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Merle L Esmay

Major professor

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CHOICE OF LAND PREPARATION TECHNIQUES
FOR RICE CULTIVATION IN INDONESIA

THE UTILIZATION OF SMALL TWO WHEELED TRACTORS AT THE FARM LEVEL IN KARAWANG AND SUBANG COUNTIES IN THE WET SEASON OF 1980

By

Soedjatmiko

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ABSTRACT

CHOICE OF LAND PREPARATION TECHNIQUES
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THE UTILIZATION OF SMALL TWO WHEELED TRACTORS AT THE
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Insufficient food production and the ever increasing demand for rice has caused the Government of Indonesia to designated rice as a strategic commodity. In its attempt to stimulate an increase in rice production the Government of Indonesia has undertaken two main efforts: 1) the expansion of newly developed agricultural land, and 2) the intensification of production of the existing rice land. In association with this program, the Government is currently operating several selective agricultural mechanization projects (including tractorization) to help small farmers. The introduction of small two wheeled tractors in densely populated areas, such as West Java, has generated considerable debate, about private benefits versus the possible adverse social impacts.

This research focused on the choice of rice land preparation techniques during the 1980 wet season in the Northern coastal plains of West Java. There were three specific objectives:

1. To evaluate the operational performance of small two wheeled tractors for rice land preparation through direct field measurement techniques.

2. To evaluate the small tractor labor utilization and cost factors for rice land preparation.
3. To develop and test a systems analysis model to evaluate and compare rice land preparation techniques.

A systems analysis approach was used as the analytical and problem evaluation technique. Model verification was conducted with direct measurement data from a stratified randomized design. Field data were analyzed using linear additive models, analysis of variance and linear regression methods. The simulation model consisted of farm level and tractor owners' subsystems.

The significant conclusions derived from the statistical and computer simulation analysis were as follows.

Small two wheeled tractors greatly increased labor capacity for rice land preparation in the Northern coastal plains of West Java. The depth of the first manual labor tillage (6.2 cm) was significantly shallower than plowing (10.7 cm) with bullocks and tractor rototilling (10.3 cm). The difference of tillage depth between bullocks and tractor was not significant. Number of effective hours worked per day were significantly greater for tractors than for either manual labor or bullocks (the average was 11.6, 7.5 and 5.8 hours per day respectively). The simulated seasonal capacity of manual labor was 0.77 hectare, 3.4 hectares for bullocks and 27.4 hectares for tractors. The total labor utilized per hectare for land preparation was 4.1 man days with tractors, 10.6 man days with bullocks and 39.2 for human labor. The total labor input for rice preharvest activities was not significantly different for farms using tractors and those using bullocks. The average portion of rice land prepared in the villages studied was 15 percent by bullocks, 29 percent by manual labor and 46 percent by tractors.

The farmers' cost for rice land preparation by bullocks was generally lower than by either manual labor or tractors. Manual labor cost was the highest at Rp 33,973/ha for two passes, and Rp 30,100 and Rp 26,600 per hectare for tractors and bullocks respectively. The tractor owners' cost for two passes of rototilling was Rp 12,800/ha and the simulated returns and costs ratio was estimated at 2.12.

The performance of locally made tractors (IRRI type design) was not significantly different than for imported tractors. The returns and costs ratio of locally made tractors (2.46) was higher than for imported tractors (2.12), and the purchase price of Rp 1,650,000 in 1980 was 30 percent lower than the average imported tractors.

Approved Merle L Esmay
Major Professor

Approved ______________________________
Department Chairman

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CHAPTER 1

INTRODUCTION

Indonesia, a nation of 142 million inhabitants, consists of 3,000 islands stretching along the equator from 95 to 145 degrees east longitude. The total area is a little more than 1.9 million square kilometers or about five times the area of the State of Texas. With a population density of $679/km^2$, Java is the most densely populated island in the world. About 90 million people, about 63 percent of the Indonesian population, live in an area that is less than 7 percent of the total land area (Central Bureau of Statistics, 1979).

Agriculture, in this oil producing country, remains a dominant sector. In 1974, agriculture shared 39 percent of the gross national product; however, it gradually decreased to 34 percent in 1978 (Bureau of Statistics, Jakarta, 1978). The World Bank data indicate that income per capita per year was $220 in 1970, with a yearly growth rate of 3.5 percent from 1970 to 1975 (The World Bank Atlas, 1977). This growth of per capita income in the last decade has caused people to shift their food preference from lower nutrient foods to rice as their main staple (Ministry of Agriculture, 1977).

The insufficient increase food production and the ever increasing demand for rice caused the Government of Indonesia to regard rice a strategic commodity. Rice production has thus become high priority in the national development program (Ministry of Agriculture, 1977).

The focus of this thesis is on the contribution of agricultural technology, specifically tractorization, to the national development process, in particular rice production intensification. Since mechanization is generally categorized as being labor saving and capital intensive, the question arises whether tractorization is an appropriate technology to be introduced in such densely populated, low per capita income regions.

This chapter presents 1) a description of the problem regarding mechanization, 2) an identification of related research, and 3) the research objectives and methodology.

1.1 The Problem of Mechanization

Inadequate food production, unemployment and uneven geographic distribution of the population are urgent problems in Indonesia. The Government has stressed the transmigration program and the intensification of agriculture to meet the ever increasing demand for food, in particular rice. The implementation of the intensive rice production program involved many of the small farmers (land holding less than 1 hectare), as they constitute almost 60 percent of the total population of Indonesia (Ministry of Agriculture, 1977; Central Bureau of Statistics, 1978). The Government is currently operating several selective agricultural mechanization projects to help these small farmers. In the coming decade these projects are to spread throughout the country. One project, the introduction of small (two wheel) tractors of 7 to 8.5 horsepower, for rice land preparation on small farms, has generated considerable debate over private benefits versus the possible adverse social impacts; while agricultural mechanization may increase land and labor productivity, reduce production cost and drudgery, it also has the potential of increasing the income disparities and unemployment. This is particularly undesirable in the labor surplus areas of Indonesia.

Furthermore, all of the small tractors introduced to date in Western Java have been imported. Their technical appropriateness for specific local conditions needs to be evaluated. Questions arise regarding the sophistication of equipment design, local repairability, durability, availability of spare parts and high initial cost. A critical question needing investigation is whether a small two wheel tractor of simple design (for example, the IRRI[1] designed tractor) can be locally manufactured for a lower initial cost and with an acceptable technical and economic performance. In the long run, agricultural mechanization should not be dependent on importation.

Past Government mechanization introduction projects have largely been based upon experimental data obtained from controlled conditions and less reliable secondary information. The present study was designed to provide data on small tractor performance, labor utilization, and the cost of rice land preparation on farmers' fields. Subsequently, these field performance data were used to verify a systems model developed to compare and evaluate human, animal and tractor performance in rice land preparation.

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[1]International Rice Research Institute.

1.2 Objectives of the Study

The present research considered the choice of technology for rice land preparation during the wet season (Monson) in the Northern coastal plains of West Java. The study had two specific objectives:

1. Evaluate the operational performance of two designs of two wheeled small tractors for rice land preparation through direct field measurement techniques.
2. Compare small tractor, animal, and manual land preparation with focus on labor utilization and cost factors for rice land preparation.
3. Develop and test a system analysis model to evaluate rice land preparation techniques.

Small tractor in this thesis is defined as 7-8.5 horsepower, two wheel, both imported (Japanese) and locally manufactured (IRRI design). This research is limited to the Northern coastal plains of West Java due to resource constraints. Further discussion regarding this specific research location will be presented in Chapter 2.

This research differs from most previous research on agricultural mechanization in Indonesia in two ways: 1) primary data are assessed by direct measurement at the farm level under farmer operational conditions, and 2) following suggestions by the Michigan State University Task Force on Farming Systems Research, the small farmer values and goals are considered to explain and analyze preferences for land preparation techniques under specific ecosystems and locations (Norman *et al.*, 1980).

1.3 Research Design and Methodology

A systems analysis approach is used as the analytical and problem evaluation technique. Model verification is conducted with data obtained by direct measurement in a stratified randomized design. Purposive sampling was conducted to select eight villages in Karawang and Subang counties as research sites. Random sampling was the method used to determine the farm survey and field measurement samples. The sample size was 216 farm households and 432 rice fields, located in eight villages in Karawang and Subang counties. The samples were stratified into three categories: 1) farms using small tractors, 2) farms using bullocks, and 3) farms using manual labor for land preparation. Field data were analyzed using linear additive models, analyses of variance and linear regression methods. The resulting generalized data were used for verification of the computer simulation model. Details of statistical analysis, systems model design and simulation modeling are presented in Chapters 4 and 5.

CHAPTER 2

DEMOGRAPHIC CHARACTERISTICS OF KARAWANG AND SUBANG COUNTIES AND EXISTING LAND PREPARATION TECHNIQUES

In Indonesia, there are two patterns of agriculture. The first is constituted by some 1,800 large estates, which manage about 2.22 million hectare of land and grow export type crops. The second consists of 14.4 million small farms, which share 14.17 million hectares of land devoted to food crop production for domestic consumption (Central Bureau of Statistics, 1973). This present research deals primarily with the small farmers associated with rice production.

In its attempt to stimulate an increase in rice production, the Government of Indonesia is undertaking two main efforts: 1) the expansion of newly developed agricultural land, and 2) the intensification of production of the existing rice land. As a large portion of the existing rice land is located on the island of Java, it is necessary to review demographic characteristics of Java in relation to Indonesia as a whole (see Table 2.1).

The ever increasing population pressure (an increase of 42 percent between 1961 and 1980) on Java reduces the availability of agricultural land for food crop production as well as pastures. Within ten years (1961-1971) land for food crop production in Java decreased by 2.5 percent. During the same time the draft animal population decreased by 7.9 percent and declined another 4.3 percent between 1971 and 1980 in

Table 2.1. Demographic characteristics of Java relative to Indonesia.[1]

Items	Units	1961	1971	1980
Population	1000 persons			
Indonesia		97,019	118,368	142,179
Java		62,993	76,030	89,657
Density	Persons/km2			
Indonesia		51	62	75
Java		477	576	679
Draft animal	1000 units			
Indonesia		n.a.	9,359	8,735[2]
Java		5,611	5,170	4,946[2]
Land for food crops	1000 ha			
Indonesia		12,844	14,168	n.a.
Java		5,647	5,505	n.a.
Milled rice	1000 metric tons			
Production				
Indonesia		8,268	10,499	13,458[2]
Java		4,803	6,455	8,134[2]
Import[4]		1,064	503	1,964[3]

[1]Source: Central Bureau of Statistics, Jakarta.

[2]In 1978.

[3]In 1977.

[4]From: Gaiser (1980).

Indonesia (see Table 2.1). A study conducted by the Agroeconomic Institute over a longer period (1930-1976), showed that the decrease of draft animal population in Java to have seen 2.6 percent per year (9). These macro level data on population growth, which has a direct bearing on the increase of manual labor supply, the decrease of draft animals and hectarages of agricultural land resources in Java and their interrelations are treated as exogenous inputs for the computer simulation model of this research. To complement these macro data concerning Java, additional data were collected about the selected villages and farms of this study in the Northern coastal plain of West Java (see Table 2.2).

2.1 Characteristics of the Counties Studied

The Northern coastal plain of West Java has been known for hundreds of years as a rice producing area. At the beginning of the 17th century, Sultan Agung, the King of Mataram (Jogyakarta) commanded Bupati Wira Perbangsa to develop rice belts surrounding Batavia (the colonial name for Jakarta). The purpose was to provide sufficient "live" food storage for the Mataram army to defend the kingdom's territory against the Dutch colonial expansion (Demography of Karawang county, 1979). Rice production systems have remained essentially unchanged since that time until the advent of the green revolution.[1] However, this historical importance of the area is not the main reason for selecting the Northern coastal plains of West Java as the research site. The relevant considerations for the location of the study were:

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[1]The green revolution is defined as a period in which modern science and technology begin to have major impact on agriculture and resulted in large continuing increases in land and labor productivity (Stevens, 1975).

1. West Java currently contributes greatly to the national rice supply. This province in 1978 produced 2.9 million tons of milled rice or about 22 percent of the total national rice production (Central Bureau of Statistics, 1978).
2. There was considerable increase in the use of small tractors during the last five years (Ministry of Agriculture, 1979).
3. The location was convenient for data acquisition in the relatively short period of time available for this project, without sacrificing essential requirements for predetermined research design criteria as discussed in Chapter 4.

Karawang and Subang counties are located in the middle of the Northern coastal plain of West Java. Eight villages from these two counties were selected as research sites. A demographic characterization of Karawang and Subang is presented in Table 2.2.

Based on Table 2.2, it was calculated that each hectare of food crop land supports approximately nine individuals in Karawang or Subang counties without taking export of foodstuff of other counties into consideration. This figure might reach a level of 14 people per hectare by the year 2000. The increase of labor supply and the in-elastic demand for manual labor due to fixed or even declining land resources, unemployment may lower manual labor wages for land preparation.

The Agroeconomic Survey Institute discovered that at the county level, approximately 65 percent of the total number of draft animals are in the productive age (between 3 to 12 years). Based upon this

Table 2.2. Demographic features of Karawang and Subang counties.[1]

Item	Unit	Karawang	Subang
Areas	km^2	1,504	2,051
Population			
Number	Persons	1,109,044	942,500
Density	Persons/km^2	738	460
Households	Numbers	250,605	230,982
Agric. population	Percent	55	87
Agric. labors[2]	Percent	15	27
Ag. male labors[2]	Percent	6	17
Pop./village (mean)	Persons	9,902	5,891
Villages	Numbers	112	160
Farm land	Ha		
Total for food crops		133,210	107,209
Low land for rice		105,096	82,184
Intensification	Percent	96	92
Draft animals[2]	Numbers	16,092	22,298
Small tractors[2]	Numbers	355	196

[1]Karawang and Subang county Bureau of Census and Statistics (1976).

[2]Agricultural Extension Service, West Java Province (1979).

information and Table 2.2, it may be estimated that the ratio of potentially available draft animals for food production was 7.4 hectares/animal in Subang and 12.7 hectares/animal in Karawang (1979). The greater ratio in Karawang coincided with the greater number of tractors in this county as compared to Subang county. Important questions related to the choice of land preparation techniques are: 1) the degree to which any increase of labor supply is evenly distributed between the urban and the rural areas; 2) the degree to which the economic structural transformation may shift manual laborers fast enough from agricultural sector to non-agricultural sectors in the urban and industrial areas; and 3) the degree to which the green revolution stimulated alternate crop management practices and brought about changes in the manual labor demand pattern for land preparation.

The World Bank working paper (1979) reported that there were differential rates of population growth between urban and rural areas. For example in the decade of 1960 to 1970 the annual population growth in the urban areas was 4.2 percent compared to 2.3 percent in the rural areas. It was believed that this differential was due mainly to the out migration from the rural to the urban areas.

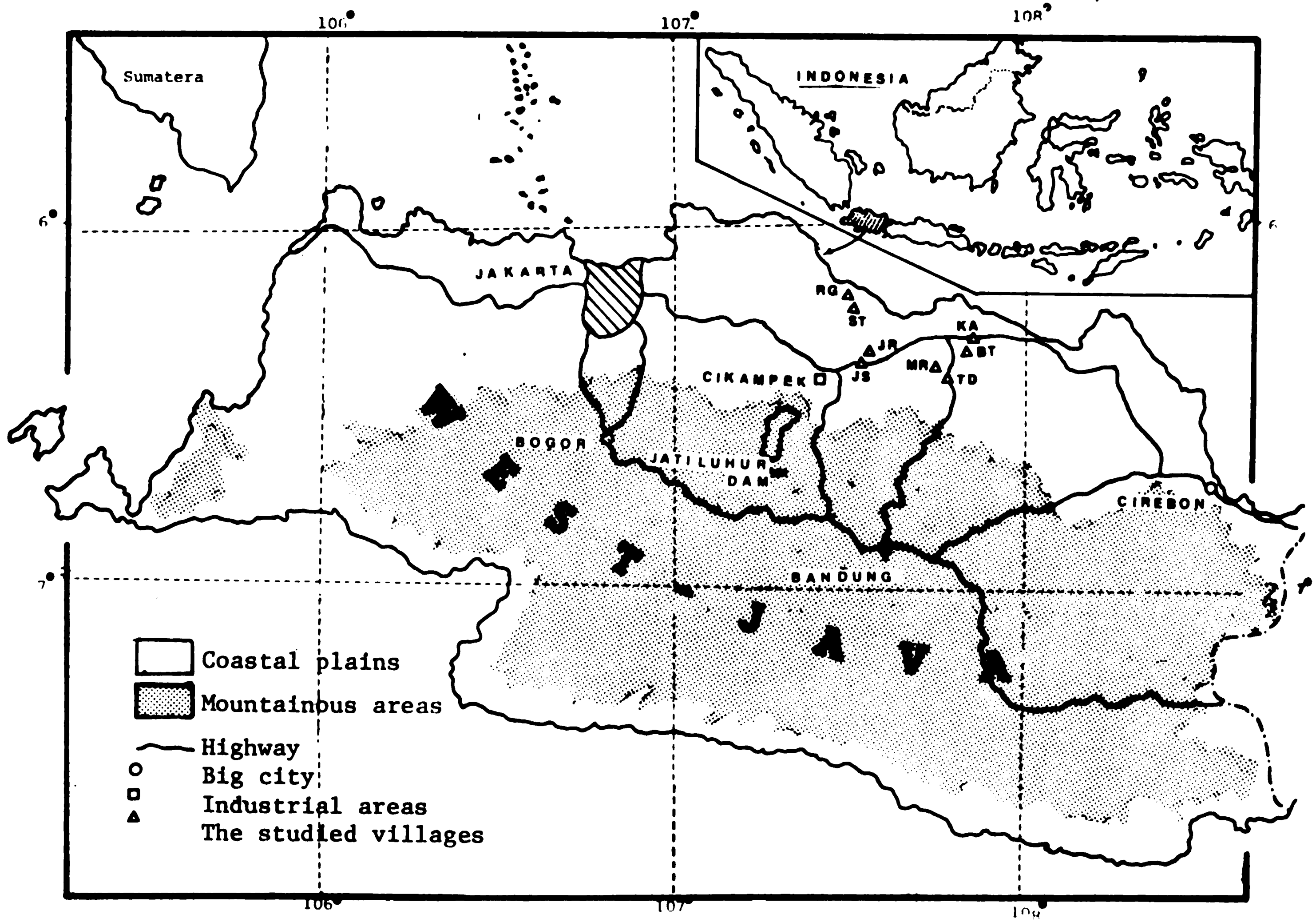

Figure 2.1. Geographic situation of the studied villages.

2.2 Rice Growing Technique in Karawang and Subang Counties

There are two seasons, wet and dry seasons, and three practices for growing rice in Karawang and Subang counties: 1) rice is grown under continuous flooded conditions, 2) "gogo" technique, where in all of rice growing stages are maintained under relatively dry conditions, and 3) "gogo rancah" technique, similar to gogo technique, but differs in its later (generative) stage, where rice field is turned into flooded condition until around two weeks before harvesting. The submerged (flooded) rice growing practice is the dominant method in the studied areas and accounts for more than 90 percent of the total rice land in Karawang and Subang counties (Agricultural Extension Service, West Java Province, 1980). This present study deals primarily with the flooded rice growing system.

In Karawang and Subang counties, it is a common technique to perform rice land preparation under submerged conditions, so that the rice field becomes soft enough for bullocks plowing or manual hoeing. The depth of water is usually around 5 to 8 cm. Rice seeds are soaked for two to three days and then sown in the seedbeds. Farmers are concerned about intensive care of rice nursery, for example, accurate water control, plant protection from birds, rat damage and other rice pests and disease attacks. Water level was raised to about 5 cm in the day time and drained in the night for aeration. The amount of land for the rice nursery was around 5 percent of the total rice field to be planted. Twenty-five to thirty kilograms of HYV rice seed was required for one hectare of rice field. The rice seedlings are kept in the nursery for twenty-one to twenty-five days for the best yield

(Farmers in the study areas, 1980). Land preparation must be done within this period (twenty-one to twenty-five days).

Tilled rice land surface was maintained evenly and squared 25 by 25 cm^2 or 20 x 30 cm^2. Rice seedlings were pulled out by hand and transplanted (three seedlings) at the intersections of the squared lines. Basal fertilizers (nitrogen and phosphate) and top dressing (nitrogen) were applied just before transplanting and two to three weeks after transplanting respectively. Water level during rice growing stages was maintained at about 5 to 10 cm deep and drained frequently one day before and after weeding and fertilizer applications. Finally, three weeks before harvesting, water was completely drained. Irrigation water supply was served for one liter per second for twenty-four hours continuously.

One liter of active ingredient (pesticide) per hectare was sprayed once every fourteen days, depending on the intensity of rice pests and disease occurrence. Spraying was done using backpack compressed air sprayers.

Rice was harvested when three-fourths of the leaves and rice grains in the field looked yellowish, and cut by ani-ani (small hand knife) or by sickles. Threshing was carried out by foot treading or by beating rice stems on bamboo racks. After one or two days of drying and cleaning, the rice was stored under village (17 percent to 18 percent) moisture content (Agricultural Extension Service, West Java, 1978).

The typical amount of rice land transplanted monthly is illustrated in Figure 2.2. The beginning of rice land preparation can be

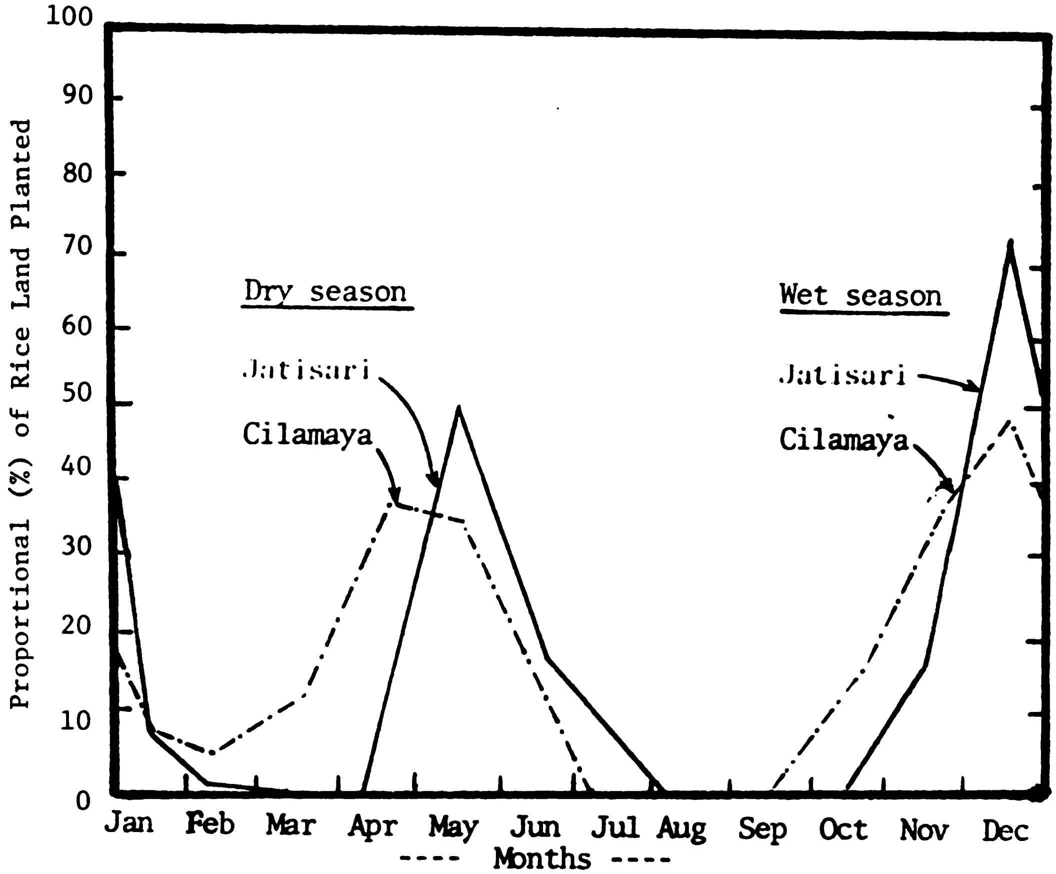

Figure 2.2. Proportion of rice land (%) transplanted each month in Cilamaya and Jatisari Districts.[1]

[1]Total rice land in Cilamaya is 9,538 hectares and 9,488 hectares in Jatisari Distric. Figure 2.2 was processed based upon district level data (average of five years, 1976 to 1980).

estimated by shifting the transplanted curves three to four weeks ahead and the amount of land prepared monthly was proportional to the monthly transplanted areas. This information was based upon the average of five year records available at the district level in Jatisari and Cilamaya, where Jatisari, Jatiragas, Sukatani and Rawa Gempol villages are located.

2.3 Rice Land Preparation Techniques and Constraints in Karawang and Subang Counties

Traditionally, rice land preparation was done by either manual labor hoeing or bullocks operated plowing and harrowing or sometimes by a combination of both manual labor and bullock tillage.

Stout (1966) summarized the objectives of primary rice tillage as: 1) to loosen the soil in a depth of 10 to 15 cm; 2) to aerate the soil; 3) to initiate the cutting and distribution of dried organic matter, to kill grass and growing weeds and to create conditions favorable for decomposition of organic matter. These objectives were true in the studied areas. Rice land preparation in Karawang and Subang counties was accomplished by two times of manual hoeing or by bullocks plowing and two times harrowing. Two times of tractor roto-tilling was evaluated by farmers as producing the same result as bullock tillage and better than manual hoeing. Additional work related to rice land preparation was needed to make rice field surfaces more even for better water distribution, reshaping or reconstructing rice field levees and cleaning plant residue and weeds to be incorporated with the already tilled soil.

It was estimated by the farmers in the study areas that bullock capacity per season was around two and one half hectares and one half hectare for manual labor when intensive or good soil tillage was expected. In the recent years, the last ten years in particular, farmers complained about the quality of rice tillage performed by either bullocks or manual labor, although they were paid on a daily basis, which should result in better tillage as compared to area based contract. For instance, shallower tillage, uneven plowing or some parts of the rice land was not tilled and sometimes land preparation was late which caused delay of transplanting. The delay of transplanting was claimed to be due partly to the shortage of bullock power for land preparation which could extend the rice seedling age in the nursery to more than 25 days. This shortage of bullock power in the villages studies was comfirmed with the estimated land and animal power ratio as it has been discussed previously in section 2.1.

The usual peak wet season land preparation activities are in the months of September through December, where water is expected to be sufficiently available from irrigation and rainfall to soften and saturate rice fields to a depth of at least 5 cm. Bernstein (1980) indicated that late commencement of rainfall and insufficient water supply might be responsible for the extended land preparation in contiguous areas over several weeks. Water induced delays in land preparation by some farmers can hold up the transplanting of the whole area. He further showed that the implementation of integrated pest control which is built upon the principle of synchronized planting may also require more concentration of labor for land preparation in a certain period. Further, farmers in the study areas explained that the new HYV seedling age was shorter as compared to indigenous varieties. Consequently land preparation should also be done in a shorter time.

Thus, the innovation of shortage of HYV, the possible delay of rainfall and water supply, the threat of rice pests and diseases and the shortage of animal power were regarded as land preparation constraints by farmers in the study areas.

CHAPTER 3

AGRICULTURAL DEVELOPMENT THEORY RELATED TO APPROPRIATE TECHNOLOGY AND PREVIOUS RESEARCH IN INDONESIA

The literature considered in this chapter is grouped into four categories: 1) agricultural development theory as related to technology, 2) review of rice production programs, 3) experience in tractorization in other developing countries of South Asia, 4) previous agricultural mechanization research in Indonesia.

The agricultural economic development strategy presented will provide some perspective on agricultural development involving small farmers and tractorization. Relevant programs will describe the extent to which mechanization may support rice production systems. The experiences of tractorization in the different countries will help identify important factors associated with labor utilization, tractor capabilities, and costs and returns.

3.1 Agricultural Economic Development Theory Related to Technological Changes

Schultz (1964) suggested that a significant growth of productivity cannot be brought about by the simple reallocation of existing resources in traditional agriculture. Significant opportunities will become available only through changes in technology. He further argued in his book "Transforming Traditional Agriculture," that peasants in traditional agriculture are rational, efficient resource allocators, and that they remain poor because there are only limited technical and economic opportunities to which they respond (in Hayami and Ruttan, 1971).

Hayami and Ruttan (1971) suggested that farmers response to changes in production was related to opportunities for more productive technology and improved relative prices. This thesis helped explain the switch from animal power to tractor power in South Asia, where, as Binswanger (1978) pointed out, such change was due primarily to one factor: prices. Hayami and Ruttan expanded Schultz' high payoff model further in their induced development model by incorporating the mechanism by which a society chooses the optimum path of technological change in agriculture. This concept maintains that change in relative price directs the invention or innovation of new and more productive technology. Further, in the induced development model, the mechanisms of induced innovation in private and public sectors interact between technical change and institutional development. Dynamic sequences of technical change and economic growth are regarded as critical elements for agricultural and economic development process.

McNamara (1972) emphasized that without rapid progress in small holder agriculture throughout the developing world, there was little chance for achieving long term stable economic growth or of significantly reducing the level of absolute poverty (in Stevens, 1975).

Stevens (1975) stated that small farmers in developing countries lack capital and were trapped in a technical and economic equilibrium of low productivity and slow growth. Accelerated growth could be generated by transforming traditional farming to more dynamic market oriented farming. The transformation could be enhanced by continuous application of science based agricultural technologies and institutional innovation.

Birowo (1977) formulated a strategy for agricultural mechanization development. He suggested four agricultural mechanization related goals for Indonesia: 1) increase labor productivity in the agricultural sector; 2) increase resource allocation efficiency; 3) improve the farm institution, for instance by strengthening the farm cooperative; and 4) facilitate the acceleration of rural industrialization.

Gotch (1972) theoretized that the rural growth problem could only be coped with if the broad spectrum of the rural population became a part of modernization. Otherwise the distributive effect of technological change would be of little help. Furthermore, he was concerned about the possibility of technological change producing social and political unrest in the countryside.

McLaughlin (1972) and Stevens (1975) concluded that help for small farmers should be through real increase in productivity. Mechanization inputs (including the small tractor) may contribute to the technological change process, but must be adapted to different cultural and economic settings. Overly sophisticated machines are generally inappropriate for the small farmers.

Finally, Khan (1977) and Esmay (1978) suggested that local manufacturing should play a dominant role in the agricultural mechanization development process. Developing nations should not make themselves dependent for the importation of machinery from foreign countries on a long term basis.

These selected strategies clearly provide guidance and identify constraints and limitations which are important for establishing any modeling framework for the choice of land preparation techniques.

3.2 Review of Rice Production which Includes Agricultural Mechanization in Indonesia

Indonesia began a series of Five Year Development Plans (FYDP) in 1969. The economic development goals were: 1) improvement of rural life by creating more job opportunities; 2) increase of net income per capita; 3) equalization of income distribution; and 4) stabilization of economic growth (Ministry of Agriculture, 1977).

Agricultural mechanization projects (including tractorization) have been promoted in conjunction with the BIMAS[1] program which is directed toward self-sufficiency of food (rice). The specific objectives of the BIMAS program has been to intensify rice production.[2] It has been implemented through:

1. The introduction of new, locally adapted agricultural technology (HYV rice, fertilizers and appropriate pesticides, better irrigation management and improvement of cultivation methods);
2. The facilitation of agricultural inputs at the village unit levels;
3. The providing of low interest credit and subsidization of agricultural production inputs;

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[1] BIMAS , Bimbingan Masa, a kind of extension service model.

[2] Ministry of Agriculture, 1977.

4. The intensification of information dissemination through "siaran pedesaan", i.e., rural broadcasting system, training and visiting, and other extension service means; and
5. The establishment of floor and ceiling prices of rice.

The total rice production increase due to this program was 4.6 percent per year during the first FYDP (1969-1973) and 2.5 percent per year during the second FYDP (Ministry of Agriculture, 1977).

One of many significant impacts of this program was related to the need for a faster land preparation. Changes in crop management by the introduction of new more productive HYV of rice (IRRI varieties) caused increased labor demand for land preparation during certain shorter periods of the year. Consequently, as these peak labor shortages developed at the village level, farmers began to look for other means to ameliorate this new production constraint.

In their induced development model, Hayami and Ruttan (1971) specifically identified such an input imbalance or disequilibrium as a dynamic sequence of the development process. It should be regarded as a critical element for the induction of technical and economic growth.

Hadisapoetro (1977) concluded that rice production intensification on the existing agricultural land was approaching the point of zero marginal product by 1977-1978. He also predicted that there will be no spectacular discovery of biogenes or agricultural chemicals to increase rice yield in the coming decade. On the other hand, the Ministry of Agriculture estimated that rice self-sufficiency could be achieved by the end of 4th. FYDP (1985) through a 5.6 percent per year increase in rice production. The goal appears impractical without a new and more productively integrated program. Expansion of agricultural land development outside of Java island through the transmigration program is one alternative. Another promising alternative is the proper selective of agricultural mechanization (Stout, B. A., 1973). Selective agricultural mechanization in this regard is defined as the most appropriate equipment or combination of them which can be socially, technically and economically justified.

Esmay (1977) learned that Indonesia was in the beginning phase of agricultural mechanization, and proposed the need for a positive selective agricultural mechanization plan in order to improve production and working conditions.

3.3 Tractorization Experiences in Other Developing Countries in South Asia

Binswanger (1978) categorized the benefit of tractors in two apparently contradictory views:

1. The substitution view is that a switch from animal power to tractor power was primarily guided by the factors of price and animal power availability.
2. The net contributor view is that power is the primary constraint of agricultural production regardless of tractor prices. The contribution of tractors lends to higher intensification and double cropping, which requires more labor, and results in a higher net return.

Esmay (1978) stressed that primary tillage was a critical operation that should be accomplished at the proper time. Chancellor and Singh (1973), in a study on the relationship between farm mechanization and crop yields in a farming district in India found that, in general, there was a slight tendency for higher yield with tractor tillage than with animal tillage, although there were some instances where the reverse was true. Chancellor (1979) recalculated data by Binswanger (1978) and concluded that the mean differences between tractor farms and bullock farms were:

1.	Crop intensity	+ 4.70%
2.	Yield per hectare	+11.58%
3.	Total crop production per hectare	+21.34%
4.	Fertilizer and other inputs used	+24.35%
5.	Labor use per hectare	- 2.80%
6.	Labor per total production	-21.56%

McInerney (1973) concluded that the general effects of the introduction of tractor technology in Pakistan are: 1) increased farm size, 2) increased crop intensity, 3) caused no benefit changes in crop yield, and 4) increased the total labor per farm but decreased the labor used per unit of cultivated area.

Experiments on tractorized as compared to bullock land preparation for rice in South Sulawesi and West Java showed yield increases of 14 percent and 10 percent respectively. Furthermore, hand weeding time was reduced by 20 percent to 40 percent, and the cost of land preparation was 34 percent less for tractor operation (Directorate of Mechanization, 1977-1978).

Binswanger (1978) concluded his analysis by stating:

1. T· actors were not responsible for substantially increased intensity, yields, timeliness or gross returns in India, Pakistan and Nepal.
2. Tractors provided the opportunity for land expansion.
3. Tractors shifted the cost advantages of farming toward the larger farms and concentrated land holding to fewer families;
4. The often incredible drudgery of most farm work was not only reduced for the tractor drivers, who usually were the farmer or his son, but also for the rest of the family. As long as there was population growth and slow growth of manufacturing and tertiary sector employment in the rural areas, reducing drudgery was not a social benefit. It was simply redistributed benefit from the poorest groups to the already richer strata of rural society.
5. Tractor farms generally did not show much less labor used per hectare than bullock farms. However, this did mean that tractors might not displace agricultural labor.

Esmay (1975) found that private ownership of mechanization in Pakistan and Bangladesh tended to displace human labor for crop production and there was no significant benefit to the small farmers.

Chancellor (1970) concluded that almost every farmer hiring tractor service in Malaysia and Thailand, combined the time saved with other resources to produce additional income. The enterprises chosen varied from 65 percent in Thailand to 75 percent in Malaysia that chose enterprises of agricultural intensification which did not displace labor from the rural to urban areas. In about 80 percent of the cases, income from these new enterprises was sufficient to cover the cost of hiring the tractor. He also found that in Thailand and Malaysia many small workshops and foundries started making implements for use with tractors and in some cases making power driven puddling machines and small tractors.

In 1978, in the Philippines more than 24 companies manufactured IRRI designed machines and in 1974 over 22,000 simple machines were produced by manufacturers and small metal workshops. Nearly half of them had no previous experience in producing agricultural machinery.

The references cited demonstrated the contradictory impact of tractorization about which planners should be aware; particularly, if it is viewed from the national development perspective as presented in section 3.2. The other relevant factor connected to this study is that the appropriateness of tractor development is location specific, where it appears to be the dominant factor. This points to the importance of the proper selection of villages for research.

3.4 Previous Agricultural Mechanization Research Work in Indonesia

At present IRRI and Rural Dynamic Institute are studying the consequences of small rice farm mechanization on production, income and rural employment in selected countries in Asia. Field surveys are being carried out in Pakistan, Indonesia, Thailand and the Philippines. The survey was designed to determine the impact of agricultural machinery at the field, household and village level. The focus is toward the effect of mechanization on production, income and employment. South Sulawesi and West Java were selected for the Indonesia studies (IRRI, 1978).

This study is different from the IRRI study in some ways and similar in other respects. The IRRI study consists mainly of a survey on the consequences of mechanization, while this research included more measurement of the field performance of technology at the farm level. Both studies are concerned about the effects of farm mechanization on rural societies.

Another research study that is relevant to this study was conducted by Gadjah Mada and Bogor universities jointly with the Agricultural Mechanization Division of the Ministry of Agriculture during 1972, 1973, 1974 and 1975. It determined soil draft resistances for land preparation in Java and four other provinces outside of Java, including South Sulawesi. The results helped predict power requirements based upon soil mechanical properties (1972-1975).

CHAPTER 4

DATA AND ANALYSIS FRAMEWORK OF FARM SURVEY AND DIRECT MEASUREMENT

Data and information regarding choice of land preparation techniques were collected with reference to their relevance to the research objectives for which they had been specified as related to the evaluation of tractor performance and its impact on labor use and cost for land preparation at the farm level.

There are three sources of data and information: 1) direct measurements of primary tillage operations, 2) farm survey on labor inputs for pre-harvest activities, and 3) documentation available at the village and county levels (for supplemental data). This chapter presents: 1) research design, 2) analysis and statistical framework and methodology, 3) data and information, and 4) summary of the statistical estimators.

4.1 Research Design

A stratified randomized block design was used for the field study. Stratification and blocking provides more precision for statistical estimator and minimizes the undesirable influence of variables unrelated to land preparation and research cost. In addition, the analysis of the data is relatively simple and missing data from individual units can be easily estimated.* The smallest administrative unit, the village, was used in geographical blocking. The population of the study was stratified into three categories: 1) farms using hand labor, 2) farms using bullocks, and 3) farms using tractors. Sampling was performed

*Steel and Torrie, 1960.

by randomly drawing farmers' names from the list of farmers in each village. Geographic, agroclimate, irrigation systems, soil fertility, land use and rice cultivation practices were the criteria used to identify villages for direct measurement of farm tillage operations and survey. A minimum of nine available tractor units was also used as criteria in the selection of villages.

4.1.1 Villages Studied

Jatiragas, Jatisari, Rawa Gempol, Bojong Tengah (in Karawang county), Bojong Tengah, Karang Anyar, Mariuk, Tambak Dahan (in Subang county) were selected as the sample villages based upon their demographic appropriateness. Jatiragas and Jatisari villages replaced two proposed villages which had an insufficient number of tractors. Bojong Tengah and Karang Anyar villages of Pusaka Negara district also replaced two previously assigned villages in Pamanukan district because farmers gave inconsistent responses based upon who asked the questions. Demographic characteristics of these eight villages are presented in Table 4.1.

Most of the rice land area of these villages was under the Jatiluhur irrigation scheme, which serves a total of 260,000 hectares in the Northern coastal plains of West Java.* The irrigation system guarantees the availability of water for double cropping of rice in each year. Irrigation schedule changes due to repair and maintenance of irrigation facilities can cause a delay of the planting date of young rice seedlings. Transplanting time is a critical time for farmers to be accomplished at the appropriate time.

Agroclimates identified for these villages were derived from Oldeman (1975). He specified that D-2 zone prevails in Mariuk and Tambak

*Bernstein, 1980.

Table 4.1. Demographic characteristics of villages under study.[4]

Item	Villages							
	JR	JS	RG	ST	BT	KA	MR	TD[5]
Location from:								
Jakarta (km)	128	119	154	147	179	170	181	185
Highway (km)[1]	5	0	37	35	4	0	21	0
Population (1979):								
Total (persons)	5409	6295	8514	6209	5862	6295	7381	10269
Male labor (%)[2]	17.84	19.28	20.11	18.77	15.63	16.42	17.12	17.58
Population growth (%)	0.57	0.70	1.41	n.a.	0.91	1.79	0.89	1.74
Male labor growth (%)	n.a.	n.a.	1.19	n.a.	0.53	0.18	0.02	0.21
Agricultural power:								
Male labor[2]	965	1214	1713	1166	917	1034	1264	1802
Bullocks	31	26	21	38	55	39	157	107
Tractors	14	9	32	47	14	10	44	9
Agricultural land:								
Total (ha)	527	471	1020	757	999	872	1188	1263
Lowland for rice (ha)	456	425	850	683	908	865	1111	1138
Holding per farm (ha)	.60	.46	.09	.75	1.14	.91	1.26	.83
Potential proportion of land tilled (%)	70	48	86	100	35	26	90	18
by tractor:[3]	70	48	86	100	35	26	90	18
by bullocks[3]	12	10	4	--	10	8	10	16
by male labor[3]	18	42	10	--	55	66	--	66
Agroclimate	D-3	D-3	E	E	D-3	D-3	D-2	D-2

[1]Highways Jakarta - Semarang or Jakarta - Bandung.

[2]Estimated by: PA/TOTPOP x 100%; where PA = number of productive male labor (15-50 years) and TOTPOP = total population in the village.

[3]Proportion of land tilled by tractor and bullocks were estimated by: capacity (hectares/season) x productive unit; and proportion tilled by manual labor by subtracting hectares operated by tractors and bullocks from the total rice land in the village. Assumption was made with no outside tractors coming into the village. Tractor and bullocks capacity were estimated 22 hectares and 2.5 hectares respectively (Agric. Ext. Serv., 1980).

[4]Source: Village offices.

[5]Abbreviation of villages' name.

Dahan, implying three or four consecutive wet months and two to four dry months as the usual pattern of rainfall. A wet month is a month 200 millimeters or more rainfall. A dry month has 100 millimeters or less rainfall. The D-3 zone was the same as the D-2 zone with five to six dry months. The E zone has less than three consecutive wet months and at least five dry months.

4.1.2 Sample Unit and Size

Farm households and rice fields were selected as sample units for farm survey and for direct measurement respectively. A rule of thumb used to define sample size is presented in equation 4.1 (Agro-economic Survey Institute, 1977).

$$(n - 1)(t - 1) \geq 15 \tag{4.1}$$

$$(n - 1)(3 - 1) \geq 15$$

$$n \geq 9$$

(rounded)

The sample size for each treatment was equal to nine units for each village (either for farm survey or field measurements). Two tillage operations were used with labor and tractor preparation for the rice land preparation. Three tillage passes with bullock operations were found in Sukatani, Karang Anyar, and Mariuk villages. There was, however, no clear difference between the second and third tillage operations. A total of 216 samples were assigned for each farm survey and the first and second tillage measurements.

The actual number of samples obtained for this study, was 608 units (see Appendix 1). Survey information pertaining to the full utilization of manual labor was difficult to assess. In Jatiragas, Rawa Gempol and Karang Anyar villages there were only a few farmers who employed only manual labor for both the first and second tillage operations. These farmers had land that was very muddy and too soft for either tractor or bullocks. At the other villages of Jatisari, Sukatani, and Mariuk, few farmers still hired manual laborers, largely because of long standing social relationships.

4.1.3 Statistical Analysis Model

The linear additive model of Steel and Torrie (1960) was used as presented in equation 4.2.

$$X_{ij} = \mu + T_i + B_j + e_{ij} \qquad (4.2)$$

where

X_{ij} = the estimated value of variable being studied

μ = the population mean

T_i = mean of variance attributed to type of tillage technology

B_j = mean of variance attributed to village (blocking)

e_{ij} = common error developed during measurement survey

The basic assumption for the linear additive model analysis of variance, where tests of significance are to be done, is that random components are independent and normally distributed about a zero mean with a common variance. It is, therefore, necessary to consider whether the

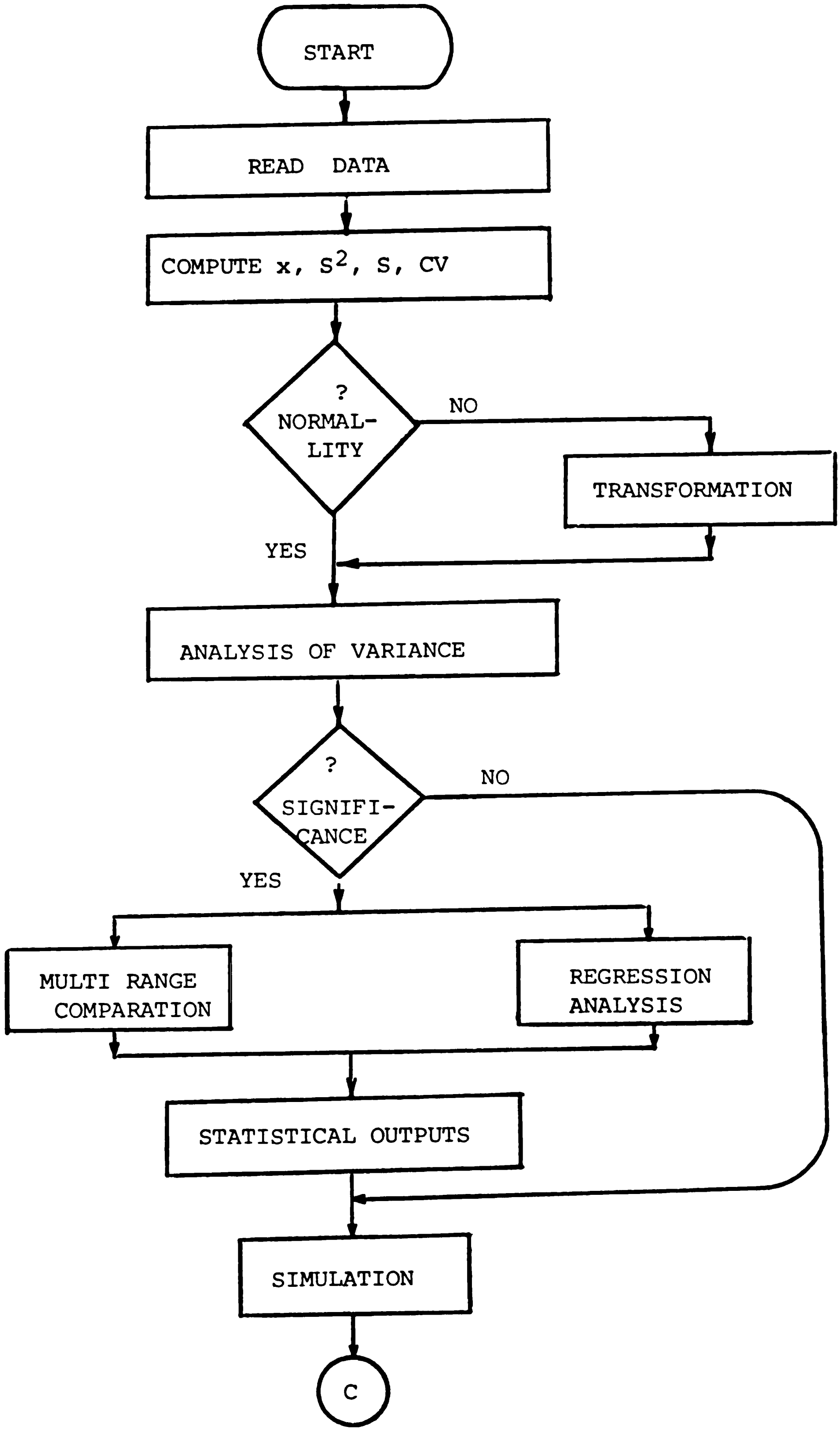


Figure 4.1. Procedure for statistical analysis.

population could be adequately described by a normal distribution. Battacharyya and Johnson (1977) suggested a check of normality distributed population with intervals of:

$\mu + 1\sigma, \mu - 1\sigma$	contains	.683
$\mu + 2\sigma, \mu - 2\sigma$	the proba-	.954
$\mu + 3\sigma, \mu - 3\sigma$	bility	.997

where

probability = percent of the population

The number of observations outside the symetric interval about the means of normally distributed population can be counted and divided by the sample size "n". The result gives the relative frequency which is compared with theoretical probability of roughly 1/3, 1/20, lnσ 1/300 (11). The expression for normality estimation is:

$$\frac{|\hat{p} - p|}{\sqrt{p(1-p)/n}} > 3 \tag{4.3}$$

where

$\hat{p}$ = observed relative frequency distribution outside the symetric interval about the means

p = theoretical probability of frequency distribution outside the symetric interval about the means

n = number of samples, which is set to be 9 (in this research)

If the left hand side of this inequality is greater than 3, it would indicate lack of normality and in this case data needs to be transformed (either square root or logarithm), before continuing further statistical analysis. In this research the sample size "n" was nine, thus the number of observations outside the symetric interval should not have exceeded four. The normality test indicated that plot size data of the first tillage operation needed to be transformed before ANOVA analysis was carried out.

The computation of statistical estimators for the expected means (μ), variance (σ^2), standard deviation (σ) and coefficient of variation (cv) are presented in equation 4.4, 4.5, 4.6 and 4.7 respectively (49).

$$\bar{x} = \varepsilon x_{ij/n} \tag{4.4}$$

$$s^2 = (\varepsilon x_{ij}^2 - \frac{(\varepsilon x_{ij})^2}{n})/(n - 1) \tag{4.5}$$

$$S = \sqrt{S^2} \tag{4.6}$$

$$CV = \frac{S}{\bar{x}} \times 100\% \tag{4.7}$$

where

$\bar{x}$ = an estimate of population means (μ)

s^2 = sample variance, an estimate for population variance (σ^2)

S = standard deviation, an estimate for σ

CV = coefficient of variation

The analysis of variance (ANOVA) is essentially an analysis of the error mean square (σ^2), an estimate of common error. The expected error mean square (calculated F-value) in ANOVA is defined as a ratio of the independent estimate of the same population variance (σ^2). Multiway classification, as suggested by Steel and Torrie (1960) which deals with two or more criteria, was used for this ANOVA.

Table 4.2. Analysis of variance for choice of land preparation.

Source	df	MS	EMS(F)
Village	(v-1) = 7	$\sigma_{\varepsilon}^2+3\sigma_v^2$	
Technology	(t-1) = 2	$\sigma_{\varepsilon}^2+8\sigma_t^2$	$\frac{\sigma_{\varepsilon}^2+8\sigma_t^2}{\sigma_{\varepsilon}^2}$
Error	(v-1)(t-1) = 14	σ_{ε}^2+	
Total	vt - 1 = 23		

The variance mean square of village effect, in which it contains treatment and common measurement errors ($\sigma+t.\sigma_v^2$) is computed by applying equation 4.8; similarly for residual or common error (σ^2) and variance mean square of treatments ($\sigma_{\varepsilon}^2+v.\sigma_t^2$) by using equation 4.9 and 4.10 respectively.

$$\sigma_v^2 = X._j^2/t-C \tag{4.8}$$

$$\sigma_t^2 = X_{i./v}-C \tag{4.9}$$

$$\sigma_{\varepsilon}^2 = TS-S_t^2-S_v^2 \tag{4.10}$$

where

X_{ij} = individual observed data

$X_{.j}$ = village sum of square

$X_{i.}$ = technology sum of square

v,t = number of village and treatment respectively

C = correction factor, which is computed by equation 4.11

$X...$ = grand total (sum of all data)

$$C = X^2... / v.t \tag{4.11}$$

If analysis of variance indicates that there was a significant difference between treatment means (manual labor, bullock and tractor performance), then multi-range comparison using the LSD (least square difference) method and regression analysis were performed. Linear regression analysis was carried out to study the correlation between: 1) plot size and time for land preparation, 2) plot size and residual untilled land, and 3) field capacity and soil draft resistance.

The LSD method is basically a student t test using pooled error variance. For instance, if the difference between bullock and tractor capacity means is to be significant at the confident level, then this difference must exceed the LSD value which is calculated as follows (49):

$$LSD_{\alpha} = t_{\alpha} S_{\sigma} \tag{4.12}$$

$$S_{\bar{\sigma}} = \sqrt{2.S^2/v} \tag{4.13}$$

where

t_{α} = tabulated t value at a given df (degree of freedom) and confident limit (α), in this case, tabulated t (df = 7, α = 5%) = 2.365 (two-tailed)

$S_{\bar{\sigma}}$ = standard difference between treatment means

In this present research the number of villages (v) was eight, therefore:

$$S_{\bar{\sigma}} = 0.5 \sqrt{S^2} \tag{4.14}$$

4.2 Relevant Criteria for Land Preparation Measurements

Criteria to determine relevant data related to land preparation techniques were derived from Hunt (1973). He suggested that the soil tillage operation can be evaluated through the analysis of capacity which is a measure of work done relative to time (rate of work). The mathematical expression of this concept is presented in equation 4.15 (Hunt, 1973) :

$$FC = \frac{W \times S \times E}{10} \tag{4.15}$$

where

FC = field capacity (hectares/hour)

W = width of cut (centimeters)

S = traveling speed (kilometers/hour)

E = field efficiency (%)

10 = conversion factor to a unit hectares/hour

Width of cut was assumed equal to the width of implement attached to the land preparation equipment: moldboard plow and comb harrow for bullocks, hoe for manual labor, or rotary tillers for tractors. Field efficiency was defined as the time of actual field work divided by the total time spent in the field; including idle, minor adjustment, refuel and other uneffective operation time. The machine or equipment efficiency was defined as the theoretical capacity divided by the actual time to complete tillage operation for one hectare of rice field.

Other technical criteria for the evaluation of land preparation techniques are elements related to power requirements such as: depth of tillage, plot size, mechanical properties of soil, tractor size in terms of horsepower (hp), water and soil condition, working environment such as degree of temperature, relative humidity, and operator skill and age.

4.2.1 Age and Experience of Land Preparation Operators

Age and experience of operators were two factors that presumably influence the degree of field capacity. Data related to these factors were obtained from interviews conducted in the rice field and presented in Table 4.3 and 4.4.

Table 4.3. Average ages of land preparation operators (years).

Village	Manual labor	Bullock	Tractor
Jatiragas	37.5	36.0	29.8
Jatisari	37.9	34.4	30.8
Rawa Gempol	36.0	31.4	30.1
Sukatani	32.2	32.4	28.1
Bojong Tengah	39.4	34.5	30.3
Karang Anyar	34.7	35.8	28.9
Mariuk	38.3	35.9	29.6
Tambak Dahan	47.6	43.3	26.2
Average:	38.8	36.6	29.2
Standard Deviation:	5.2	4.4	1.5
Coef. Variation (%):	13%	12%	5%

Table 4.3 suggests that manual labor and bullock operator ages did not differ significantly (5% level). On the other hand, tractor

operator ages were significantly younger than either manual laborers or bullock operators (1% level). The age range, as listed in Appendix 3, served as one factor to estimate the potential number of male manual labor participating in land preparation by village.

Table 4.4. Operator experience in land preparation (years).

Village	Manual labor	Bullock	Tractor
Jatiragas	16.5	15.5	2.0
Jatisari	17.3	14.2	1.5
Rawa Gempol	20.0	13.9	1.2
Sukatani	15.1	14.4	2.4
Bojong Tengah	23.8	14.8	1.1
Karang Anyar	17.8	19.5	1.8
Mariuk	24.3	25.6	1.7
Tambak Dahan	27.0	24.3	0.9
Average:	20.2	17.8	1.6
Standard deviation:	4.3	4.8	0.5
Coef. Variation (%):	21%	27%	31%

Years of operator experience are presented in Table 4.4 and Appendix 4. The average years of experience for tractor operators was 1.6 years as compared with 18 and 20 years for bullock and manual labor experiences respectively. The tractor technology in Tambak Dahan was in the introductory stage with an average operator experience of less than one year. The longest tractor operator experience was found in Sukatani which was 2.4 years.

4.2.2 Hours Worked Per Day

The range of temperature and relative humidity in rice fields in the course of the day time were 22-31 centigrade and 89-91 percent respectively.* It was common in the study areas for three to four operators to work one tractor in shifts, while for bullock operation there was only one operator. Therefore as indicated in Tables 4.5 and 4.6, tractors were operated for more hours per day.

Table 4.5. Hours worked per day on the first tillage operation.

Village	Manual labor		Bullock		Tractor	
	Eff.	Idle	Eff.	Idle	Eff.	Idle
Jatiragas	7.7	1.7	5.2	0.5	15.4	1.8
Jatisari	6.8	1.2	5.2	0.4	13.3	1.8
Rawa Gempol	7.7	1.3	6.7	1.0	10.0	1.6
Sukatani	6.6	1.2	5.1	0.4	13.3	1.4
Bojong Tengah	7.4	1.5	6.9	0.9	9.6	1.1
Karang Anyar	8.3	1.5	6.1	0.8	11.7	1.9
Mariuk	8.0	1.5	5.1	1.0	12.8	2.5
Tambak Dahan	7.9	1.8	7.0	1.4	10.1	1.5
Average:	7.5	1.5	5.9	0.8	12.0	1.7
Standard Dev.:	0.6	0.2	0.8	0.3	2.0	0.4
Coef. Variation:	8%	13%	14%	37%	17%	23%

*) Directorate of Geophysic and meterology, 1975.

Table 4.6. Hours worked per day on the second pass of tillage operation (hours).

Village	Manual labor Eff.	Manual labor Idle	Bullock Eff.	Bullock Idle	Tractor Eff.	Tractor Idle
Jatiragas	6.3	0.9	4.7	0.3	12.8	2.3
Jatisari	6.8	1.3	5.7	0.5	9.3	0.6
Rawa Gempol	7.7	1.5	4.9	0.4	9.6	1.4
Sukatani	7.7	1.3	n.a.	n.a.	15.0	2.2
Bojong Tengah	8.2	1.7	7.1	1.6	10.3	1.6
Karang Anyar	8.9	1.9	6.9	1.4	11.4	2.1
Mariuk	7.7	1.8	5.6	1.0	10.0	2.6
Tambak Dahan	7.6	0.4	5.2	1.7	11.4	1.9
Average:	7.6	1.3	5.7	1.0	11.2	1.8
St. Deviation:	0.8	0.5	0.9	0.6	1.9	0.6
Coef. Variation:	10%	37%	16%	60%	17%	33%

Note: n.a. = data were not available.

If necessary, tractors may be operated almost 24 hours per day, as was found in Jatiragas (see Appendix 5). Draft animals particularly water buffalo (bullocks), which have dark skin, cannot work for more than three hours consecutively. They need to be cooled down by allowing them to submerge in water for 15 to 30 minutes or by splashing them with water. The actual time used for the first and second field operation was defined as effective time. Idle time included the time for rest, eating, minor adjustment and repair, refueling and resting for draft animals in the field. The number of working hours per day was an important measure of the seasonal capacity for land preparation. Working hour data were recorded based upon one full day of operation. For some verification the operators were asked whether they had worked normally during the recording day. If, for instance, they had not, they were asked for any possible deviations. This check was particularly important for tractors as they are mobile. Sometimes the tractor operations started as early as 5 o'clock in the morning and left as late as 1 o'clock after midnight or sometimes tractors only worked a few hours before moving to another village. A highly significant greater number of hours worked were found for the first and second operations of tractor technology as compared to either bullock and manual labor (1% level). The idle time was not significantly different between tractor and hand labor in either the first and second operations, however, bullock idle time was significantly higher relative to the tractor for the first and second operations (5% level).

4.2.3 Depth of Tillage

Depth of tillage and soil mechanical properties as measured in kilograms/square centimeter are two factors associated with power requirements for land preparation. Data regarding these measurements is presented in Table 4.7. Depth of tillage was measured only for the first operation. The softening process of the top soil in the second operation could not be differentiated as to whether it was caused by second tillage operation or by water. This situation made the depth measurement for the depth of the second operation to be not accurate. A spring type cone penetrometer was used to measure soil hardness. The cone area was six square centimeters and the cone angle was 30°. Measurement was

Table 4.7. Depth of tillage and soil mechanical properties.

Village	Depth of tillage ML[1] (cm)	BL[2] (cm)	TR[3] (cm)	Soil mechanical properties Hardness (kg/cm^2)	PI (%)
Jatiragas	6.08	12.48	10.71	1.762	36.60
Jatisari	6.41	11.30	9.92	1.583	35.78
Rawa Gempol	6.41	10.79	10.25	0.825	35.63
Sukatani	5.60	11.23	8.80	1.300	33.69
Bojong Tengah	6.10	10.92	10.50	1.297	35.84
Karang Anyar	6.16	10.13	11.29	1.243	34.15
Mariuk	7.45	9.97	11.23	0.917	29.06
Tambak Dahan	5.30	9.08	10.06	0.726	29.42
Average:	6.19	10.71	10.34		
Std. Deviation:	0.64	1.05	0.80		
Coef. Var.:	10%	10%	8%		

[1]Manual labor
[2]Bullock
[3]Tractor

taken from the surface down to 40 centimeters. Figure 4.1 illustrates the measured gradient of soil hardness profiles. The index of soil plasticity (PI) associated with soil hardness was also considered as an essential element for evaluation of tractor performance for land preparation.* A total of 81 soil samples for depths of 0, 10 and 20 centimeters were taken and analyzed at the Gadjahmada University soil laboratory to determine the soil plasticity index.

*Kishu, 1972.

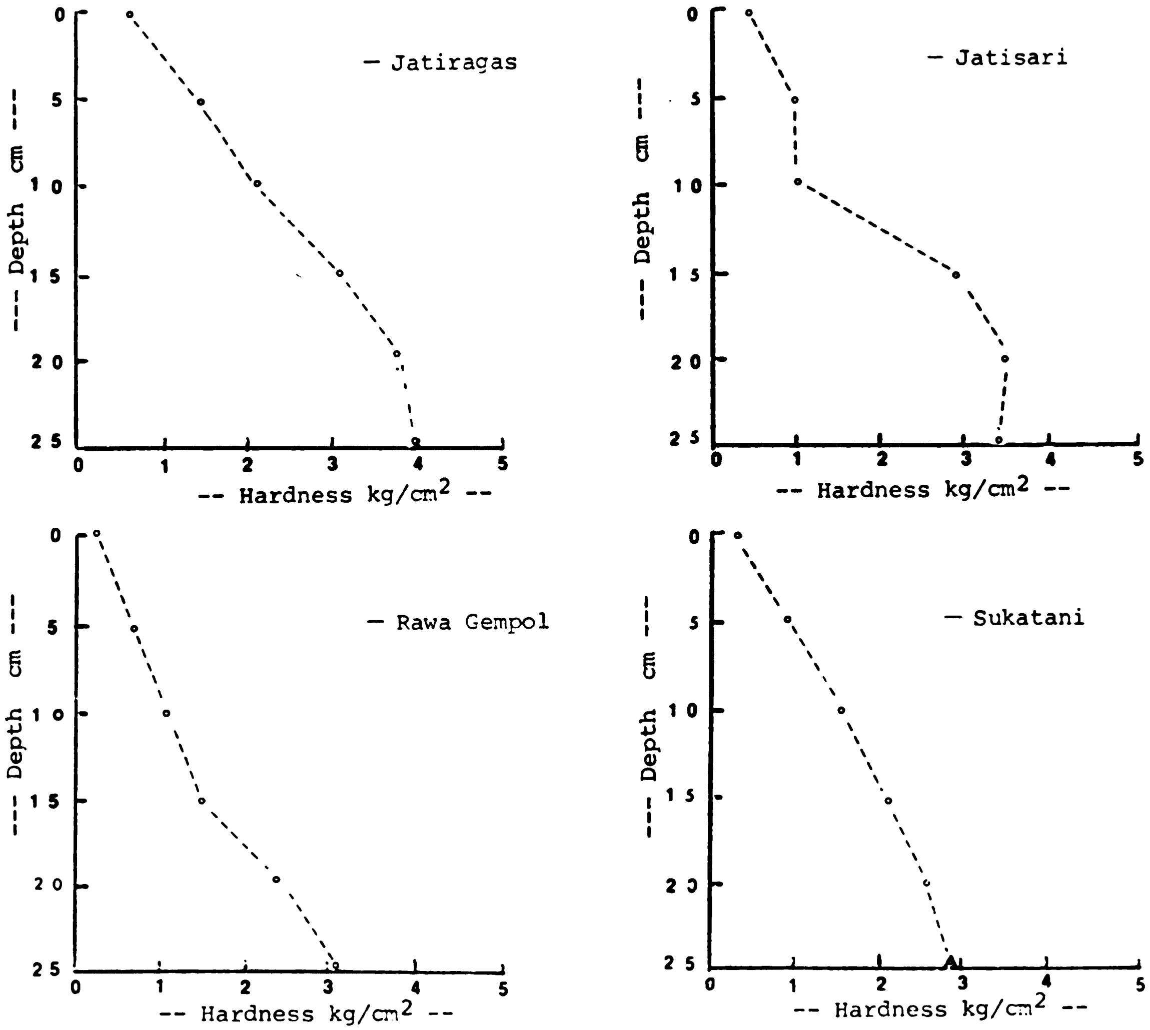


Figure 4.2a. Soil hardness profiles.

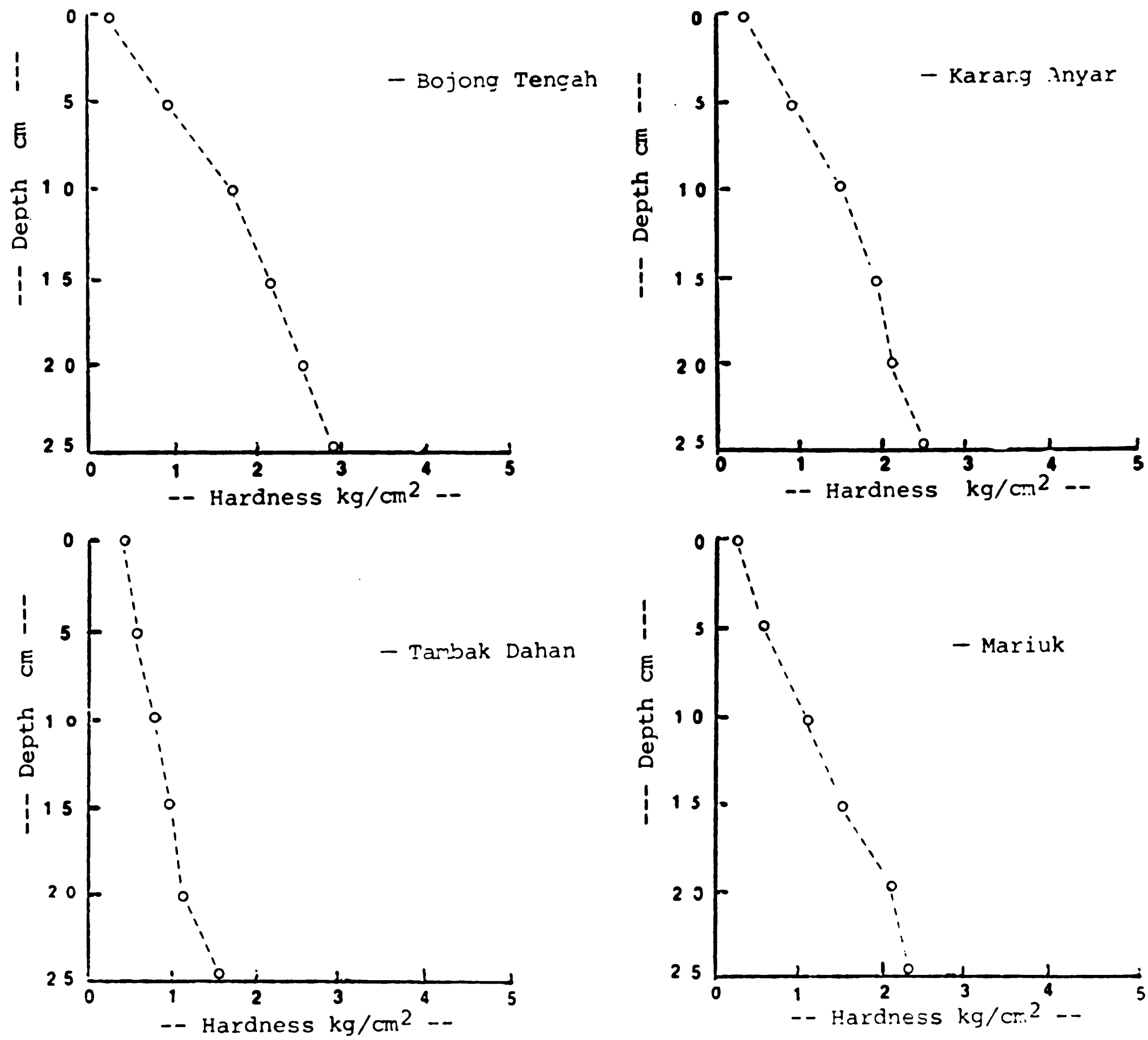


Figure 4.2b. Soil hardness profiles.

4.2.4 Plot Size and Percentage of Untilled Land

It is generally hypothesized that plot size effects land preparation equipment field capacity.* Therefore, plot size (dimensions) was measured as well as time for tillage operation and the residual of untilled land on the corners and levee sides of rice field. Manual labor was used to complete land preparation after bullock and tractor operations. There was always some residual untilled land after bullock and tractor operations. Large steel wheels attached to tractors, to avoid sinkage, prevented tractors from approaching the plot corners and levee sides closely and resulted the increase of untilled areas. Similarly, long wooden plow bars used in bullock operations caused difficulty in maneuvering the draft animal around the corners of the rice fields and resulted in untilled land on those corners and levee sides. Table 4.8 shows that plot size tilled by tractors was significantly larger than for either bullocks or manual labor (5 percent level).

Table 4.8. Plot size and residual untilled rice land.

Village	Plot size (ha)*			Residual land (%)**	
	HL	BL	TR	BL	TR
Jatiragas	0.165	0.107	0.147	7.61	7.61
Jatisari	0.103	0.123	0.158	4.09	8.38
Rawa Gempol	0.889	0.130	0.167	3.43	6.43
Sukatani	0.126	0.169	0.154	4.59	6.89
Bojong Tengah	0.144	0.144	0.150	2.86	8.10
Karang Anyar	0.108	0.116	0.166	3.81	6.78
Mariuk	0.165	0.138	0.209	3.96	7.78
Tambak Dahan	0.126	0.088	0.149	4.38	6.11
Average:	0.128	0.127	0.163	4.34	7.26
Standard Deviation:	0.028	0.024	0.020	1.43	0.82
Coefficient Variation:	22%	19%	12%	33%	11%

*Average of first and second operation.
**First operation only.

*Hunt, 1973.

The 7.26 percent of residual untilled land left by tractors was significantly higher (1 percent limit) than the 4.34 percent left by bullock tillage.

A linear regression indicated a weak correlation between plot size variation and percentage of untilled residual land, with a coefficient of determination of 0.08 and 0.01 respectively. This implied that for a plot size range of 0.09 to 0.17 hectares, the percentage of untilled land was quite independent from plot size.

4.2.5 Travelling Speed of Bullocks and Tractors

The traveling speed is associated with field capacity and power requirement for the tillage operation. The rate of traveling speed was recorded in seconds for distances of either 10 to 20 meters of tillage operation. Tractors were found to operate nearly as fast as bullocks (see Table 4.9). An LSD analysis indicated that the difference of travelling speed was highly significant (1 percent level). Bullocks pulled a plow (18-25 cm wide) for the first operation and a comb harrow (125-160 cm wide) for the second and third passes, while rotary tillers with 20 to 24 blades (54-64 cm wide) were used by tractors.

4.2.6 The Actual Field Capacity

The total time required to complete the land preparation was measured for each rice plot. The total time consisted of the net (effective) time plus the idle time. Conversion of measured time in minutes per plot to hours per hectare were made and the results are presented in Tables 4.10 and 4.11 for the first and second operations respectively.

Table 4.9. Travelling speed of bullocks and tractors (km/hr).

Village	First operation		Second operation	
	Bullocks	Tractors	Bullocks	Tractors
Jatiragas	1.33	2.94	1.22	2.03
Jatisari	1.36	3.28	1.01	2.64
Rawa Gempol	1.19	2.31	1.11	2.42
Sukatani	1.25	2.03	1.03	2.06
Bojong Tengah	1.30	1.81	1.01	2.44
Karang Anyar	1.14	2.31	1.33	3.03
Mariuk	1.14	2.25	1.01	2.14
Tambak Dahan	1.08	2.01	1.33	1.92
Average:	1.22	2.37	1.13	2.33
Standard Deviation:	0.10	0.50	0.14	0.37
Coefficient Variation:	8%	21%	13%	16%

In summary of Tables 4.10 and 4.11, the average effective time required for tillage in hours was 309.6, 52.3 and 14.8 per hectare, for two passes for manual labor, bullocks and tractors respectively.

A slight negative regression slope along with a small coefficient of determination, of less than 0.1, suggested that within a plot range of 0.09 to 0.17 hectares there was a weak association at 5 percent confident level between plot size and time efficiency.

4.2.7 Fuel and Oil Consumption

Diesel fuel consumption was recorded based upon operating time, rather than unit areas. This approach was considered more adequate, as tractor operators usually filled the fuel tank before they started in

Table 4.10. Average time required for the first tillage of one hectare of rice land (hours).

Village	Manual labor	Bullock	Tractor
Jatiragas	241.8	40.7	6.3
Jatisari	240.0	31.3	8.3
Rawa Gempol	134.0	28.0	8.3
Sukatani	149.3	36.2	8.0
Bojong Tengah	134.0	31.8	11.3
Karang Anyar	140.7	36.8	7.7
Mariuk	240.0	48.3	8.2
Tambak Dahan	247.2	47.8	10.8
Average:	190.9	37.5	8.6
Standard Deviation:	55.2	7.5	1.6
Coefficient Variation:	29%	20%	19%

the morning and again at lunch, dinner or rest time. Measurement was made by marking a fuel stick when full. The fuel level was exactly filled to this mark each time the measurements were made with the tractor standing exactly horizontal. Data regarding fuel and oil consumption are presented in Table 4.12.

The amount of fuel used was recorded in cubic centimeters/minute, then converted to liters/hour. Oil consumption was not measured directly. Tractor operators were asked to provide information on oil use and this was checked by physical observations. Operator information was generally confirmed as being accurate.

Table 4.11. Average time required for the second tillage of one hectare of rice land (hours).

Village	Manual labor	Bullock	Tractor
Jatiragas	126.0	20.7	6.7
Jatisari	79.0	15.8	5.2
Rawa Gempol	98.3	15.0	5.7
Sukatani	112.3	29.5*	6.7
Bojong Tengah	122.2	11.7	5.8
Karang Anyar	79.5	27.8*	5.7
Mariuk	143.5	27.0*	6.8
Tambak Dahan	189.2	13.3	7.3
Average:	118.7	14.8**	6.2
Standard Deviation:	36.3	2.7	0.7
Coefficient Variation:	30%	18%	12%

*Second and third passes.

**Average for second pass only.

The higher fuel consumption rate in Jatisari for both the first and second operations coincided with higher soil hardness values and the higher travelling speeds (see Tables 4.7 and 4.9). In Tambak Dahan, lower fuel consumption for the first operation was found along with the lower degree of soil hardness and slower travelling speed. Also, most tractors used in this village were relatively new (see Tables 4.4, 4.7, and 4.9). In general, fuel consumption levels varied only slightly between villages. The coefficient of variation was less than 15 percent. The average oil consumption was found to be 0.042

Table 4.12. Average fuel and oil consumption for tillage operations (liter/hour).

Village	First pass	Second pass	Oil
Jatiragas	1.249	1.183	0.047
Jatisari	1.486	1.330	0.036
Rawa Gempol	1.192	1.122	0.036
Sukatani	1.276	1.174	0.049
Bojong Tengah	1.030	1.067	0.030
Karang Anyar	1.308	1.109	0.040
Mariuk	1.199	1.285	0.050
Tambak Dahan	0.968	1.171	0.050
Average:	1.214	1.180	0.042
Standard Deviation:	0.162	0.088	0.008
Coefficient Variation:	13%	7%	19%

liters per hour. This level of consumption for 7-8.5 horsepower tractors was close to the level recorded by The Directorate of Agricultural Mechanization, which was 0.8 liters per 100 horsepower-hours.

4.2.8 Locally Made Tractor Performance

Field measurements of locally made tractors (7-8.5 hp) were conducted in Gabus Wetan village, located about 90 kilometers from the nearest sample village. Five tractor measurements were conducted and the data are presented in Table 4.13. This locally manufactured (IRRI type) tractor was powered by a diesel engine. Sprockets, chains, pulleys and two v-belts were used for transmitting mechanical power

Table 4.13. Field performance data on locally made tractors.

		Plowing	Harrow	Imported* (average)
Depth of cut	cm	10.0	--	10.34
Traveling	km/hr	4.8	4.3	2.33
Width of cut	cm	24.3	125-160	64
Fuel consumption	lt/hr	0.941	1.327	1.214
Oil consumption	lt/hr	0.034		0.042
Field capacity	hr/ha	12.5	3.83	8.6
Machine efficiency	%	56	37	62
Plot size	ha	0.05	0.115	0.167
Residual land	%	12	--	7.26
Worked hours/day				
a. mean	hr	9.7	--	12
b. std. dev.	hr	0.94	--	2
Price	Rp. 1,000	1,650	--	2,330
Operator wage	%	15	--	14.3

*The average imported tractor data are provided for comparison. These are first operation data.

from the engine to the steel wheels. The lower plowing efficiency was probably in part due to the lack of steering clutch. A new design, with steering clutch was still being tested when this research was conducted so was not yet available for field use.

4.3 Labor Use and Cost for Land Preparation Derived from Farm Survey

The level of agricultural supply, price level, inflation and interest rate and their complex linkages were assumed as exogenous factors to the farmers. Farm survey, operator interviews and literature studies were conducted to obtain relevant exogenous data. Landholding of the sample farms, rice yield and production inputs were also recorded to find their association with cost and labor use for land preparation.

4.3.1 Equipment Price and Operator Wages

Price levels for hoe, bullocks and tractors are presented in Table 4.14. Tractor price was based upon the price of the "standard" unit of small tractors for rice fields, which include floating steel wheel, rotary hoe (blade) set and rubber tires. Higher tractor prices were found in Jatiragas, Rawa Gempol and Karang Anyar and coincided with greater proportion of land and bullocks in those villages (see Table 4.1). While the highest tractor price was found in Tambak Dahan, Sukatani and Mariuk had the lowest tractor prices and also experienced a longer time of tractorization. In Jatisari many sample farms obtained their lower tractor price by direct purchase from the dealers rather than through the Rural Bank. The bullock price was found lowest in Mariuk, possibly because this village has the highest number of either bullocks or tractors.

Most tractors in the sample villages (except in Sukatani, Mariuk and Jatisari) were obtained on credit through the Rural Bank at 10.5 percent to 12 percent interest rate yearly, with six seasonal (six

Table 4.15. Operator wages.

Village	Manual labor RP/day	Bullock[1] RP/day	Tractor[2] %
Jatiragas	538.5	1656.2	15.0
Jatisari	558.3	1533.3	15.0
Rawa Gempol	513.3	1366.7	15.0
Sukatani	542.9	1280.0	11.6
Bojong Tengah	508.8	1933.3	16.3
Karang Anyar	494.1	1256.5	14.3
Mariuk	505.9	1142.8	16.7
Tambak Dahan	500.0	2142.8	10.6
Average:	520.2	1538.9	14.3
Standard Deviation:	23.2	352.0	2.1
Coefficient Variation:	4%	23%	15%

[1]Including cost for bullocks.

[2]Percentage of custom-rate.

Lower operator wages for all technologies were found in Karang Anyar. The highest wage rate for bullock operations was found in Tambak Dahan, where worked hours per day for this technique was the longest (first operation, see Table 4.4 and 4.5). Lower bullock operator wages in Mariuk and Sukatani, along with low manual labor wages in Mariuk coincided with the high tractor population in those villages (see Table 4.1).

4.3.3 Land Holding of Sample Farms

Land holding in Northern plains of West Java, like in other parts of the country, generally classify the economic status of farmers. The average land holdings of sample farms are presented in Table 4.16.

Table 4.16. Land holding by sample farms (hectare).

Village	Farm utilizing: Manual labor	Bullocks	Tractors
Jatiragas	0.17[1]	0.62	0.89
Jatisari	2.03	1.15	2.21
Rawa Gempol	0.92	3.70	2.30
Sukatani	1.05	1.73	2.90
Bojong Tengah	1.13	2.05	1.01
Karang Anyar	1.28	1.94	5.06[2]
Mariuk	1.82	1.26	4.30
Tambak Dahan	1.34	1.05	1.94
Average:	1.22	1.69	2.58
Standard Deviation:	0.57	0.95	1.47
Coefficient Variation:	46%	56%	57%

[1]Four samples.

[2]One sample farm of 15 hectares.

The average land holding for farms using tractors was significantly larger as compared to those using manual labor or bullocks (1 percent level). Furthermore, the larger tractor farm land holdings in Sukatani, Rawa Gempol and Mariuk, coincided with the greater number of tractors in those villages.

4.3.4 Labor Inputs for Preharvest Rice Production Activities

The proportion of labor input for land preparation as compared to the total preharvest labor input in the rice production system is important. The numeric values for labor input as given by the farmers, are shown in Table 4.17.

Table 4.17. Labor input for preharvest rice production activities.

Village	Total input (hr)			Land preparation (%)*		
	ML	BL	TR	HL	BL	TR
Jatiragas	1106	555	432	39	21	13
Jatisari	1150	696	697	45	41	35
Rawa Gempol	1273	678	625	48	26	24
Sukatani	1241	808	809	36	36	25
Bojong Tengah	1699	1110	946	38	22	18
Karang Anyar	1209	771	858	37	24	19
Mariuk	1342	871	745	47	37	29
Tambak Dahan	1175	747	817	60	34	34
Average:	1274	779	741	44	30	25
Std. Dev.:	202	163	159	8	8	8
Coef. Variation:	16%	18%	21%	26%	21%	31%

Note: Figures are rounded.

*Percentage of the total preharvest rice production labor input.

Table 4.17 shows that the labor input on farms using manual labor is significantly greater than on bullock and tractorized rice farms. There appears to be no significant difference in labor input between bullock and tractor farms. This table also indicates that total preharvest labor input on bullock and tractor farms was not significantly different (5 percent level). The percentage of labor for land preparation relative to the total preharvest labor input shows highly significant differences between manual labor, bullock and tractor farms.

4.3.5 Fertilizers and Chemicals Used in the Sample Farms

Fertilizers commonly used in the study areas were urea, and triple or double superphosphates. The fertilizer doses for each were recommended by the BIMAS program to be around 200 to 300 kilograms of urea and 100 to 150 kilograms of superphosphate per hectare. Other agricultural chemicals used for controlling rats, stemborers and brown hoppers are diazinon, sumithion and phosphorus. The amounts of chemicals applied are presented in Table 4.18. This table indicates that the average application rate of fertilizers and chemicals does not differ significantly between farms using manual labor, bullocks or tractors. The application of these chemicals was highest in Karang Anyar and lowest in Jatiragas.

Most of the rice varieties used were IRRI types (IR-26, IR-28 and IR-36). The occurrence of more frequent rice damage by pests and diseases in Karang Anyar might cause farmers to plant more rice seed to provide some reserve. Rawa Gempol used the least amount of seed. This village receives more sunshine (agroclimate zone E) and has better crop management along with highest yield per hectare. Table 4.19 demonstrates that farms using tractors obtained a significantly higher yield (5 percent level).

Table 4.18. The amount of fertilizers and chemicals used in sampled rice farms (per ha).

Village	Fertilizers (kg)			Chemicals (liters)		
	ML	BL	TR	ML	BL	TR
Jatiragas	414	296	337	2.9	1.6	2.0
Jatisari	338	357	374	4.5	1.8	2.6
Rawa Gempol	345	357	316	3.7	4.5	2.4
Sukatani	286	343	286	3.6	5.6	3.6
Bojong Tengah	356	319	357	4.6	6.3	5.6
Karang Anyar	333	360	429	6.7	6.4	9.0
Mariuk	375	325	331	5.4	3.5	4.9
Tambak Dahan	337	335	343	3.8	3.2	4.5
Average:	348	333	347	4.4	4.1	4.3
Standard Deviation:	37	30	42	1.2	1.9	2.2
Coef. Variation:	11%	9%	12%	27%	46%	53%

Table 4.19. Level of seeds planted and rice yield on the sample farms.

Village	Seeds (kg/ha)			Yield (ton/ha)*		
	HL	BL	TR	HL	BL	TR
Jatiragas	n.a.	29	27	4.1	4.5	4.9
Jatisari	26	31	23	4.4	4.5	4.6
Rawa Gempol	31	29	20	3.8	4.8	6.8
Sukatani	29	28	27	4.6	4.6	4.3
Bojong Tengah	24	25	23	3.9	4.7	4.7
Karang Anyar	43	34	34	4.0	4.2	4.5
Mariuk	29	31	26	4.0	4.1	4.0
Tambak Dahan	31	27	27	3.9	4.5	5.0
Average:	30	29	26	4.1	4.5	4.8
Standard Deviation:	6	3	4	0.3	0.2	0.8
Coefficient Variation:	21%	9%	16%	7%	5%	17%

*At the harvest moisture content.

CHAPTER 5

DEVELOPMENT MODEL AND SIMULATION FOR LAND PREPARATION TECHNIQUES

Perhaps it is typical that developing countries, such as Indonesia, have relatively frequent, complex and uncertain problems that need immediate relevant information for decision makers to use in planning. The choice of land preparation techniques for rice cultivation is a case in point. Traditional analyses are not sufficient to deal with the problems of availability of agricultural power at peak seasons; commencement of rainfall as related to suitable time for tillage operation; or the control of the outbreak of rice pests and diseases (e.g., rat, stemborer, brown hopper).

A computer assisted systems analysis approach can serve as an effective means for dealing with such problems. This chapter presents a computer aided systems analysis approach for prediction and comparative analysis for alternate choices of land preparation techniques in the Northern coastal plain of West Java. While researchers traditionally have relied on conventional, large computers for such analyses, they are not always readily available in many developing countries. For this reason, a micro computer with BASIC language was used for analysis and simulation of the choice of land preparation techniques in the present research.

5.1 A Systems Approach for Comparing Preparation Alternatives

A system is defined as a set of elements or components which interact or link with each other in the performance of given functions (Manetsch *et al.*, 1974 and Naylor *et al.*, 1968). Components are differentiated into: 1) exogenous (environmental) variables, 2) fixed or controllable input (endogenous) variables, 3) input parameters, and 4) output variables. An imaginary line or systems boundary separates endogenous systems components from exogenous (environmental) variables. While exogenous components influence the system's behavior or performance, conversely the system itself does not have, or has only a weak influence on the exogenous variables.

Manetsch *et al.* (1979) suggested four major phases in the application of the system approach process: 1) feasibility evaluation, 2) abstract modeling, 3) implementation design, and 4) system operation and implementation. Simulation is associated with the last three phases.

5.1.1 Identification of System Components

The first step is feasibility evaluation, which includes the process of identifying the system components. The need for analysis, as well as components, linkages and functions of land preparation system are identified and illustrated in Figures 5.1 and 5.2. Weather, irrigation schedules, prices, population, rate of inflation, non-agricultural employment and rice pests and diseases are all defined as exogenous components. Input parameters, as system design elements, serve to specify the structure of the system. These parameters tend to be fixed and are

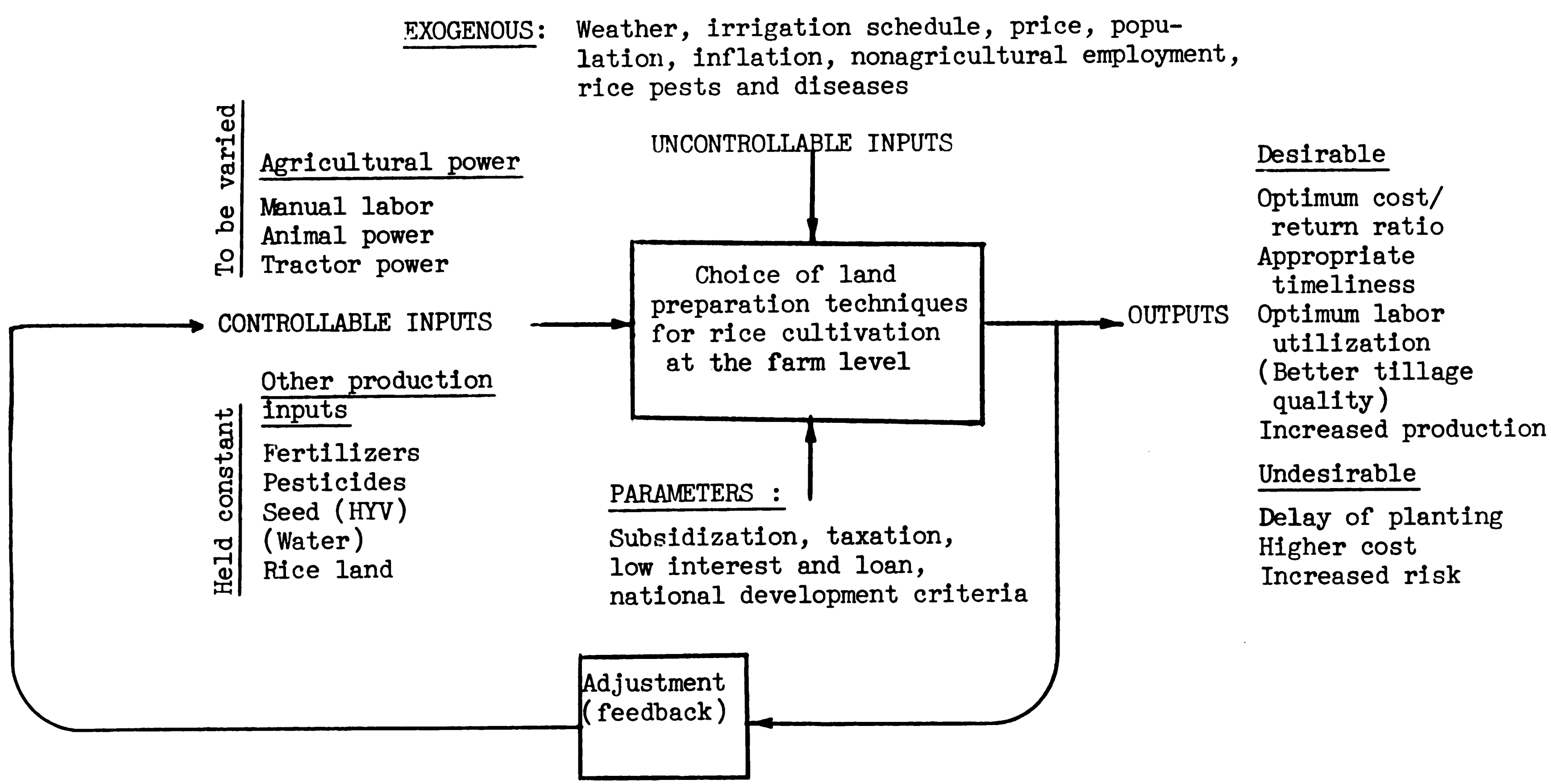
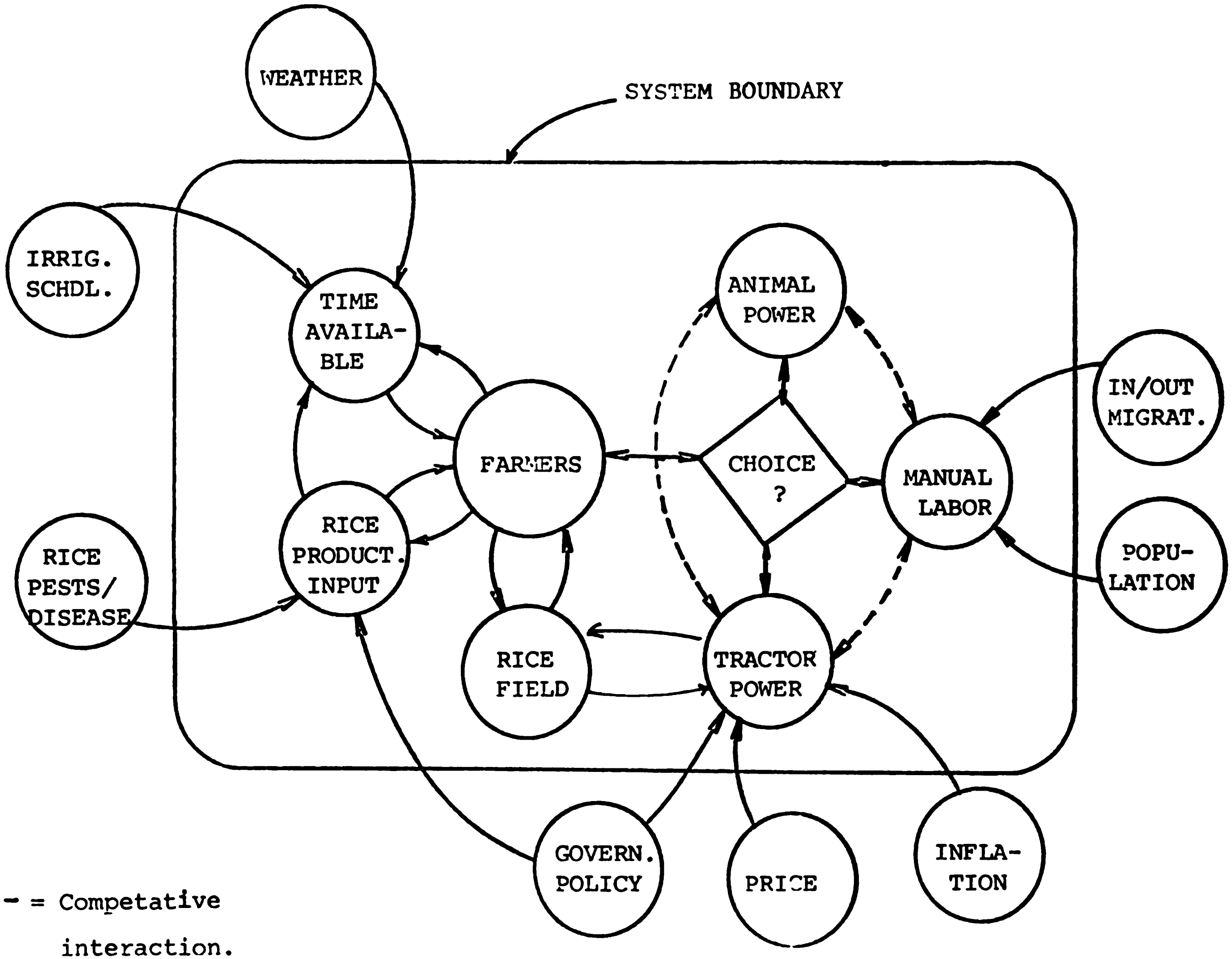


Figure 5.1. Blackbox diagram for choice of land preparation techniques at farm and village levels.



------ = Competative interaction.

Figure 5.2. Simplified causal loops model for choice of land preparation techniques at the farm level.

important as decision variables (Manetsch et al., 1974). In the present case, the Government policy was classified as an input parameter; it consists of such elements as subsidization, availability of soft loans at low interest rates, taxation and national development criteria (as they have been discussed previously in Chapter 3). Production function levels other than agricultural power for tillage are held constant during the simulation process. They are seeds, fertilizer, pesticides, rice land and, to some extent, water. The controllable inputs are manual labor, bullock and tractor power. The number and combinations of these controllable input levels may be changed during the operation (simulation) of the system model to alter the performance and results.

The desirable system output for the land preparation consists of optimizing cost, optimizing labor utilization, timliness of completing the land preparation, and increasing leisure time. The farmers studied indicated concern with any delay in planting, the increased costs for land preparation with no additional, i.e., greater yield, and the failure to synchronize planting time in one tertiary irrigation block with water availability; and serious pest and disease damages. It was these factors which were defined as undesirable systems output, that stimulate farmers to readjust their management practices accordingly, thus leading to a feedback mechanism.

5.1.2 System Linkages

The linkages and interactions between identified components in the rice land preparation system are illustrated in the causal loop model presented in Figure 5.2. The engineering/technological interaction, as related to field performance, are described with equations and criteria developed by Hunt (1973). The relative tillage costs and timeliness are dominant factors which guide in the shift of economic preferences for the choice of land preparation.

Mathematical relationships, detailed quantitative description and measurement units are discussed in subsection 5.2. The following discussion is limited to a qualitative description of the relationships among the critical components in the system.

The beginning of the rainy season and the amount of rainfall, as well as any changes in the irrigation schedule are two dominant factors in setting a suitable period for land preparation. These two factors vary from season to season. Farmers will not, generally, start tillage operation until irrigation water has saturated the soil to a depth of 5-10 cm along with the occurrence of frequent rainfall in "sepasar" (local term for 5 days), as farmers want to be assured of the availability of sufficient water. The situation is made more difficult by heavy rains (i.e., more than 40 millimeters per day) which delays the tillage operations. The delay due to the unavailability of tillage means varies from village to village. These possible delays may cause farmers to try to utilize tractors although they might cost more.

Labor supply is influenced by population growth, migration and the availability of other employment. Government policies, price change and inflation rate are exogenous factors that influence relative costs and returns for the tillage operation. For instance the calculated fixed cost of owning a tractor with a uniform series of capital recovery will decrease when the inflation rate is higher than the interest rate and vise versa (see equation model 5.9).

5.2 Rice Land Preparation Model

Systems researchers utilize models as an abstraction of the real world. To model the real world allows for an effective evaluation of the many linkages and factors that constitute the system. The diagrammatic causal loop model of Figure 5.2, shows the significant components with their relevant linkages. The hours worked per day was a critical factor related to field capacity and land preparation costs. A lower number of hours worked per day by manual labor and bullocks results in higher land preparation costs as payment is on a daily basis. Farmers have to compensate for delays due to rainfall and change of irrigation schedule by working longer days in the field during land preparation. Stochastic system modeling, which involves random probability methods, was used for time analysis with reference to the factors discussed above.

The threat of rice pests and diseases forces farmers to synchronize their seeding and transplanting time with that of the surrounding fields. This technique increases the concentration of the demand for agricultural labor and power during a shorter period of time.

There was a significant change in days available for land preparation due to the relatively shorter nursery period for higher yielding varieties (YHV) compared to the traditional rice varieties. The time period for land preparation was between 35 to 42 days when farmers grew indigenous varieties as compared to 21 to 25 days for HYV.

The number of panicle bearing rice tillers was reduced when transplanting was delayed. This creates problems when the farmer has planted the nursery seedbeds and then hired labor and farm family members are not sufficient to complete tillage operations in the necessary period of days. A logical computer program is illustrated by the flow chart of Figure 5.3. The model consists of two subsystems: 1) the farm level, and 2) the tractor owner. The tractor owner subsystem will predict profitability which provides relevant feedback information for Government planners as well as tractor owners.

The random probability (stochastic) models for the rainfall effect on the available tillage days and available agricultural power were
NOT APPLICABLE TO FLOODED SOILS
derived from Hillier and Liberman (1974). The technique for generating a random observation from a normal distribution was obtained by applying the central limit theorem. Decimal numbers of a normal distribution have a mean of 0.5 and standard deviation eaual to $1/\sqrt{12}$. This theorem states that the sum of random decimal numbers ("n") have approximately a normal distribution with a mean of n/2 and a standard deviation eaual to $\sqrt{n/12}$. Therefore the probability value of expected variable (X) is expressed as:

$$X = SD \times (Q - M/2) \; / \; \sqrt{M/12 + \mu} \qquad (5.1)$$

where

X = expected value of the variable being predicted

SD = standard deviation

Q = $\sum_{i=1}^{m}$ random number

μ = an estimate for the mean

M = number of observations

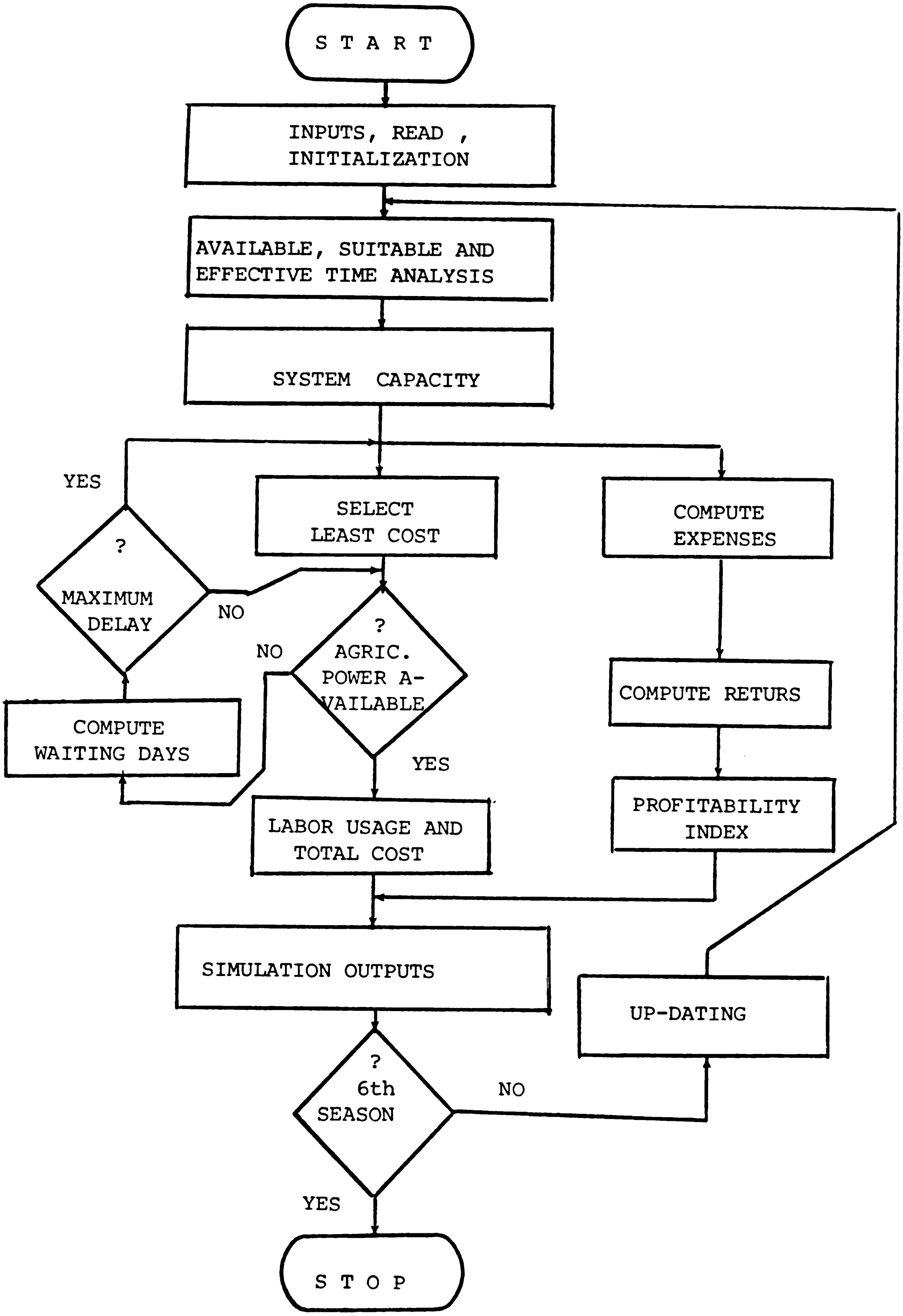


Figure 5.3. Simplified flow chart for land preparation model at the farm level.

Q-values are obtained through a computer random number generation program. The values for μ and σ are derived from statistical inferences.

For computer programming convenience, equation 5.1 was modified as:

$$X = \sigma \times (Q - 12/2) / \sqrt{12/12} + \mu \tag{5.2}$$

In this case the value of M (number of iteration or looping) for computer program is set equal to 12. Thus equation 5.2 becomes:

$$X = \sigma \times (Q - 6) + \mu \tag{5.3}$$

The computer subroutine to find Q from a normal distributed random probability is designed as follows:

```
4980  ******    SUBROUTINE RANDOM PROBABILITY    ******
4990  S = 0.0
5000  FOR K = 1 TO 12
5010  A = RND (1): S = S + A
5020  NEXT K
5030  Q = S - 6
5040  RETURN
5050  END
```

The other extensively used subroutine is the waiting time (in days) for predicting availability of hired manual labor or animal power as described in the following computer program:

```
4840  ******  SUBROUTINE WAITING TIME FOR RAINFALL  ******
4850  ******  AND AVAILABILITY OF TRADITIONAL AGRI- ******
4860  ******            CULTURAL POWER              ******
4870  H = 0.0: N = 6
4880  Z8 = 0.0: FOR M8 = 1 TO N: GOSUB 4980
4890  Z8 = Z8 + Q: M8: Z8 = Z8 / N
4900  H6 - H4 + Z8
4910  IF H6 >= 1.0 THEN 4950
4920  H8 = H8 + INT (H6 + 0.5)
4930  IF H8 >= H5 THEN 4950
4940  GOTO 4880
4950  RETURN
4960  END
```

5.2.1 Time, Cost and Seasonal Capacity Analysis

The time period of this model extends over six wet seasons from 1980 to 1985. This time span is chosen with regard to the estimate of tractor service life of six years (Directorate of Agricultural Mechanization, 1977-1978). The time analysis for the seasonal working hours and days computed from the equations:

$$ED = (AD + 7) - (DL \times RN) \tag{5.4}$$

$$EH = (MH + \sigma \times Q) \tag{5.5}$$

where

ED = potential suitable days in a season (in days)

AD = allowable days based upon the irrigation schedule (in days)

DL = delay caused by late start of rain (in days)

RN = number of heavy rainfall days (more than 40 millimeter/day) which might prevent tillage operations

EH = potential available hours in a season (hours)

MH = mean of working hours per day (hours)

σ = standard deviation for working hours per day (hours)

Q = random probability number (see equation 5.1)

7 = number of extended days from the irrigation schedule commonly allocated in the study areas

The potentially suitable days and available hours in a season are meant to represent the actual time spent in the rice field for rice land preparation, including idle time. The effective days and hours are the actual time spent for doing physical land preparation activities, excluding idle time. The effective hours are used to predict the machine performance efficiency and capacity. The suitable days, and available hours are used for estimating cost of land preparation.

Delay (DL) and rainfall (RN) are random variables computed from the subroutine of random probability logic to obtain seasonal waiting time values. The capacity of each technology in each season is predicted by dividing the total effective working hours per season by field capacity (hours per hectare).

Land preparation custom rates in the villages studied were paid for a day or bau contract basis. (Note: 1 bau = 0.7 hectare). Area based contracts were more commonly practiced for tractor operations, while traditional land preparation was paid for on a day basis. The algebraic expressions used for these two cost models were:

$$\text{MLCOST} = (\text{CD} + \text{CD} \times \text{RATE1}) + (\text{CM} + \text{CM} \times \text{RATE1}) \times 10{,}000 / \text{CAP} \times \text{HD} \tag{5.6}$$

$$\text{BLCOST} = (\text{CD} + \text{CD} \times \text{RATE2}) + (\text{CM} + \text{CM} \times \text{RATE2}) \times 10{,}000 / \text{CAP} \times \text{HD} + \text{RES} \times \text{HLCOST} \tag{5.7}$$

$$\text{TRCOST} = \text{COSTBAU} / 0.7 + (\text{CM} + \text{CM} \times \text{RATE3}) + \text{RES} \times \text{HLCOST} \tag{5.8}$$

where

MLCOST = manual labor cost (rupiah/hectare)

CAP = capacity of technology (square meter/hour)

HD = random hours worked per day (hours)

10,000 = conversion number from square meter to hectare

CM = cost of meals for operators (rupiah/day)

BLCOST = cost of land preparation for bullocks (rupiah/hectare)

TRCOST = cost for land preparation for tractor (rupiah/hectare)

RATE = rate of annual increase of cost or price (%/year)

All variable values subject to change over time are up-dated each season using the discrete arithmetic method.

5.2.2 Farm Level Subsystem Model

The logical path of this subsystem followed the least cost preference and maximum delay constraint considerations. Rice farmers attempted to select the least cost for land preparation in the sequential order of manual labor, bullocks and tractor power. Since the tractor tillage price was paid based upon unit areas, farmers gave attention to quality of the tillage operation with specific regard to depth of cut and the residual untilled land left on the plot corners and levee sides.

The unit cost of land preparation of manual labor and bullocks, which were usually in terms of rupiah per day, were estimated from farmers' responses about the past year's experiences. The area rate for these two techniques may vary from season to season depending on the degree of effectiveness during the working hours per day and the available days per season; e.g., when during a full day of rain, farmers would only serve meals. This traditional contract does not apply to tractor operators. Full payment is, however, made to manual labor or bullock teams whether they work a full day or not. Hours worked per day for these two techniques are a function of the number of working days per season.

A farmer's decision as to the type of tillage operation depended on the least cost and the availability of traditional technology. If, for instance, bullock cost for land preparation was lower, but the number of waiting days exceeded the maximum tolerable days, the farmer looked for alternative technologies. The tolerable maximum waiting days varied depending on the customary practices in each village.

Information regarding the demand for tractor land preparation can arrive relatively quickly at the tractor owners outside the village through the tractor owner association. Since tractors are mobile, it is assumed in this model that tractors have a greater degree of ability to serve in land preparation than traditional methods. Random probability and waiting day subroutines are used to predict the possible waiting days for the availability of traditional power in this model. The simulation model outputs for farm level subsystems are in the form of: 1) labor used (man days/hectare), 2) labor and technological capacity (hours/hectare and hectare/season), 3) the first and second pass of land preparation costs along with the total cost (rupiah/hectare), and 4) number of waiting days and possible combination of technologies chosen which provide the total least cost information.

5.2.3 Tractor Owner Subsystem Model

The mathematical model for analyzing the tractor owning costs and returns are presented by equations 5.9 to 5.12. The subsystem will predict the comparative profitability of tractor ownership under different purchasing arrangements and operating conditions. The tractor returns from the tillage operation are based on land prepared. Therefore, tractor owners attempt to operate their tractors as many hours per day as possible. The tractor expenses are predicted by Garmo and Canada, 1973; Kepner, *et al.*, 1978.

$$\text{ANCOST} = P \times (i-e)(1+i-e)^n/((1+i-e)^n-1) \qquad (5.9)$$

$$\text{OPCOST} = \text{FCOST} + \text{OCOST} + \text{RMCOST} + \text{OPWAGE} \qquad (5.10)$$

$$\text{TOTCOST} = (\text{ANCOST}/X + \text{OPCOST}) \times \text{CAP} \qquad (5.11)$$

where

i = annual interest rate (%)

e = annual rate of inflation (%)

ANCOST = annual (fixed) cost (RP/season)

P = purchasing price (RP)

OPCOST = operational cost per hour (RP/hour)

FCOST = cost of fuel (RP/liter)

OCOST = cost of oil (RP/liter)

RMCOST = cost for repair and maintenance (RP/hour)

OPWAGE = operator wage (RP/hour)

X = number of effective working hours/wet season of 1980

CAP = capacity (hours per hectare)

Diesel fuel and oil prices at the village level were RP 53 and RP 500 per liter respectively (December 1980). Repair and maintenance costs could not be obtained accurately, because many tractors were new and tractor owners did not have sufficient information yet. Therefore, the level of repair and maintenance cost was estimated at 1.2 percent per 100 hours worked times 90 percent of the purchase price. Of the total of 1.2 percent, 0.8 percent was assumed for spare parts and 0.4 percent for mechanic's wages (Hunt 1973; Subdirectorate of Agricultural Mechanization, 1977-1978). The wet season fixed cost was estimated as being equal to the dry season fixed cost or in other words equal to 50 percent of the annual fixed cost.

Annual fixed cost for capital recovery was computed from a uniform series payment. There was no tax, insurance or shelter costs for small tractors.

The operational (variable) cost consists of fuel, oil, repair and maintenance costs and operator wages. The operator wage is paid as a percentage of gross return. Therefore, the operators are stimulated to work for more hours/day. The tractor net earnings in the wet season of 1980 was computed by subtracting total expenses from the customary rate paid by farmers.

5.3 Systems Simulation

Naylor (1960) defined simulation as the operation of a model that represents an actual world system. Manipulation of the system inputs makes it possible to simulate the system's behavior under given assumptions. Simulation models are best at providing an optimal range of information rather than a single optimal point. In the present modeling, each village was simulated individually along with the general or average condition. Since the input in each village varies, the generalized similation output should not be interpreted as an actual representation of the values of the variables being studied in each village. After the simulation model was verified, the sensitivity analysis was performed using average values of variables being studied. The generalized simulation was made to test the system modeling sensitivity under various levels of controllable input data. The degree of alterations of the system inputs were based upon the means or rates plus or minus the standard deviation or otherwise specified.

The percentage and maximum probabilities of the delay of commencement of rain and waiting day estimations were obtained from key farmers, sample farms and "PPL", the Field Extension Workers, in the study areas. This information was reconfirmed with the district irrigation service. In Jatiragas, for example, the probability of a delay of rainfall commencement is 75 percent and usually the maximum days of this delay does not exceed 12 days. The probability of obtaining manual labor and bullocks in Tambah Dakan, for instance, is 66 percent and farmers, in this village, usually cannot wait for the availability of traditional power more than five days. Heavy rainfall which may prevent tillage operation in Sukatani village, to give another example, is around 2.364 days, with standard deviation of 1.851 days.

Specific exogenous data on manual labor migration from and to the villages were not available. Therefore, their numeric values are extrapolated from the population growth rate at the village level. The dynamic population of rural dwellers and bullocks for simulation inputs were derived from Table 4.1 of Chapter 4. Some environmental inputs related to financial analyses are presented in Table 5.2.

Table 5.1 Annual rates of change for components of the financial analyses.

Item	Rate of increase
Manual labor wage rates[1]	11%
Bullocks wage rates[1]	11%
Tractor purchase price[1]	14%
Retail price of rice (December)[2]	21%
General index price (at rural area)[1]	15%
General inflation (at national level)[3]	18%

[1]Central Bureau of Statistics (in Berustein, 1980)
[2]Bustanil Arifin (National Logistics Board, 1978)
[3]Central Bureau of Statistics, 1978

The rate of increase of the variables presented in Table 5.2 were obtained by regression analyses using data presented in Appendix 2. Other system inputs, such as fuel and oil consumption, hours worked per day, and land resources were derived through statistical inferences as discussed in Chapter 4.

Sensitivity analyses were run three times to test the responsiveness of the simulation model to various input values derived from the average of village data.

Critical controllable and parameter input components to be varied for these sensitivity analyses are 1) number of tractor and bullocks, 2) tractor prices, rate of interest, inflation and life expectancy of tractor, and 3) hours and days worked available per season. The combination and levels of numerical values of those critical components for the three sensitivity analyses are presented in Table 5.3.

Table 5.2. Examples of input values for sensitivity analyses

Item	Sensitivity Analysis		
	1	2	3
Number of tractors (units)	23	39	7
Number of bullocks	58	9	107
Tractor price (RP 1000)	2300	2300	2300
Rates of inflation (%/year)	15	15	18
Rates of interest (%/year)	10.5	10.5	12
Hours worked/day (hours)			
(a) manual labor	9.0	7.5	7.5
(b) bullocks	6.7	5.8	5.8
(c) tractors	13.3	11.6	11.6
Available days	35	30	30
Tractor life expectancy (years)	6	6	6

Note: Run 1, 2 and 3 indicate the run number under different input values

The numerical values of column 2 in Table 5.3 are obtained from the average data of eight villages discussed in Chapter 4, while figures in column 1 and 3 (run 1 and 3) are calculated based upon column 2 $\pm$ the standard deviations. These variation levels of inputs are assumed close to the variation may exist in the real world.

5.3.1 Systems Simulation Inputs

The uncontrollable exogenous inputs were simulated through random probability and waiting subroutines. The commencement and number of days of heavy rainfall were calculated statistically from the daily rainfall records over the past 31 years (1948-1980) at the Sukamandi rice seed farm which is located almost at the center of the villages studied. The values of these variables are presented in Table 5.4.

Table 5.3. Probability of delay, wait and heavy rainfall.

Village	Delay		Wait		Heavy Rainfall	
	Prob. %	Max. days	Prob. %	Max. days	Means days	SD days
Jatiragas	.75	12	.66	5	2.364	1.851
Jatisari	.75	10	.75	7	2.364	1.851
Rawa Gempol	.80	12	.58	4	2.364	1.851
Sukatani	.70	15	.60	4	2.364	1.851
Bojong T.	.80	14	.50	7	.535	.589
K. Anyar	.70	14	.70	5	2.364	1.851
Mariuk	.75	14	.50	4	.535	.589
T. Dahan	.90	10	.66	5	.535	.589
Average:	.77	13	.62	5		
Standard Dev.:	.06	2	.09	1		

Source: Sukamandi Seed Farm (1980).

5.3.2 Systems Simulation Outputs and Discussion

The systems simulation output of the farm level subsystems were 1) technical performance, which was measured in terms of technological capacity (hours/hectare; hectare/man day and hectares/season), 2) costs of the first and second tillage passes along with their total cost (Rupiah/hour, Rupiah/hectare), 3) labor utilization, including manual labor for tillage operations on the corners and levee sides (man days/hectare), and 4) number of waiting days along with a combination of land preparation techniques to produce possible least cost. The relationship between capital substitution for labor in land preparation is illustrated by isoquant curve.

The simulation outputs of the tractor owner's financial subsystem were 1) expenses for variable (operating), and seasonal (fixed) costs (Rupiah/hour, Rupiah/hectare), and 2) earning (Rupiah/hour, Rupiah/hectare) along with profitability levels (ratio of total present worth cost and earnings).

Total and effective working hours for land preparation in a season were important factors associated with the simulated technological capacity as well as financial analysis. The simulated outputs of effective hours per season are presented in Table 5.4. In this simulation model the available time due to irrigation schedule, delay of the commencement of rainfall and due to heavy rainfall along with periods necessary for softening rice land have been incorporated. The effective hours worked were simulated each day within the effective days of a season. The effective days were also obtained through the random probability subroutine.

Table 5.4. Simulated effective working hours in wet season, 1980 (hours)

Village	Manual labor	Bullocks	Tractors
Jatiragas	204	149	497
Jatisari	195	162	373
Rawa Gempol	212	166	309
Sukatani	206	148	488
Bojong Tengah	223	208	336
Karang Anyar	250	194	343
Mariuk	246	172	418
Tambak Dahan	236	188	385
Average:	221	173	394
Standard deviation:	21	22	69
Coefficient variation:	9	13	18

Table 5.4 shows that tractor technology made possible to double the effective working hours in a season compared to bullocks technology and one and three fourths of the manual labor.

The hourly manual labor and bullocks input per hectare in the eight villages showed a moderately high variation, with a coefficient of variation of 21 percent and 26 percent respectively (see Table 5.5). The variation of time required for tractors to complete land preparation per hectare in the eight villages was the most stable with a coefficient of variation equal to 13 percent.

The hectarages capacity per season showed moderate variation for all these technologies with coefficients between 22 percent and 25

Table 5.5. Simulated capacity of manual labor, bullocks and tractor technologies for wet season 1980 (two passes of tillage operations).

Village	Hours/hectare			Hectares/season		
	ML	BL	TR	ML	BL	TR
Jatiragas	368	61	13	0.55	2.4	38.3
Jatisari	319	47	13	0.60	3.4	27.6
Rawa Gempol	231	43	14	0.91	3.9	22.1
Sukatani	262	48	15	0.78	3.1	33.2
Bojong Tengah	257	43	17	0.87	4.8	19.5
Karang Anyar	220	51	13	1.13	3.8	29.5
Mariuk	383	62	15	0.64	2.8	27.9
Tambak Dahan	436	61	18	0.70	3.1	21.2
Average:	309	52	15	0.77	3.4	27.4
Standard Deviation:	63	8	2	0.19	0.7	6.4
Coefficient Variation:	21	26	13	25.0	22.0	23.0

percent. In general, seasonal capacity of tractors was almost 36 times greater than manual labor and eight times greater than bullocks technology.

In summary, tractor tillage required 15 man hours per hectare for two passes (or about 105 to 127 horsepower hours per hectare) and the seasonal capacity was 27.4 hectares. While manual labor and bullocks technology requires 309 and 52 hours per hectare respectively and their seasonal capacities were 0.74 and 3.4 hectares respectively. These results indicate that two wheeled tractors produce a large increase in (partial) labor productivity for rice land preparation.

The simulated proportions of rice land prepared by manual labor, bullocks and tractors in each village are presented in Table 5.6.

Table 5.6. Simulated proportion of rice land prepared by manual labor, bullocks and tractors, wet season, 1980.[1]

Village	Total rice land (ha)	Proportional (%) prepared by ML	BL	TR
Jatiragas	456	9	10	81
Jatisari	425	24	14	62
Rawa Gempol	850	6	6	88
Sukatani	683	16	10	74
Bojong Tengah	908	48	22	30
Karang Anyar	865	56	11	33
Mariuk	1111	9	27	64
Tambak Dahan	1138	61	21	18
Average:	804	29	15	56
Standard Deviation:	268	23	7	26
Coefficient Variation (%):	33	79	49	46

[1]Assuming no import and export of manual labor, bullocks and tractors.

These proportions indicate great variation with coefficients of variations of all technologies above 30 percent.

In Jatiragas, Rawa Gempol, Sukatani villages manual labor was already displaced by tractor technology (for detailed simulated results see Appendix 19). The proportion of rice land prepared by manual labor in these three villages was mostly the residual untilled land after bullocks and tractor operations. In Jatisari, Karang Anyar, Mariuk and Tambah Dahan villages part of manual labor was displaced by tractors while in Bojong Tenhah there was a shortage of agricultural power. It was assumed that there was no migration of manual labor into this village. In this simulation 65 percent to 70 percent of all draft animals were assumed to be participating in land preparation.

Further study in this area appears necessary, as one of the national development criteria is related to the increase of employment, while the present simulation indicates labor displacement in some of the villages studied.

The amount of rice land prepared per man day is presented in Table 5.7. The variation of labor productivities of all technology is moderately high with coefficients of variation 27 percent, 23 percent and 29 percent for manual labor, bullocks and tractor power respectively. The average labor capacity with tractor technology of 0.8493 hectare/ man day is 34.6 and 7.9 times greater than manual labor and bullocks respectively.

The simulated labor utilization (man days per hectare) in the wet season of 1980 is presented in Table 5.8. Additional manual labor for tillage operations of the residual land was incorporated into the labor requirements for bullocks and tractors. In summary, based on simulated data for the wet season of 1980, the ratio of labor utilization for the three technologies were manual labor ÷ bullocks ÷ tractor equivalent to 9.6 ÷ 2.6 ÷ 1. This ratio implies that tractorized farms may save 9.6 times man days of manual labor or 2.6 times bullock man days for each tractor man day utilized.

Table 5.7. Simulated amount of rice land prepared per man day (two passes of tillages).

Village	Labor capacity (hectares/man day) ML	BL	TR	BL/ML	Ratio TR/ML	TR/BL
Jatiragas	.0192	.0803	1.1511	4.2	59.9	14.3
Jatisari	.0212	.1174	.8303	5.5	39.2	7.1
Rawa Gempol	.0332	.1330	.7085	4.0	21.3	5.3
Sukatani	.0312	.1057	1.2603	3.4	40.4	11.9
Bojong Tengah	.0301	.1617	.5867	5.4	29.5	3.6
Karang Anyar	.0392	.1272	.8912	3.2	22.7	7.0
Mariuk	.0203	.0929	.7538	4.6	37.2	8.1
Tambak Dahan	.0230	.0994	.6132	4.3	26.6	6.2
Average:	.0272	.1147	.8493	4.3	34.6	7.9
Standard Dev.:	.0073	.0259	.2438	.8	12.6	3.5
Coef. Variation (%):	27	23	29	19	36	44

Simulation outputs for cost of land preparation in the wet season of 1980 are presented in terms of Rupiah per hour and Rupiah per hectare in Table 5.9 and 5.10 respectively.

In this simulated hourly cost of land preparation, additional manual labor in bullocks and tractor operations, idle time except machine idle time and prices of meals, snacks and tobacco have been incorporated in the farmers' costs. Table 5.9 shows that the variation in the average farmer's cost for manual labor, tractor and tractor owner's costs had lower variation as indicated by coefficients of 10

Table 5.8. Simulated total labor utilization for two tillage operations (man day/ha).[1]

Village	Manual labor	Bullocks	Tractors
Jatiragas	52.0	14.5	4.9
Jatisari	47.2	10.4	5.1
Rawa Gempol	30.9	8.6	3.4
Sukatani	32.0	10.8	2.9
Bojong Tengah	33.3	7.1	4.4
Karang Anyar	25.5	8.8	2.8
Mariuk	49.3	12.7	5.1
Tambak Dahan	43.5	11.9	4.3
Average:	39.2	10.6	4.1
Standard Deviation:	9.9	2.4	0.9
Coef. Variation (%)	25	23	23

[1]Manual labor for tillage operation on residual untilled land was included.

percent to 13 percent. Bullocks hourly cost varied somewhat higher with a 17 percent coefficient of variation. Hourly costs and levels of labor utilization will be used to construct isoquant curve (presented in Figure 5.5).

The simulated land preparation costs per hectare for two passes are presented in Table 5.10. The farmers' costs included meals for the operators and costs of additional manual labor for bullocks and tractor operations.

Table 5.9. Simulated hourly total costs of land preparation in the wet season of 1980 (Rupiah/hour).[1]

Village	Farmers' costs for Manual labor	Farmers' costs for Bullocks	Farmers' costs for Tractors	Owners' costs[2]
Jatiragas	106	433	1693	844
Jatisari	113	364	1821	771
Rawa Gempol	95	307	1702	941
Sukatani	96	345	1584	666
Bojong Tengah	91	314	1325	917
Karang Anyar	81	255	1546	965
Mariuk	91	269	1448	782
Tambak Dahan	97	366	1342	1002
Average:	96	332	1558	861
Std. Deviation:	10	58	178	115
Coef. Variation(%):	10	17	11	13

[1]Average of the first and second operations.
[2]Tractor owners' cash return is presented in Table 5.10.

Farmers' costs of land preparation costs per hectare for manual and bullocks varied considerably between villages with coefficients of variation of 26 percent and 27 percent respectively. The cost for tractors paid by farmers was quite stable with a low (4 percent) coefficient of variation. In most villages (except in Jatiragas and Tambah Dahan) the farmers' cost for bullock tillage was lower than for tractor. In Rawa Gempol, Sukatani and Karang Anyar, where manual labor costs were also lower than tractor costs. The lowest tractor owners'

Table 5.10. Simulated costs of land preparation per hectare, two passes for wet season, 1980 (x RP 1000).

Village	Farmers' costs Manual labor	Bullocks	Tractors	Owners' costs[1]
Jatiragas	45.4	39.7	31.0	11.0
Jatisari	42.7	26.1	31.6	10.2
Rawa Gempol	26.1	21.3	29.9	13.1
Sukatani	28.9	25.7	30.1	9.8
Bojong Tengah	28.3	20.1	28.8	15.5
Karang Anyar	21.8	19.9	27.8	12.9
Mariuk	42.0	25.3	31.0	11.7
Tambak Dahan	36.7	34.7	30.6	18.1
Average:	34.0	26.6	30.1	12.8
Std. Deviation:	8.8	7.1	1.3	2.8
Coef. Variation(%)	26	27	4	22

[1]Tractor owners' cash returns were RP 27,143 per hectare for each village except in Bojong Tengah and Karang Anyar which were RP 25,712 and RP 25,000 per hectare respectively.

cost was found in Sukatani, possibly because this village had a longer experience with tractorization. Also operator wages were lower and longer hours were worked per day and per season (see discussion in Chapter 4, and Table 5.4). On the other hand, tractor owners' cost in Tambak Dahan was the highest among the villages. Less operator experience, highest tractor purchase prices and lowest tractor utilization were found in Tambak Dahan. These factors apparently caused the tractor owning cost to be the highest in Tambak Dahan. Table 5.10 further indicates that in the wet season of 1980, tractor owners generally made great profits, their average return being almost two times their costs.

The simulated profitability index of the tractor owners in each village is presented in Table 5.11. This simulated result was obtained with the assumption of a 10.5 percent interest and 18 percent inflation rate, along with tractor life expectancy of 6 years.

Table 5.11. Tractor owners' earnings, costs and profitability index, (earnings/costs), wet season 1980.

Villages	Capital cost per season (Rp 1000)	Income from custom land preparation per season (Rp 1000)	Total cost for land preparation per season (Rp 1000)	Profitability index (earnings/ costs)
Jatiragas	149.9	1,039.6	421.3	2.47
Jatisari	116.4	749.1	281.5	2.66
Rawa Gempol	149.8	599.9	289.5	2.07
Sukatani	125.3	901.1	325.4	2.77
Bojong Tengah	144.1	501.4	302.2	1.66
Karang Anyar	173.6	737.5	380.5	1.94
Mariuk	124.0	757.3	326.4	2.32
Tambak Dahan	188.8	575.4	383.7	1.50

[1]Figures are rounded.

Further study to include dry season financial analysis is necessary in order to obtain an overall review of the profitability.

A simulated result of locally manufactured tractors compared to imported tractor performances are presented in Table 5.12.

Table 5.12. Simulated locally manufactured and imported tractor performances for rice land preparation (two passes, wet season, 1980).

Item		Local tractor (7~8.5 hp)	Imported tractor[1] (7~8.5 hp)
Capacity			
Hours/hectare		16	15
Hectares/season		19.8	27.4
Hectares/man day		.59	.85
Total labor input[2]			
Man day/hectare		6.1	4.1
Operating costs			
Rupiah/hour[3]	(a)	623	847
	(b)	842	876
Rupiah/hectare[3]		11013	12800
Purchase price (RP 1000)		1650	2354
Returns/costs		2.46[5]	2.12[5]
Hours worked			
In a season (180)		324	394
In a day		9.7	11.6

[1]Average for eight villages.

[2]Manual labor for tillage operation on residual untilled land is included.

[3]Total cost (fixed and variable costs); a, b are the first and second tillage operations.

[4]Figures are rounded to the one-tenth.

[5]Earning/cost.

Table 5.12 shows that the hourly field capacity and hectares/man day of locally manufactured tractors was 6.7 percent less than that of imported tractors. As has been discussed previously, this was due to technical problems with the steering mechanism. The capacity of imported tractors in Bojong Tengah and Tambah Dahan, however, was shown to be 6 percent and 12 percent lower than that of locally manufactured tractors. In the near future, the locally produced tractor will have a better acceptance for the following reasons: 1) a built-in steering clutch will improve maneuverability of the new model, 2) the simplicity of design was more appropriate for tractor operators, few of whom have more than an elementary education, 3) plowing was more preferable for the first-over tillage operation than rotary tillage, and 4) ease of repair (power transmitting devices, in particular) and better availability of spare parts. Hours worked per season is an important function of owning cost. Although the seasonal hours worked for the imported tractors were 22 percent higher, the return per hectare to the owner for local tractors was 10 percent less. This was due partly to a lower (30 percent) purchase price.

A simulated situation with regard to the farmers' preference for a combination of land preparation techniques based upon least cost opportunity and maximum waiting time for the availability of traditional agricultural power is summarized in Table 5.13. In Jatisari, for instance, the projected land preparation cost for traditional power was RP 24,800/ha and the maximum number of days waited was four days. In Bojong Tengah, the lowest cost for the first tillage operation was with bullocks at a cost of RP 12,400 per hectare, however, farmers would not

Table 5.13. Simulated necessary waiting days for traditional agricultural power and least cost opportunity (wet season, 1980).

Village	Technology ML	Technology BL	Technology TR	Total wait (days)	Cost RP 1000
Jatiragas					
(a)[1]			(17.3)	0	30.1
(b)			(13.7)		
Jatisari					
(a)		(14.2)(2)[2]		4	24.8
(b)	(10.6)(2)				
Rawa Gempol					
(a)		(8.9)(*)[3]	(16.1)	1	27.1
(b)	(11.0)(1)				
Sukatani					
(a)		(11.8)(*)	(16.3)	1	28.7
(b)	(12.4)(1)				
Bojong Tengah					
(a)		(12.4)(*)	(16.4)	1	24.9
(b)		(8.5)(1)			
Karang Anyar					
(a)		(12.2)(*)	(15.4)	0	27.7
(b)	(7.5)(*)		(12.3)		
Mariuk					
(a)		(17.1)(*)	(17.2)	0	31.0
(b)		(8.2)(*)	(13.8)		
Tambak Dahan					
(a)		(20.4)(*)	(16.8)	0	30.6
(b)	(10.0)(*)		(13.8)		

[1]"a" and "b" indicate the first and second tillage operation respectively.

[2]The figure in the first and second parenthesis are cost (RP 1000) and waiting days respectively.

[3]The "*" indicates the waiting days for the availability of manual labor and bullocks exceeded the maximum waiting days.

wait the necessary seven days for the availability of bullock power. Therefore, the first tillage operation was with tractors. The combination of tractors for the first pass and bullocks for the second pass would result in a cost of RP 24900/hectare with one day of waiting for bullock power for the second tillage operation.

The sensitivity tests were made to identify the degree of this model response to various input variables. The examples of these test results are presented in Table 5.14.

Table 5.14. The sensitivity analysis results.

Item	Sensitivity analysis 1	2	3
Capacity			
hours/hectare	15	15	15
hectare/season	29.5	26.6	26.6
hectares/man day	0.89	0.80	0.80
Total labor input for land preparation (man day)	3.6	4.5	4.3
Farmers' cost			
wet season 1980 (RP 1000/ha)[1]	30.3	30.6	30.6
wet season 1985 (RP 1000/ha)[1]	60.5	60.1	69.2
Owners' cost			
wet season 1980 (RP 1000/ha)[1]	12.1	10.5	13.0
wet season 1985 (RP 1000/ha)[1]	20.5	18.0	23.8

Note: Sensitivity 2 was used as basic run; in sensitivity 1, hours worked per day were altered; alteration of interest and inflation rates were made in sensitivity 3 (see Table 5.3).

[1]Projected cost.

Table 5.14 shows that tractor capacity (hectare/season or hectare/ man day) increased 11 percent when the hours worked per day increased with one unit of standard deviation value. Total labor input for land preparation (man day/hectare) decreases 20 percent. Therefore, this system modeling for tractor operation was not sensitive to hours worked per day, with reference to tractor capacity. However, labor input (man day/hectare) was sensitive to hours worked/day. Farmers' cost (in the wet season of 1980) does not respond much to changes of interest and inflation rates. The projected cost in 1985 indicates sensitive response to changes of interest and inflation rates. Tractor owners' costs in the wet season of 1980 and 1985 increases 20 percent to 29 percent due to changes of interest and inflation rates. This means that the simulated tractor owners' cost model is sensitive to changes of interest and inflation rates.

CHAPTER 6

CONCLUSIONS

From the data presented above, it can be concluded that:

1. Small two wheel tractors (7.0 to 8.5 horsepower) greatly increase labor capacity in rice land preparation in the Northern coastal plains of West Java. The tractor time required to complete two passes of tillage operations per hectare (15 hours) was significantly less than the time required for tillage as performed by either bullocks or manual labor (52 and 309 hours per hectare respectively).

2. The simulated amount of land prepared for each technology per day in the wet season of 1980 was 34.6 and 7.9 times larger for tractor than manual labor and bullocks respectively. The hectarages of land prepared for each technology per day were 0.0272, 0.1147 and 0.8493 hectare for manual labor, bullocks and tractor technology.

3. For both the first or the second pass of tillage operations, tractors travelled two times faster than bullocks, with the average of both speed of 2.35 km/hr for the tractor and 1.17 km/hr for the bullocks.

4. The depth of the first manual labor tillage (6.2 cm) was significantly shallower than plowing with bullocks (10.7 cm) and tractor rototilling (10.3 cm). The difference of tillage depth between bullocks and tractor was not significant.

5. The percentage of residual untilled land left by tractors was 7.3 percent of the total plot area and was significantly higher than 4.3 percent left by bullocks tillage. Within the plot size ranges of

0.09 to 0.21 hectare, the degree of tractor (machine) efficiency and the residual untilled land were weakly influenced by the plot dimension (the regression coefficient of determination was less than 0.1).

6. Number of effective hours worked per day was significantly greater for tractors than for either bullocks or manual labor; the averages being 11.6, 5.8 and 7.5 hours per day respectively. The simulated effective hours worked for the wet season of 1980 were 221 hours for manual labor, 173 for bullocks and 374 hours for tractors. Given these simulated hours worked per season, the capacity per season of manual labor was 0.77 hectares, 3.4 hectare for bullocks and 27.4 hectares for tractors.

7. The total labor utilized in land preparation including additional manual labor for preparing residual land after bullocks and tractor operations was greatly reduced on farms using tractors as compared to farms using manual or bullock power. Tractorized farms utilized a total of 4.1 man days/ha for primary tillage as compared to 10.6 man days/ha on farms using bullocks and 39.2 man days/ha in farms using manual labor.

8. The total labor for land preparation plus related work derived from farm surveys was 25 percent, 30 percent, and 44 percent of the total labor input for rice preharvest activities for tractorized, bullocks and manual labor farms respectively. The total labor input for rice preharvest activities on farms using manual labor for land preparation (1979) was significantly greater than either bullocks or tractorized farms. There appeared to be no significant difference in preharvest labor input between bullock and tractor farms. The

average labor input for rice preharvest activities was 1274 hours for farms using manual labor, 779 hours for farms using bullocks and 741 hours for farms using tractors.

9. The simulated averages of land prepared at the village level (wet season, 1980) by tractors was 56 percent of the total rice land with the ranges of 18 percent in Tambak Dahan to 88 percent in Rawa Gempol village. The average proportion of rice land prepared by bullocks was 15 percent. A shortage of manual labor and bullock power for the wet season of 1980 at the village level was predicted in Bojong Tengah. There was some degree of simulated manual labor displaced by tractors in Jatisari, Karang Anyar, Mariuk and Tambak Dahan. Manual labor for land preparation in Jatiragas, Rawa Gempol and Sukatani villages had already been displaced by small tractors. In these villages manual laborers mostly prepared only the residual untilled land left by tractors and bullocks.

10. Simulated farmer costs of rice land preparation for the wet season of 1980 were generally lower for bullocks than either tractor or manual labor, except in Jatiragas and Tambak Dahan. Manual labor cost was the highest, with a total cost of RP 33,975 per hectare for the tillage operations. The farmers' costs for tractor and bullock land preparation (two passes) were RP 30,100 and RP 26,600 per hectare respectively. The tractor owners' costs for two passes of rototilling was RP 12,800 per hectare. The average simulated tractor owners' returns and costs ratio in the wet season of 1980 was calculated to be 2.12.

11. The capacity of locally manufactured tractors (7.0 to 8.5 hp, IRRI type design) was not significantly different from the imported

tractors. The field capacity was 16 hours per hectare to complete plowing and harrowing operations. The simulated labor utilization on farms using locally made tractors for land preparation was 6.1 man days. The returns and costs ratio was 2.46, which was higher than imported tractor profitability index. The price of locally manufactured tractors was RP 1,650,000 in 1980 (standard for rice field) which was 30 percent lower than the average price of imported tractors.

12. The level of rice production inputs (e.g., fertilizer, seed and chemicals) used were not significantly different between farms using manual labor, bullocks and tractors. Farms using tractors had significantly larger land holdings than those of bullocks and manual labor farms.

13. Farms using tractors and bullocks produced significantly higher rice yields per hectare as compared to farms using manual labor (survey results). The yield level at harvest moisture level in the wet season of 1979 was 4.1, 4.5 and 4.8 ton/hectare for manual, bullocks and tractorized farms respectively. The higher rice yield of 0.3 ton per hectare for tractor as compared to bullock farms was not statistically significant. In monetary terms, this 0.3 ton of rice difference was estimated at RP 21,000 (in 1979).

CHAPTER 7

SUGGESTIONS FOR FURTHER STUDY

This research compared alternatives of rice land preparation technologies during the wet season of 1980. It is suggested that dry season conditions be similarly studied to determine the complete financial analysis for tractor ownership on an annual basis.

The farm survey indicated that there was no significant difference in total labor input for rice preharvest activities on farms using bullocks and tractors. It may be desirable to conduct research in this area by direct measurement at the farm level.

The farm survey further indicated that farms using tractors produced higher rice yields per hectare, as compared to farms using traditional techniques. Further detailed study by direct measurement of this correlation between rice yield and land preparation technique at the farm level is suggested.

APPENDIX

Appendix 1 : Number of samples obtained

Villages	Field measurement						Farm survey		
	First tillage			Second tillage			ML	BL	TR
	ML	BL	TR	ML	BL	TR			
Jatiragas	4	9	9	9	9	9	4	7	9
Jatisari	6	9	9	9	9	9	5	7	9
Rawa Gempol	9	9	9	9	9	9	6	9	9
Sukatani	4	9	9	9	6	9	5	6	9
Bojong Tengah	9	9	9	9	9	9	9	9	9
Karang Anyar	9	9	9	9	9	9	9	9	9
Mariuk	9	9	9	9	9	9	8	9	9
Tambak Dahan	9	9	9	9	9	9	9	9	9
Sub-total	59	72	72	72	69	72	55	65	72
Total	416						192		
Grand total	608								

Appendix 2. Rate of increase of labor wages for land preparation at the village level.

			Village A				Village B			
	General Index		Manual labor		Bullocks		Manual labor		Bullocks	
Year	BPS	Weighted[1]	(Rp/hr)	Index[1]	(Rp/hr)	Index[1]	(Rp/hr)	Index[1]	(Rp/hr)	Index[1]
1971	100	-	-	-	-	-	-	-	-	-
1974	210	100	29.60	100	133.90	100	45.20	100	190.80	100
1975	254	121	33.80	114	151.60	113	45.20	100	190.80	100
1976	292	139	35.00	118	182.00	136	48.30	107	201.50	106
1977	312	149	40.40	136	183.70	137	53.90	119	290.00	152
1978	344	164	43.30	146	196.20	146	66.40	147	322.50	169

Source: Reanalyzed from Bernstein, Table 23, 24 and 25 (1980).

[1]The rate of general index increase = 15%
The rate of hand labor and bullocks wages = 11%, except for bullocks in Village B, which was 19%.

Appendix 3: Ages of operators (years).

No.	Villages	Technology	Mean	Range	S.D.	CV.(%)
1	Jatiragas	Manual labor	37.5	29-45	6.8	18
		Bullocks	36.0	27-50	8.8	24
		Tractors	29	25-35	3.2	11
2	Jatisari	Manual labor	37.9	20-60	10.7	28
		Bullocks	34.4	25-40	5.0	15
		Tractors	30.8	25-40	5.1	16
3	Rawa Gempol	Manual labor	36.0	30-55	7.8	22
		Bullocks	31.4	20-45	9.0	29
		Tractors	30.1	24-42	6.6	22
4	Sukatani	Manual labor	32.2	24-36	4.0	12
		Bullocks	32.4	25-45	6.9	21
		Tractors	28.1	23-35	4.7	17
5	B. Tengah	Manual labor	39.4	25-55	11.2	28
		Bullocks	34.8	25-50	8.4	57
		Tractors	30.3	20-40	7.9	26
6	K. Anyar	Manual labor	34.7	25-50	9.9	29
		Bullocks	35.5	20-45	9.2	26
		Tractors	28.9	25-37	4.3	15
7	Mariuk	Manual labor	45.1	35-65	11.0	24
		Bullocks	42.8	35-55	8.2	19
		Tractors	30.3	25-40	5.1	17
8	T. Dahan	Manual labor	47.6	30-60	11.0	23
		Bullocks	43.3	30-52	7.7	18
		Tractors	26.2	20-30	3.5	13

Note: SD = standard deviation; CV = coefficient of variation

Appendix 4: Operator experience (years).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	16.5	1-30	12.8	78
		Bullocks	15.5	2-30	11.2	72
		Tractors	2.0	1- 4	1.2	60
2	Jatisari	Manual labor	17.3	1-40	12.0	69
		Bullocks	14.2	1-20	7.4	52
		Tractors	1.6	1- 3	0.7	44
3	Rawa Gempol	Manual labor	20.0	10-40	8.8	44
		Bullocks	13.9	5-25	7.3	52
		Tractors	1.2	0.1- 2	0.9	75
4	Sukatani	Manual labor	15.1	6-25	8.0	53
		Bullocks	14.4	3-30	9.9	69
		Tractors	2.4	0.1- 5	1.5	61
5	B. Tengah	Manual labor	23.8	10-40	10.6	45
		Bullocks	14.8	9-30	8.4	57
		Tractors	1.1	0.1-2	0.6	55
6	K. Anyar	Manual labor	17.8	2-30	9.4	53
		Bullocks	19.5	9-30	8.0	41
		Tractors	1.8	1- 4	1.1	61
7	Mariuk	Manual labor	24.3	2-50	13.3	55
		Bullocks	25.6	15-40	9.8	38
		Tractors	1.7	1- 3	0.8	47
8	T. Dahan	Manual labor	27.0	10-40	14.2	53
		Bullocks	24.3	10-35	9.3	38
		Tractors	0.9	0.1- 2	0.6	67

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 5: Effective worked hours per day for the first operation (hours).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	7.8	6.0- 8.5	1.2	15
		Bullocks	5.2	4.3- 7.2	0.9	17
		Tractors	15.4	9.5-24.0	4.9	32
2	Jatisari	Manual labor	6.8	5.0- 9.0	1.5	22
		Bullocks	5.2	4.5- 6.	0.8	15
		Tractors	13.3	7.0-20.0	4.5	34
3	Rawa Gempol	Manual labor	7.7	4.8- 9.5	1.6	21
		Bullocks	6.7	4.0- 9.0	1.6	24
		Tractors	10.0	4.0-12.5	3.6	36
4	Sukatani	Manual labor	6.6	5.0- 8.0	1.1	17
		Bullocks	5.1	3.8- 6.2	0.8	16
		Tractors	9.6	7.0-16.5	3.0	31
5	B. Tengah	Manual labor	7.4	4.7- 9.3	1.8	24
		Bullocks	6.9	5.2- 8.0	1.2	17
		Tractors	9.6	7.0-16.5	3.0	31
6	K. Anyar	Manual labor	8.3	5.0-10.0	1.6	19
		Bullocks	6.1	4.2- 7.5	1.2	3
		Tractors	11.7	8.0-16.0	2.8	10
7	Mariuk	Manual labor	8.0	5.5- 9.8	1.5	19
		Bullocks	5.1	3. - 9.0	2.3	45
		Tractors	12.8	9.5-19.0	3.6	28
8	T. Dahan	Manual labor	7.9	5.5- 9.6	1.4	18
		Bullocks	7.0	4.2-10.0	2.0	29
		Tractors	10.1	7.0-15.5	2.6	26

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 6 : Effective worked hours per day for the second operation (hours).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	6.3	4.2-10.6	2.0	32
		Bullocks	4.7	3.5- 6.6	1.0	21
		Tractors	12.8	11.3-15.0	1.3	10
2	Jatisari	Manual labor	6.8	4.0- 9.0	1.6	23
		Bullocks	5.7	4.5- 7.0	0.7	12
		Tractors	9.3	6.0-11.6	2.2	24
3	Rawa Gempol	Manual labor	7.7	5.0-10.0	1.6	21
		Bullocks	4.9	4.2- 7.9	0.9	18
		Tractors	9.6	6.2-13.2	2.5	26
4	Sukatani	Manual labor	7.7	4.2- 9.5	1.7	22
		Bullocks	n.a.	n.a.	n.a.	n.a.
		Tractors	15.0	8.0-22.5	4.6	31
5	B. Tengah	Manual labor	8.2	7.1- 9.2	0.9	11
		Bullocks	7.1	5.6- 9.2	1.4	20
		Tractors	10.3	8.0-12.5	0.7	7
6	K. Anyar	Manual labor	8.9	8.0-10.0	0.7	8
		Bullocks	6.9	5.5- 9.2	1.6	23
		Tractors	11.4	8. -13.5	2.1	18
7	Mariuk	Manual labor	7.7	6.0- 9.2	1.0	13
		Bullocks	5.6	3.2- 9.5	2.3	41
		Tractors	10.0	8.0-20.0	4.8	48
8	T. Dahan	Manual labor	7.6	5.0- 8.0	1.1	14
		Bullocks	5.2	4.5- 6.0	0.5	10
		Tractors	11.4	10.5-16.5	2.9	25

Note: S.D. = standard deviation; C.V. = coefficient of variation; n.a. = not available.

Appendix 7 : Idle time for the first tillage operation (hours)

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	1.7	1.5-2.0	0.2	14
		Bullocks	0.5	0.3-1.2	0.3	58
		Tractors	1.8	1.0-3.5	0.8	44
2	Jatisari	Manual labor	1.2	0.3-2.5	0.9	75
		Bullocks	0.4	0.3-5.2	0.1	25
		Tractors	1.8	0.6-3.0	0.8	44
3	Rawa Gempol	Manual labor	1.3	1.0-2.0	0.5	38
		Bullocks	1.0	0.5-2.6	0.9	89
		Tractors	1.6	0.0-3.0	0.9	60
4	Sukatani	Manual labor	1.2	0.2-1.6	0.6	50
		Bullocks	0.4	0.2-0.6	0.1	25
		Tractors	1.4	0.6-2.6	0.8	57
5	B. Tengah	Manual labor	1.5	0.3-2.5	0.8	53
		Bullocks	0.9	0.3-1.5	0.4	44
		Tractors	1.1	0.5-2.6	0.7	64
6	K. Anyar	Manual labor	1.5	0.5-2.3	0.6	40
		Bullocks	0.8	0.3-1.6	0.4	51
		Tractors	1.9	0.6-2.6	0.7	37
7	Mariuk	Manual labor	1.5	0.5-2.0	0.6	40
		Bullocks	1.0	0.5-2.2	0.7	72
		Tractors	2.5	1.0-4.0	1.2	49
8	T. Dahan	Manual labor	1.8	0.6-3.0	0.8	44
		Bullocks	1.4	0.2-3.0	1.2	86
		Tractors	1.5	0.5-2.6	0.6	40

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 8 : Idle time for the second tillage operation (hours).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	0.9	0.2-2.5	0.8	89
		Bullocks	0.3	0.2-0.5	0.1	27
		Tractors	2.3	1.2-3.3	0.7	30
2	Jatisari	Manual labor	1.3	0.5-1.8	0.4	31
		Bullocks	0.5	0.3-0.6	0.1	28
		Tractors	0.5	0.3-0.6	0.1	25
3	Rawa Gempol	Manual labor	1.5	0.2-2.0	0.6	40
		Bullocks	0.4	0.2-0.6	0.1	31
		Tractors	1.4	0. -2.5	0.8	59
4	Sukatani	Manual labor	1.3	0.3-0.2	0.5	38
		Bullocks	n.a.	n.a.	n.a.	n.a.
		Tractors	2.2	1.0-3.5	1.0	45
5	B. Tengah	Manual labor	1.7	1.0-2.5	0.5	29
		Bullocks	1.6	0.6-2.5	0.8	48
		Tractors	1.6	0.6-2.6	0.7	43
6	K. Anyar	Manual labor	1.9	1.2-2.2	0.3	15
		Bullocks	1.4	0.7-3.0	0.8	58
		Tractors	2.1	1.6-2.6	0.4	17
7	Mariuk	Manual labor	1.8	1.2-2.5	0.4	22
		Bullocks	1.0	0.2-2.5	0.8	85
		Tractors	2.6	0.6-3.5	0.9	35
8	T. Dahan	Manual labor	0.4	0.2-0.5	0.1	27
		Bullocks	1.7	0.2-2.2	0.6	35
		Tractors	1.9	0.2-3.3	0.9	47

Note: S.D. = standard deviation; C.V. = coefficient of variation; n.a. = not available.

Appendix 9 : Depth of tillage of the first tillage operation (centimeters).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	6.08	5.91- 6.27	0.17	2.90
		Bullocks	12.48	10.85-16.28	1.65	13.21
		Tractors	10.71	9.00-14.14	1.85	17.26
2	Jatisari	Manual labor	6.41	5.72- 7.26	0.65	10.23
		Bullocks	11.30	9.26-18.00	2.64	23.41
		Tractors	9.95	9.53-10.26	0.30	3.06
3	Rawa Gempol	Manual labor	6.41	5.81- 6.83	0.38	5.94
		Bullocks	10.79	9.00-11.91	0.92	8.53
		Tractors	10.25	8.34-11.46	1.16	11.36
4	Sukatani	Manual labor	5.61	5.27- 6.25	0.37	6.66
		Bullocks	11.23	9.56-12.00	0.86	7.66
		Tractors	8.80	5.97-10.91	1.60	18.25
5	B. Tengah	Manual labor	6.10	5.85- 6.31	0.20	3.26
		Bullocks	10.95	8.26-12.37	1.27	11.61
		Tractors	10.50	8.12-11.92	1.20	11.48
6	K. Anyar	Manual labor	6.16	5.48- 6.56	0.37	6.15
		Bullocks	10.13	7.07-11.92	1.53	15.14
		Tractors	11.29	6.57-17.14	3.81	33.73
7	Mariuk	Manual labor	7.45	5.53- 9.40	1.25	16.88
		Bullocks	9.79	7.80-11.26	1.16	11.91
		Tractors	11.23	10.20-12.46	0.94	8.41
8	T. Dahan	Manual labor	5.30	5.35- 5.66	0.35	6.71
		Bullocks	9.08	7.93- 9.90	0.90	9.90
		Tractors	10.06	9.13-11.26	0.89	8.87

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 10 : Traveling speed of the first pass (kilometer/hr)

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Bullocks	0.48	0.34-0.55	0.06	12.43
		Tractors	1.06	1.01-1.09	0.02	2.43
2	Jatisari	Bullocks	0.49	0.35-0.78	0.14	29.33
		Tractors	1.18	1.06-1.31	0.12	10.83
3	Rawa Gempol	Bullocks	0.43	0.36-0.46	0.03	6.83
		Tractors	0.83	0.78-0.88	0.04	5.25
4	Sukatani	Bullocks	0.45	0.33-0.54	0.06	14.22
		Tractors	0.73	0.39-1.39	0.29	39.43
5	B. Tengah	Bullocks	0.47	0.36-0.53	0.06	13.51
		Tractors	0.65	0.34-1.14	0.25	38.92
6	K. Anyar	Bullocks	0.41	0.38-0.45	0.02	6.02
		Tractors	0.83	0.65-1.06	0.11	13.53
7	Mariuk	Bullocks	0.41	0.31-0.52	0.06	16.62
		Tractors	0.81	0.50-1.25	0.34	42.05
8	T. Dahan	Bullocks	0.39	0.32-0.44	0.05	14.14
		Tractors	0.74	0.51-0.96	0.17	22.99

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 11: Traveling speed of the second pass (kilometer/hr)

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Bullocks	0.44	0.32-0.60	0.10	22.79
		Tractors	0.73	0.57-0.86	0.10	14.92
2	Jatisari	Bullocks	0.38	0.25-0.60	0.09	25.31
		Tractors	0.95	0.48-1.22	0.23	24.88
3	Rawa Gempol	Bullocks	0.40	0.36-0.45	0.03	8.39
		Tractors	0.87	0.82-0.99	0.06	6.92
4	Sukatani	Bullocks	0.37	0.28-0.44	0.06	16.95
		Tractors	0.74	0.69-0.81	0.03	4.93
5	B. Tengah	Bullocks	0.38	0.20-0.52	0.10	28.29
		Tractors	0.88	0.71-1.13	0.16	19.01
6	K. Anyar	Bullocks	0.48	0.37-0.64	0.08	18.29
		Tractors	1.09	0.80-1.41	0.22	20.49
7	Mariuk	Bullocks	0.38	0.27-0.48	0.07	19.27
		Tractors	0.77	0.60-0.91	0.11	14.76
8	T. Dahan	Bullocks	0.48	0.36-0.77	0.16	33.94
		Tractors	0.69	0.60-0.79	0.07	10.30

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 12 : Fuel and oil consumption (liter/hr).

No.	Villages	Fuel/Oil	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Fuel 1	1.249	0.824-1.841	0.349	27
		Fuel 2	1.183	1.020-1.428	0.156	13
		Oil	0.047	0.031-0.068	0.009	21
2	Jatisari	Fuel 1	1.486	1.120-1.761	0.272	18
		Fuel 2	1.330	1.082-1.485	0.117	9
		Oil	0.036	0.025-0.050	0.009	25
3	Rawa Gempol	Fuel 1	1.192	0.964-1.471	0.189	16
		Fuel 2	1.122	1.003-1.237	0.075	7
		Oil	0.036	0.025-0.060	0.116	32
4	Sukatani	Fuel 1	1.276	0.658-1.829	0.376	29
		Fuel 2	1.174	0.870-1.409	0.183	16
		Oil	0.049	0.024-0.081	0.024	48
5	B. Tengah	Fuel 1	1.030	0.668-1.432	0.225	22
		Fuel 2	1.067	0.705-1.500	0.374	35
		Oil	0.030	0.027-0.032	0.004	14
6	K. Anyar	Fuel 1	1.308	0.806-1.636	0.311	24
		Fuel 2	1.109	0.631-1.562	0.312	28
		Oil	0.040	0.026-0.350	0.010	25
7	Mariuk	Fuel 1	1.199	0.909-1.500	0.237	20
		Fuel 2	1.285	0.919-1.875	0.277	22
		Oil	0.050	0.020-0.088	0.026	52
8	T. Dahan	Fuel 1	0.968	0.698-1.286	0.199	21
		Fuel 2	1.171	0.932-1.338	0.155	13
		Oil	0.050	0.030-0.060	0.020	40

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 13 : Percentage residual untilled land after the first bullock and tractor operation (%).*

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Bullocks	7.61	2.78-17.87	4.77	62.65
		Tractors	7.61	2.63-13.19	3.76	49.41
2	Jatisari	Bullocks	4.09	2.03- 6.48	1.59	38.99
		Tractors	8.38	5.64-12.00	2.44	29.17
3	Rawa Gempol	Bullocks	3.43	0.98- 6.94	2.02	58.98
		Tractors	6.43	4.67- 7.90	1.12	17.48
4	Sukatani	Bullocks	4.59	0.95- 7.40	1.88	40.94
		Tractors	6.89	3.50-11.98	2.64	38.30
5	B. Tengah	Bullocks	2.86	1.54- 5.20	1.20	42.07
		Tractors	8.10	5.36-13.63	2.51	30.95
6	K. Anyar	Bullocks	3.81	1.86- 6.22	1.70	44.54
		Tractors	6.78	4.39-15.49	3.44	50.75
7	Mariuk	Bullocks	3.96	0.64-12.11	3.42	86.57
		Tractors	7.78	3.21-12.44	2.69	34.59
8	T. Dahan	Bullocks	4.38	1.42-14.68	4.28	97.69
		Tractors	6.11	3.06-10.50	2.72	44.56

Note: S.D. = standard deviation; C.V. = coefficient of variation;
* = percentage of the rice field (jolat) area.

Appendix 14 : Estimated prices of hoe, bullocks and tractor (Rupiah, 1000, 1980).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Hoe	1.592	1.000-2.500	343	21
		Bullocks	300	200- 400	56	19
		Tractors	2,380	1,950-2,700	230	10
2	Jatisari	Hoe	1.481	1.000-2.000	330	22
		Bullocks	270	210- 330	35	13
		Tractors	1,850	1,600-2,450	790	43
3	Rawa Gempol	Hoe	1.469	1.000-2.000	386	26
		Bullocks	300	270- 350	19	6
		Tractors	2,380	1,900-2,700	290	12
4	Sukatani	Hoe	1.386	500-1.600	321	23
		Bullocks	280	100- 400	130	46
		Tractors	2,000	1,300-2,500	450	22
5	B. Tengah	Hoe	1.744	1.500-2.500	382	22
		Bullocks	270	200- 320	36	13
		Tractors	2,290	1,300-2,800	600	26
6	K. Anyar	Hoe	1.744	1.300-2.000	271	15
		Bullocks	300	250- 320	24	8
		Tractors	2,760	1,950-3,700	560	20
7	Mariuk	Hoe	1.400	1.000-2.000	283	20
		Bullocks	260	100- 350	65	25
		Tractors	1,970	1,050-2,890	690	35
8	T. Dahan	Hoe	1.473	1.000-2.500	461	31
		Bullocks	310	300- 320	16	5
		Tractors	3,200	2,180-3,600	543	17

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 15 : Operator wages (Rufriah/day for manual labor and bullocks; percentage (%) for tractor operators).

No.	Villages	Technology	Mean	Range	S.D.	C.V.(%)
1	Jatiragas	Manual labor	538.5	500- 600	50.5	9
		Bullocks	1,656.2	1,000-2,000	301.0	18
		Tractors	15.3	15- 16	0.3	2
2	Jatisari	Manual labor	558.3	500- 600	51.5	9
		Bullocks	1,533.3	1,500-1,600	48.5	3
		Tractors	15.0	15-15	0.0	0
3	Rawa Gempol	Manual labor	513.3	500- 600	35.2	7
		Bullocks	1,366.7	500-2,500	431.6	32
		Tractors	15.0	15-15	0.0	0
4	Sukatani	Manual labor	542.9	500- 600	51.3	9
		Bullocks	1,280.0	1,000-1,500	258.8	20
		Tractors	11.6	10- 15	2.4	21
5	B. Tengah	Manual labor	508.8	500- 650	36.4	7
		Bullocks	1,933.3	1,000-2,600	627.8	32
		Tractors	16.3	10- 25	4.0	24
6	K. Anyar	Manual labor	494.1	400- 500	24.2	5
		Bullocks	1,256.5	500-1,900	490.3	39
		Tractors	14.3	12- 15	1.3	9
7	Mariuk	Manual labor	505.9	500- 600	24.2	5
		Bullocks	1,142.8	500-2,000	602.2	53
		Tractors	16.7	10- 20	3.7	22
8	T. Dahan	Manual labor	500.0	500- 500	0.0	0
		Bullocks	2,142.8	1,500-2,000	363.1	17
		Tractors	10.9	10- 12	1.0	9

Note: S.D. = standard deviation; C.V. = coefficient of variation.

Appendix 16. Simulated farmers' costs of land preparation per hectare for the first and second operations, during the wet season of 1980 (Rp 1000).

Village	Manual labor		Bullocks		Tractors	
	A[1]	B[1]	A[1]	B[1]	A[1]	B[1]
Jatiragas	27.7	17.7	19.2	20.4	17.9	13.8
Jatisari	32.1	10.6	14.2	11.9	17.9	13.8
Rawa Gempol	15.0	11.0	8.9	12.3	16.1	13.8
Sukatani	16.5	12.4	11.8	13.9	16.3	13.8
Bojong Tengah	15.5	12.8	12.4	8.5	16.4	12.3
Karang Anyar	14.3	7.5	12.2	7.7	15.4	12.3
Mariuk	26.1	16.0	17.1	8.2	17.2	13.8
Tambak Dahan	26.7	10.0	20.4	14.3	16.8	13.8
Average:	21.7	12.2	14.5	12.1	16.7	13.4
Std. Deviation:	7.1	3.3	4.0	4.2	0.9	0.7
Coef. Variation (%):	33	27	26	35	5	5

[1]"A" and "B" are the first and second operations respectively.

[2]Figures are rounded.

Appendix 17. Simulated costs of owning tractor per hour (wet season, 1980).[1]

Village	Fixed cost (RP 1000/season)	First operation (Rp/hr) Variable	Total	Second operation (Rp/hr) Variable	Total
Jatiragas	149.9	613	870	560	818
Jatisari	116.4	508	712	626	830
Sukatani	125.3	479	673	465	660
Bojong Tengah	144.1	493	879	570	956
Karang Anyar	173.6	591	967	588	964
Mariuk	124.0	519	775	533	789
Tambak Dahan	188.8	525	984	561	1021
Average:	146.5	535	847	564	876
Std. Deviation:	25.1	47	115	49	121
Coef. Variation(%):	17	9	14	9	14

[1]Rates of interest 10.5%/year; inflation 18%/year; expected tractor service life = 6 years.

Appendix 18 : Labor input for rice preharvest activities (man hours per hectare).

	Hand labor			Bullock			Tractor		
JATIRAGAS	Mean	SD	CV(%)	Mean	SD	CV(%)	Mean	SD	CV(%)
Nursery	68.57	32.32	47.1	34.90	7.95	22.8	31.22	12.68	41.0
Land preparation	251.43	32.32	12.9	15.75	14.30	90.8	13.12	7.10	54.1
Hoeing	182.86	64.65	35.4	102.09	77.79	76.2	45.20	33.78	74.7
Additional field work	177.14	8.08	4.6	96.39	24.08	25.0	75.61	39.64	52.4
Transplanting[1]	102.86	16.16	15.7	71.53	20.29	28.4	82.07	37.61	45.8
Basic fertilizing	17.14	8.08	47.1	7.03	2.64	37.6	6.73	2.47	36.7
Top dressing	34.29	16.16	47.1	14.87	5.21	35.0	13.85	5.28	38.1
Weeding[1]	180.0	12.12	6.7	149.37	33.65	22.5	116.89	72.03	61.6
Spraying	47.14	16.16	28.3	16.76	6.92	41.3	18.81	6.89	36.6
Irrigation care	--	--	--	1.91	0.77	40.3	1.62	0.86	53.0
Miscellaneous	34.29	16.16	47.1	22.15	0.34	1.5	27.83	9.37	33.7
Total:	1105.72			532.75			432.95		
JATISARI									
Nursery	33.52	1.32	3.9	27.55	10.65	38.7	27.21	14.41	52.9
Land preparation	400.0	84.32	21.1	41.33	20.17	48.8	39.0	40.44	103.7
Hoeing	122.67	94.25	76.8	148.57	81.35	54.8	178.02	85.21	47.9
Additional field work	85.33	24.65	28.9	94.05	37.10	39.4	46.69	18.00	38.6
Transplanting[1]	100.36	37.43	37.3	96.73	64.39	66.6	79.05	20.46	25.9
Basic fertilizing	13.43	5.47	40.7	18.98	13.27	69.9	12.07	6.28	52.0
Top dressing	29.14	13.44	46.1	20.24	14.07	69.5	12.07	6.28	52.0
Weeding[1]	236.43	114.18	48.3	179.85	84.81	47.2	186.26	66.15	35.5
Spraying	71.62	41.23	57.57	20.00	8.67	43.4	36.92	34.49	93.4
Irrigation care	16.00	--	--	14.29	--	--	66.29	28.46	3.7
Miscellaneous	41.14	7.92	19.3	34.29	22.86	66.7	38.86	16.48	42.4
Total:	1149.64			695.88			722.44		

[1]Done by women, converted to man hours by multiplying by 0.75.

Appendix 18 (cont'd)

RAWA GEMPOL	Hand labor			Bullock			Tractor		
	Mean	SD	CV(%)	Mean	SD	CV(%)	Mean	SD	CV(%)
Nursery	20.68	19.80	95.7	44.76	20.67	46.2	43.65	6.01	13.8
Land preparation	508.86	158.83	31.2	34.29	0	0	15.36	4.02	26.2
Hoeing	107.50	38.89	36.2	77.14	14.85	19.3	--	--	--
Additional field work	132.61	48.20	36.3	64.76	23.79	36.7	133.23	40.28	30.2
Transplanting[1]	138.16	96.40	69.8	107.14	10.71	10.0	134.34	25.96	19.3
Basic fertilizing	15.18	20.47	134.8	7.62	0.82	10.8	13.75	3.60	26.2
Top dressing	12.22	9.12	74.6	28.57	5.71	20.0	13.75	5.38	39.2
Weeding[1]	202.68	13.75	6.8	205.36	30.93	15.1	178.75	33.17	18.6
Spraying	45.36	33.61	74.1	62.86	9.90	15.7	29.27	14.54	49.7
Irrigation care	57.14	--	--	--	--	--	35.02	32.78	93.6
Miscellaneous	32.38	24.57	75.9	45.71	0	0	28.00	8.22	29.4
Total:	1272.77			678.21			625.12		
SUKATANI									
Nursery	40.00	24.24	60.6	51.62	9.94	19.2	48.11	18.47	38.4
Land preparation	400.00	242.44	60.6	85.00	18.10	21.3	22.11	4.21	19.0
Hoeing	150.00	111.12	74.1	240.00	--	--	48.00	--	--
Additional field work	80.00	32.32	40.4	123.81	34.44	27.8	132.44	40.42	30.5
Transplanting[1]	99.11	26.52	26.8	104.46	11.36	10.9	119.58	70.14	58.7
Basic fertilizing	11.43	1.05	9.2	24.43	9.65	39.5	27.78	11.85	42.7
Top dressing	22.86	16.16	70.7	19.50	6.36	32.6	28.44	12.72	44.7
Weeding[1]	294.64	75.75	25.7	208.21	54.17	26.0	267.75	88.26	33.0
Spraying	57.14	48.49	84.9	35.43	12.04	34.0	47.11	20.95	44.5
Irrigation care	45.71	--	--	38.10	3.30	8.6	35.56	28.03	78.8
Miscellaneous	40.00	8.08	20.2	31.62	8.58	27.1	32.00	10.58	33.1
Total:	1240.89			962.18			808.88		

[1]Done by women, converted to man hours by multiplying by 0.75.

Appendix18 (cont'd)

BOJONG TENGAH	Hand labor			Bullock			Tractor		
	Mean	SD	CV(%)	Mean	SD	CV(%)	Mean	SD	CV(%)
Nursery	34.92	12.00	34.4	66.16	28.83	43.6	46.13	14.68	31.8
Land preparation	351.49	140.91	40.1	90.85	42.41	46.7	23.80	2.86	12.0
Hoeing	196.24	79.81	40.7	151.84	64.55	42.5	149.84	60.86	40.6
Additional field work	90.29	50.26	55.7	130.29	46.84	36.0	83.81	69.83	83.3
Transplanting[1]	136.83	31.36	22.9	121.13	11.03	9.1	132.26	12.64	9.6
Basic fertilizing	20.00	13.93	69.7	31.39	26.03	82.9	18.25	12.85	70.4
Top dressing	51.05	19.37	37.9	54.73	23.21	42.4	40.79	19.58	48.0
Weeding[1]	252.38	99.05	39.2	253.57	56.69	22.3	286.64	93.59	32.7
Spraying	74.54	53.14	71.3	83.81	42.38	50.6	68.18	35.78	52.5
Irrigation care	67.71	77.41	114.3	56.19	41.90	74.6	34.29	--	--
Miscellaneous	66.79	48.77	73.0	70.53	38.48	54.6	62.00	16.46	26.5
Total:	1342.24			1110.49			945.99		
KARANG ANYAR									
Nursery	45.71	39.59	86.6	44.45	19.11	43.0	36.51	17.83	48.8
Land preparation	232.38	62.94	27.1	48.66	22.61	46.5	14.21	4.14	29.1
Hoeing	213.33	92.38	43.3	138.96	116.18	83.6	40.00	--	--
Additional field work	121.90	123.27	101.1	85.31	15.16	17.8	111.75	44.55	39.9
Transplanting[1]	95.24	21.63	22.7	99.37	23.65	23.8	97.86	44.41	45.4
Basic fertilizing	46.67	28.62	61.3	13.54	5.60	41.4	20.00	14.20	71.0
Top dressing	34.29	11.43	33.3	38.54	38.66	100.3	25.71	9.48	36.9
Weeding[1]	210.71	48.31	22.9	170.77	65.64	38.4	278.93	44.09	15.8
Spraying	85.71	45.36	52.9	102.64	84.10	81.9	107.94	50.83	47.1
Irrigation care	--	--	--	--	--	--	80.00	--	--
Miscellaneous	60.00	44.45	74.1	39.27	10.33	26.3	45.36	15.00	33.1
Total:	1145.94			781.51			858.27		

[1] Done by women, converted to man hours by multiplying by 0.75.

Appendix 18 (cont'd)

MARIUK	Hand labor			Bullock			Tractor		
	Mean	SD	CV(%)	Mean	SD	CV(%)	Mean	SD	CV(%)
Nursery	32.14	10.27	32.0	52.38	29.35	56.0	57.51	15.18	26.4
Land preparation	462.86	62.25	13.4	117.04	52.56	44.9	28.02	5.93	21.2
Hoeing	162.86	49.71	30.5	134.20	55.45	41.3	40.00	--	--
Additional field work	67.14	31.08	46.3	133.89	32.69	24.4	145.87	50.68	34.7
Transplanting[1]	129.91	17.70	13.6	130.18	32.41	24.9	99.46	24.91	25.0
Basic fertilizing	10.95	3.60	32.9	10.73	3.35	31.2	15.32	5.84	38.1
Top dressing	23.57	6.75	28.6	19.49	8.30	42.6	17.98	8.86	49.3
Weeding[1]	243.75	93.86	38.5	158.81	38.99	24.6	172.25	59.76	34.7
Spraying	74.29	44.26	59.6	60.92	37.72	61.9	72.10	30.99	43.0
Irrigation care	91.43	--	--	64.75	72.54	112.0	54.33	42.31	77.9
Miscellaneous	42.86	5.71	13.3	38.57	8.94	23.2	41.81	30.17	72.2
Total:	1341.76			920.96			744.65		
TAMBAK DAHAN									
Nursery	31.79	20.21	63.6	31.31	14.97	47.8	27.88	13.70	49.1
Land preparation	473.41	143.0	30.2	61.68	31.48	51.0	36.40	18.84	51.8
Hoeing	68.14	37.78	56.9	197.75	122.29	61.8	121.59	108.44	89.2
Additional field work	87.65	56.10	64.0	53.34	40.58	76.1	148.98	84.15	56.5
Transplanting[1]	161.39	41.70	25.8	146.77	71.24	48.5	129.16	35.36	27.4
Basic fertilizing	20.48	15.56	76.0	17.11	5.48	32.0	17.14	13.32	77.7
Top dressing	20.48	15.56	76.0	17.11	5.48	32.0	19.30	12.73	66.0
Weeding[1]	213.10	111.21	52.2	139.82	70.19	50.2	175.39	131.53	75.0
Spraying	28.59	15.78	55.2	28.13	17.80	63.3	74.03	51.62	69.7
Irrigation care	18.00	--	--	16.00	--	--	31.00	32.53	104.9
Miscellaneous	52.00	23.52	45.2	38.43	17.90	46.6	50.23	55.43	110.4
Total:	1175.03			747.45			831.1		

[1]Done by women, converted to man hours by multiplying by 0.75.

Appendix 19. Manual labor balance in village level.

Item	JR[8]	JS[8]	RG[8]	ST[8]	BT[8]	KA[8]	MR[8]	TD[8]
Proportion of rice land:								
Total rice land (ha)	456.00	425.00	850.00	683.00	908.00	865.00	1111.40	1138.00
Prepared by bullocks (ha)[1]	46.87	61.67	53.47	65.80	198.20	93.37	298.64	237.98
Prepared by tractors (ha)[1]	368.10	262.69	745.29	508.88	274.22	284.39	707.97	203.64
Residual untilled land (ha)[2]	41.02	24.53	51.23	108.30	27.88	22.83	104.77	22.86
Prepared by manual labor[3] (ha)	0.00	76.09	0.00	0.00	407.69	464.38	0.00	673.50
Demand for manual labor (persons)								
Miscellaneous needs[4]	245	211	441	470	479	465	537	535
Tractor and bullock operator	62	44	110	168	83	55	234	102
Residual untilled land	77	38	53	159	33	21	167	31
Main tillage	displaced	119[6]	displaced	displaced	477	424	displaced	918
Total demanded	384	412	604	797	1072	965	938	1586
Supply of manual labor[5]	965	1214	1712	1165	916	1034	1264	1805
Supply-demand	581	802	1108	368	- 156[7]	69	326	219

[1]Calculated based upon = seasonal capacity x number of available (productive) agricultural power.
[2]Estimated based upon percentage of untilled land after bullock and tractor operations.
[3]Obtained by substracting land prepared by bullock and tractor and residual land from the total rice land.
[4]Assumed average 15 man days per hectare, including for upland (PPL, Field Extension workers and key farmers in each village).
[5]Computed from Table 4.1.
[6]Partly displaced.
[7]Need more agricultural power.
[8]JR = Jatiragas; JS = Jatisari; RG = Rawa Gempol; ST = Sukatani; BJ = Bojong Tengah; KA = Karang Anyar; MR = Mariuk; TD = Tambak Dahan.

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