar and Harold C. Cochrane, June 1986.