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# Indonesian Farming Systems Research and Development

## The Food Crop Subsystem

Agency for Agricultural Research and Development

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ACKNOWLEDGMENT

The research data contained in this report comes from reports and papers prepared by scientists working within the Indonesian Cropping Systems Working Group. Only a small part of the available data from those studies is included. The research strategy and data presented are intended to be descriptive rather than comprehensive. Hopefully enough detail is included to give a clear picture of cropping systems research, its role in the development of farming systems, and its interrelationship with other research that is discipline and commodity-oriented. Since data from the many routine component technology studies are not unique to cropping systems research, none are included in this report, even though vitally important to the overall research effort.

The authors wish to express their appreciation to the many scientists, technicians, and field workers who collectively carried out this research effort and who have made a major contribution to Indonesian agricultural development. Support from the International Rice Research Institute and collaborating national programs through the Asian Cropping Systems Network is gratefully acknowledged.

# FOREWORD

Cropping systems research and development in Indonesia has been a good example of agricultural scientists anticipating and carrying out research in response to feedback from farmers and the extension services in specific target areas. Consequently, the research has not only directly helped farmers produce more and have more income but has provided the research base for support of production and transmigration programs. The results and experiences from these research activities have been widely used.

There have been many reports, papers and workshops resulting from this research. The authors do not present new data but simply put together in one manuscript some of the procedures, results and impacts of the work as it developed from multiple cropping, to cropping systems and finally to holistic farming systems research. Consequently, the farming systems research that is presently being carried out by the Agency for Agricultural Research and Development (AARD) is back stopped by a core of scientists that has training and experience in systems research. We are confident that this research will be relevant and will build upon the past experiences.

AARD sincerely appreciates the financial and technical support received from the International Development Research Centre (IDRC) of Canada and the United States Agency for International Development (USAID) for carrying out the research and training activities.

Gunawan Satari
Director General
Agency for Agricultural
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# INDONESIAN FARMING SYSTEMS RESEARCH AND DEVELOPMENT: THE FOOD CROP SUBSYSTEM

Farming Systems Working Group[1]
Agency for Agricultural Research and Development

## INTRODUCTION

The problems that farmers face are always interrelated. Attempts to solve a specific problem may create new problems. This interrelationship poses a dilemma for agricultural researchers, who, by training and temperament, like to simplify. Agricultural research in developed countries is usually directed toward disciplines or kind of crop or animal. Such specialization permits in-depth study of the components of a farming system. A common research technique is to study one aspect of a system while holding other factors constant. This technique is a powerful tool, but, when carried to an extreme, it becomes counter-productive and produces a kind of research irrelevance. Fortunately, extension workers and farmers are able to incorporate certain useful aspects of the research into the existing situation. However, even in developed countries there is a trend at present for scientists to devote more time and effort to systems research that addresses the immediate problems farmers face. This is similar to the approach that was used in the early days of agricultural research and is appropriate in many situations in developing countries today.

Unfortunately, the interdisciplinary, integrated, and holistic approach to farm research sounds complicated. It does not fit the scientific method that is commonly taught in colleges and universities. It requires strong administrative commitment to provide for staffing and funding needs. Furthermore, there are problems in mobilizing and maintaining the interest of scientists because of the difficulty of establishing scientific identity in an interdisciplinary research program. But for those who empathize with farmers and their conditions this kind of research is highly

[1]Prepared by the Cropping Systems Agronomists for the Farming Systems Working Group, Agency for Agricultural Research and Development, September 1981 and revised for this book.

rewarding. The reward comes from the realization that one is identifying problems and directly meeting the needs of people. There is an additional reward in working with colleagues from other disciplines, and there is fascination in understanding how farmers cope with problems and situations that scientists tend to shy away from.

In addition to relevant problem-focused research, agricultural scientists should provide the technology and ideas for future agricultural development activities. It would be expedient for these scientists to do the research before they are requested to provide answers. The stimulus for agricultural development should come from researchers rather than the stimulus for research coming from development. In this way agricultural scientists can support national goals, bring credit to themselves, and gain support for their research organizations.

A comprehensive national farming systems program by definition should address the many situations that exist horizontally across the country and vertically within any system. This is not easy to do at any one time. Some rationale must be adopted to established priorities, scope, and depth of research.

In response to the need to develop crop technology to better meet the needs of Indonesia's small farmers, cropping systems research in farmers' fields was initiated in 1972 by the Central Research Institute for Agriculture (CRIA), subsequently renamed the Central Research Institute for Food Crops (CRIFC). Initially, research was focused at two sites -- the lowland irrigated area of Indramayu, West Java and the upland transmigration[1] area of Bandarjaya, Central Lampung, Sumatra. Working at these sites, the CRIFC staff gained field experience in how to conduct effective cropping systems research. At the same time, the demand for such applied research increased as the Government's transmigration program was expanded. CRIFC and the seven research institutes located throughout the archipelago responded to the need to increase the number of sites and environments studied. While CRIFC pioneered cropping systems research in Indonesia, other research institutes within the Agency for Agricultural Research and Development (AARD) have been

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1 Government program for movement of people from highly populated areas of Java to less populated areas in the outer islands.

conducting systems research on estate crops, fisheries, forestry, livestock, and related areas throughout the country. Today, systems research is in progress in irrigated lowland, rainfed, high elevation/mountainous, tidal swamp, and upland areas. Over 20 sites have been established during the past decade.

In recent years, agricultural scientists have gradually recognized the need to conduct interdisciplinary research that addresses the needs of small, mixed farms with a wide number of interrelated farming operations. Often, draft power is needed to enable small farmers to cultivate their land; crop residues are used to feed livestock (especially sheep and goats); and livestock wastes are used to stimulate fishpond production. Each enterprise uses labor and cash inputs, so it is impossible to focus on one enterprise without taking into consideration competing demands for farmer owned/supplied resources. While individual institutes had always conducted commodity-based research, with the establishment of the AARD the potential for integrated systems research activities across institutes was increased. Requests were made to AARD to conduct farming systems research in newly opened transmigration areas and upper river watersheds where the stability of the farming systems was being threatened by soil erosion. AARD has accepted these challenges and has committed itself to the farming systems approach to improving rural welfare. An AARD working group was established in order to coordinate the diverse but complementary research activities of all the agencies within the research network in order to maximize the total impact.

If we look at some of the achievements that have been made and at some of the specific situations that now exist in Indonesian agriculture, the prospects for the success of the farming systems approach appear significant.

## Achievements

- Indonesian cropping systems scientists have developed a strong and comprehensive research and development program over the last 10 years which has evolved into a farming systems research program.

- In collaboration with colleagues in the Asian Cropping Systems Network, a methodology for effective interdisciplinary cropping systems research has been developed. Indonesia has been a leader in this development and has demonstrated the effectiveness of the methodology for intensifying cropping systems on the irrigated and rainfed lowland rice lands of Java and on the fragile and infertile upland soils of Sumatra, Kalimantan, and Sulawesi.

- Except for the original research sites in Indramayu, West Java and Bandarjaya, Central Lampung, most site selection for research has been in response to requests from various Indonesian development projects.

- A team of interdisciplinary scientists has been initiated and trained through formal training courses within and outside Indonesia and through experience in the field. These activities have provided a core of personnel who are now ready and able to conduct comprehensive and phased research that can effectively identify and remove constraints that farmers face to increased crop production and economic well being.

- Farming systems research in transmigration areas and upper watershed projects has begun. A precedent for successful interdisciplinary research among all research centers in the AARD has been established.

## The Present Situation

Although the emphasis is still on crops, farming systems research in Indonesia considers all farm-related activities from land preparation, which includes animals and family labor, to marketing, which includes transportation and infrastructure development. Following this strategy, initial research concentrates on food crops production for the family's subsistence. Concurrently, constraints to increased production or land use are identified. For example, in upland areas family labor with hand tools can cultivate only about 0.6 ha of land per year. There is a shortage of power to make use of the remaining land resources. Animal power may be the solution; so, the farmer will need animal-drawn farm machinery and forage for feed. With animals, the farmer may be able to cultivate more land because of the

additional power and utilize even more for forage crops. Use of animal manure and excess forage for green manure will improve soil fertility. Additional land may be used profitably for production of perennial crops for spices, food, fiber, and fuel. Furthermore, structures developed for water control and soil conservation can be used to impound water for family use, for fishponds, and for animals. Thus, cropping systems research systematically evolves into farming systems research but on a limited, manageable scale.

Much of the farming systems research that has been conducted in Indonesia may be described as food crops systems research. The research is carried out by a coordinated group of scientists from various disciplines. It is interdisciplinary and integrated with other Government agencies and activities (extension, local government, irrigation, and national production programs). It is focused upon specific target areas and is limited in scope to make more efficient use of research staff and funds. Indonesia has developed methodology and staff sufficiently strong to continue this research. But renewed efforts in the form of longer-term research projects are needed to stabilize the gains that have been made. Although production of food crops sufficient for subsistence has been and will continue to be a first step in the development of farming systems for small Indonesian farm operations, greater effort will be made to study and improve all production aspects of the farm operation.

## RESEARCH APPROACH

Experienced scientists in agricultural research systematically make use of existing information for planning and designing their research. In many instances this is an intuitive process and is not apparent. This process is important within any research discipline but is especially important in cropping/farming systems research where even experienced scientists may not have the intuition and background to understand and anticipate problems and solutions. A more systematic approach is needed not only for young and inexperienced scientists but also for senior researchers and administrators.

## Inventory of Resources

In addition to the traditional commodity and discipline-oriented research activities, there needs to be developed a systematic way of arriving at priorities for adaptive agricultural research for all disciplines within an agricultural research organization. The subsequent research should precede development projects and even provide the initiative for such projects. The first priority is an inventory of natural resources and a description of the present agricultural situation. The final stage in this process is usually the development of "land use capability maps". Such maps are being developed for Indonesia and are very useful; but for researchers the logical sequence of information that is needed for development of such a map may be more valuable than the final product. A series of maps presented in a sequence from the edaphological classification of land, through the physical determinants, and finally to the individual food crops and farming systems would be more useful. It helps the scientists see the current situation and what research might have more relevance in all disciplines.

## Edaphological Classification of Land

An edaphological classification distinguishes land areas that differ in the chemical and physical characteristics of the soil and water environment without reference to climate and other overlapping factors such as slope or land form. As a first approximation, based on experience and data available, the following classifications may be used for Indonesia. In each case the amount of land area for each classification should be included, if possible, on an island by island basis.

A. Upland areas (not mountainous)
B. Lowland rice areas (padi sawah)
   1. Irrigated
      a. Fully (> 10 months)
      b. Partially (7-9 months)
      c. Partially (5-7 months)
   2. Rainfed
C. Swamp areas (lebak)
D. Tidal areas (pasang surut)
E. Mangrove areas

## Environmental Determinants

The effects of environmental factors on land use capability vary depending upon the edaphological character of the land. The following environmental factors may be looked upon as modifiers when used in combination with the edaphological map.

**Soil.** On a national scale only the major soil groups can be effectively shown. Soils delineated should be those whose characteristics necessitate different land management practices. For example, differences in inherent nutrient status would not be a reason for delineating between two soils unless one soil required unusual amounts of fertilizer for corrective treatment.

**Rainfall.** On a national scale, classification based on numbers of wet and dry months is sufficient. At the working level (kabupaten), bar graphs which show monthly rainfall distribution are more useful.

**Elevation.** A biological classification in which altitudes of 500, 1000, and 1500 m are delineated would be sufficient for a national map. The first two correspond to the elevation above which cold tolerant rice cultivars are needed (500 m) and the altitude above which wheat grows well (1000 m). At altitudes higher than 1500 m or so, the use of the land for food crops is limited.

**Slope.** The average slope above which agricultural activity is limited is difficult to define. A slope of 15% has been considered the cut-off point for food crops. But obviously, many times land with more than 15% slope has been used for crop production without any extreme problems with erosion. On Java and Bali, where terracing is widely practiced for padi sawah, much steeper slopes are modified for use, and the slope factor becomes almost irrelevant. This is an example of farmers modifying or removing physical constraints to crop production. Nevertheless, slope is an important land characteristic and must be given high priority in determining land use especially for upland agriculture.

## Present Land Use Map

In development of land use or research objectives within an area, the most significant data available are the present land

use and information obtained from farmers. What exists cannot be disregarded. On a national scale the following land use classifications may be useful:

A. Upland food crops
B. Lowland rice (including gogorancah -- dry seeded rice that is later flooded -- and swamp and pasang surut rice)
C. Mixed alang-alang (Imperata cylindrica) and brush land
D. Forest (primary and secondary)
E. Perennial estate crops
F. Pasture

Land use information can be valuable in two ways. First, it is useful to relate land use for distinctly different vegetation or crops which have different ecological needs to a physical setting that can be characterized. Further breakdown by crop or species of plants provides the "standards" for evaluating land capability. It gives some basis for modification of present land use or extrapolation of a particular kind of land use into new areas having similar agro-climatic conditions. Second, production figures for different food crop commodities from different areas of the country provide a basis for comparison. If production in areas with similar agro-climatic conditions differs greatly, we are provided with an ideal problem for relevant applied and basic research projects. We have a rational basis for developing research priorities.

## Use of Resource Maps

It is important that cropping/farming systems scientists have an idea of the kinds of resource materials that are likely to be available. In many instance these are not conveniently catalogued and available in one place. Demand for and use of these materials, however, generally improves their availability.

### Survey Maps

The combination of all the factors that affect crop production into one land use capability map is difficult, although the Center for Soils Research has made these kinds of maps,

which are useful for many purposes. For an overview the inventory maps described at the beginning of this chapter (scale of 1 : 2,500,000) are adequate. It would be useful to have more detailed reconnaissance maps of each major island group at a scale of 1 : 250,000.

## Working Maps

Working maps at a scale of 1 : 50,000 are needed for provinces or groups of provinces that may be treated as units. This would translate to 1 cm of map for each 0.5 km of land, which would provide sufficient detail for most agricultural purposes. Unfortunately, data in this detail are not available for much of Indonesia, although enough data are available to provide thorough agro-climatic decriptions of parts of many of the major agricultural areas. Furthermore, many surveys funded by the Ministries of Transmigration and the Public Works are detailed descriptions of forested and grass covered lands not yet investigated by agricultural researchers. These reports have been prepared by some of the best consulting firms available anywhere, and the data in them, along with the research and experience of the AARD staff, are valuable resources. In combination with the survey maps, enough information is available to provide the bases for interpretation and horizontal transfer of technology needed for establishing national research priorities.

The usefulness of the large scale survey maps and working maps may be enhanced by considering only the relevant combinations. For example, considering the categories in the edaphological classification of land and the modifier maps, the following combinations would be useful:

**Upland areas.** If we can identify certain upland crops, perennial crops, or farming systems used in one location we might expect to find (or plan to grow) the crop or system in another location with similar agro-climatic conditions. The upland areas farming systems are the most complex, and the following maps would be needed:

A. Soils map
B. Rainfall map
C. Elevation map
D. Slope map

**Lowland rice areas.** The combinations of variables are fewer and the effects of soil and rainfall are minimized by the system, particularly in irrigated areas. These areas are well known to AARD scientists, and extrapolations of recommendations for cultivars, cropping patterns, and farming systems are relatively easy. Maps needed are:

A. For irrigated areas
   1. Soils map
   2. Rainfall map (not so important)
   3. Elevation map

B. For rainfed areas
   1. Soils map
   2. Rainfall map
   3. Elevation map

**Lebak and pasang surut areas.** For lebak and pasang surut areas more detail is needed than we have indicated in the survey maps for Indonesia. In many instances the delineation of factors such as depth and nature of peat and acid sulphate are not clear. Transfer of technology from one area to another is risky until we have more detailed information. However, our work has been made easier by farmers who have pioneered the development of some of these areas. We should work with the pioneers first and then push into the unsettled areas as we gain more information and experience. Data required are:

A. For lebak areas
   1. Nature of peat (peat domes)
   2. Depth of water
   3. Acid sulfate condition

B. For pasang surut areas
   1. Acid sulfate condition
   2. Depth of water
   3. Direct or indirect tides

## Selection of Target Area

Farming systems research is a coordinated and integrated effort to develop technology that will enable farmers to increase production. The technology must be acceptable to the farmers

who will use it. In some cases it may be desirable to identify and remove constraints to the farmers through government programs. Increased production may result from better management of present farming systems, introduction of an extra crop(s) or form(s) of husbandry per year (intensification), or expansion of agricultural activities into newly opened or underused land areas (extensification).

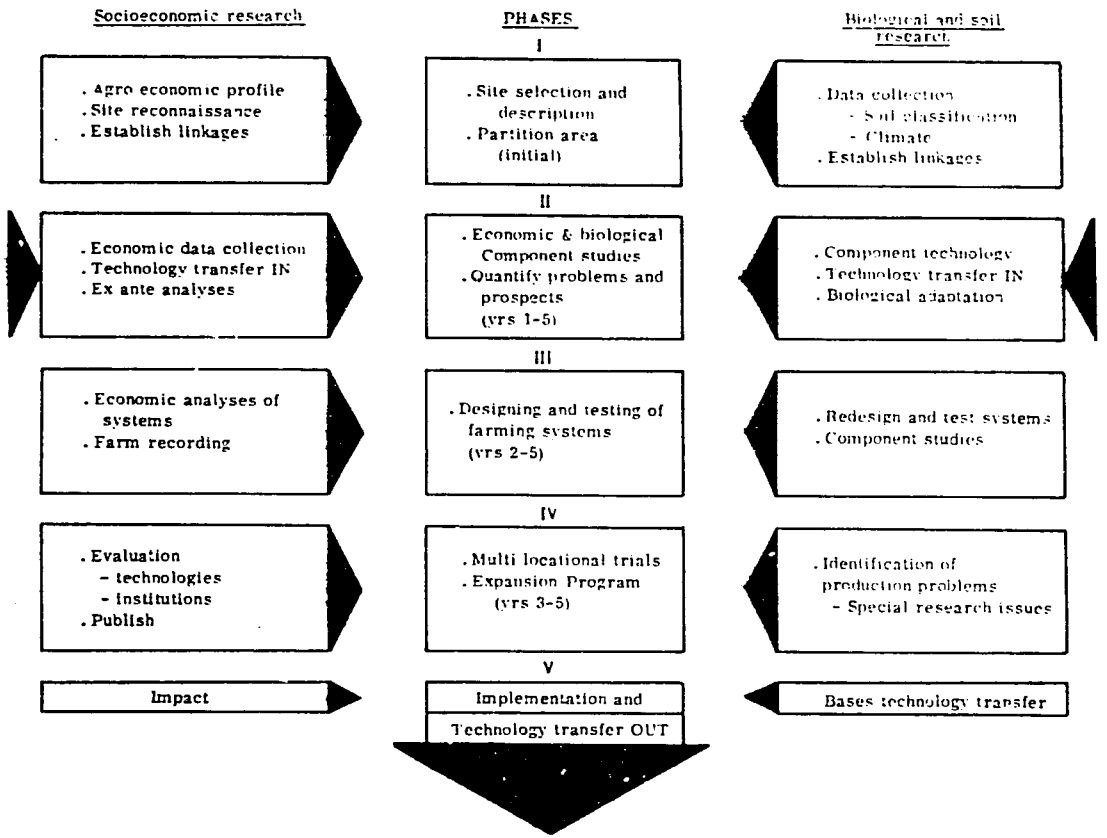
The research is carried out by a coordinated group of scientists from various disciplines. It is focused upon specific target areas to make more efficient use of research staff and funds. The selection of target areas for farming systems research is very crucial. The Indonesian program emphasizes the following criteria for selection of target areas:

- Critical areas in terms of food shortage and government designation
- Large areas having similar soils and climate
- Feasibility of intensifying cropping patterns and farming systems based on prior evidence
- Availability of markets and infrastructure

A diagram for the farming systems research in Indonesia (Fig. 1) shows five distinct phases, their associated research activities, and the approximate time frame that follows after selection of the target areas.

## Edaphic Target Areas

Target areas for farming systems research may fall within one agro-climatic region or a distinct edaphological land area. For farming systems in which crop production is dominant, we attempt to delineate distinct land areas that differ based on the chemical and physical characteristics of the soil and water environment. For example, land for lowland rice is different from land for upland rice even though the soil, climate, and other overlapping factors such as slope or land form may be the same. This approach is very useful for developing cropping systems technology across political boundaries. This is the basis for specifying the characteristics of national production programs such as BIMAS for upland crops, irrigated lowland rice, and rainfed lowland rice. Consequently, for food crops systems research, the identification and delineation of the following edaphological conditions is useful. (Figure 2 shows how these delineated areas relate to each other in a natural setting).




1. Parallel biological and socioeconomic research activities required for the five distinct research and implementation phases of a Farming Systems Research program little inflow of technology.

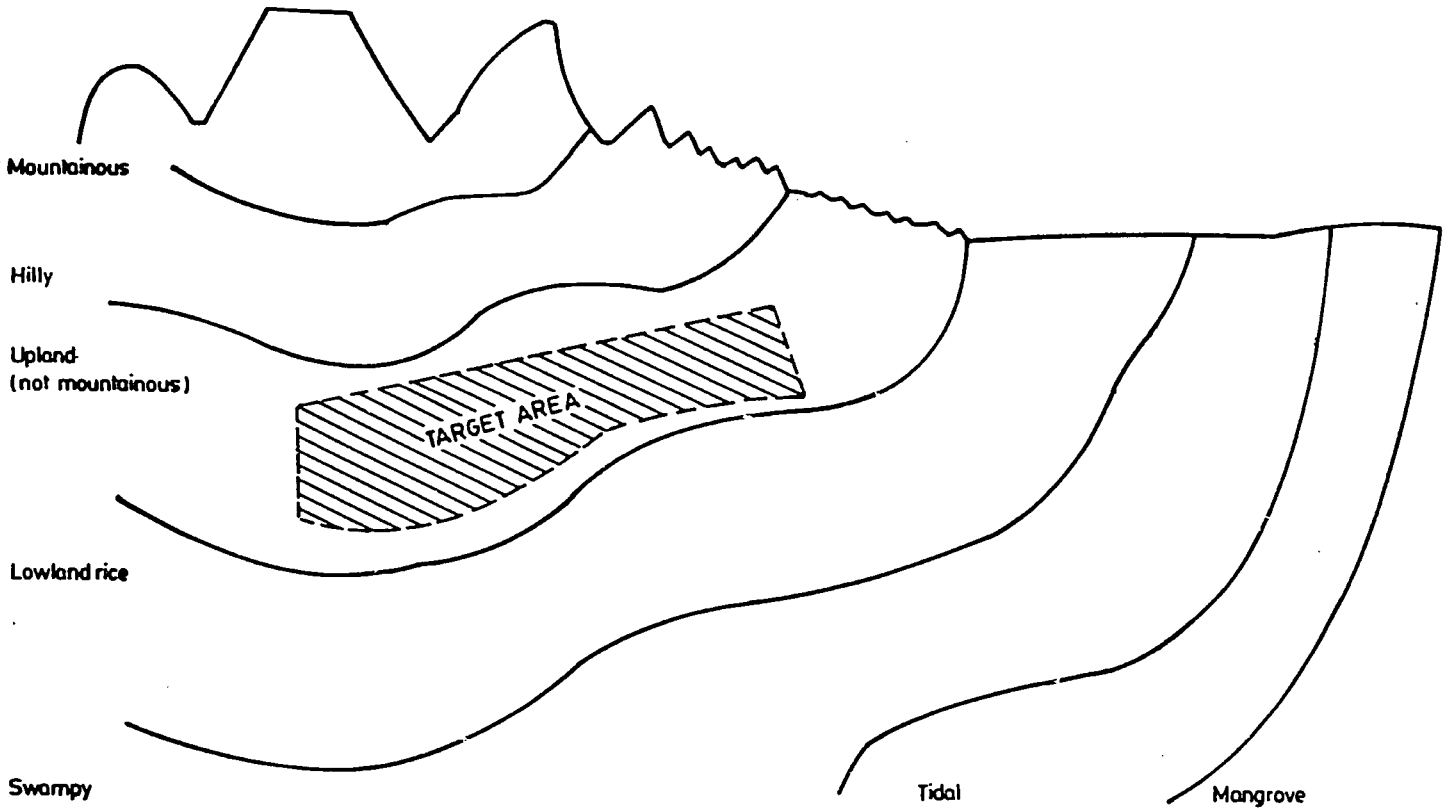



**Figure 2.** Identification of a target area within a specific edaphological zone simplifies farming systems research and development.

A. Upland (not mountainous)
B. Lowland rice
   1. Irrigated
   2. Partially irrigated
   3. Rainfed
C. Swampy (lebak)
D. Tidal (pasang surut)
E. Mangrove (no crops)

**Developmental Target Areas**

In many instances the target areas will be in less developed regions and will consist of many different ecological conditions. This is true for many new transmigration, watershed, and rural development projects delineated by policy decisions. Rather than addressing a specific or limited number of edaphological conditions, the target area may represent a geographical region and may cut across many isograms. Land use and farming systems must be developed for each. Usually, elevation and interrelating climate and soil are dominating factors that must be considered. Because we are dealing with farming systems, as a first priority, land not suitable or not designated for settlement and use by small farmers should be delineated. The delineation of conditions might be as follows:

A. Forests and wildlife preserves
B. Forest concessions
C. Range lands for animal production
D. Perennial crops estates
E. Farming systems
   1. Mixed farming
   2. Food crops systems

Figure 3 shows some of the different land uses and how they relate to each other. Usually the administration of a development project for such an area would be at a level that would permit coordination of efforts. But at the operational level, the ministry or agency reponsible for each kind of land use would carry out its own activity.

For example, forest and wildlife preserves might be the responsibility of the Ministry of Natural Resources. Land for production and harvest of forest products might be under the Ministry of Forestry. Range lands for animal production are

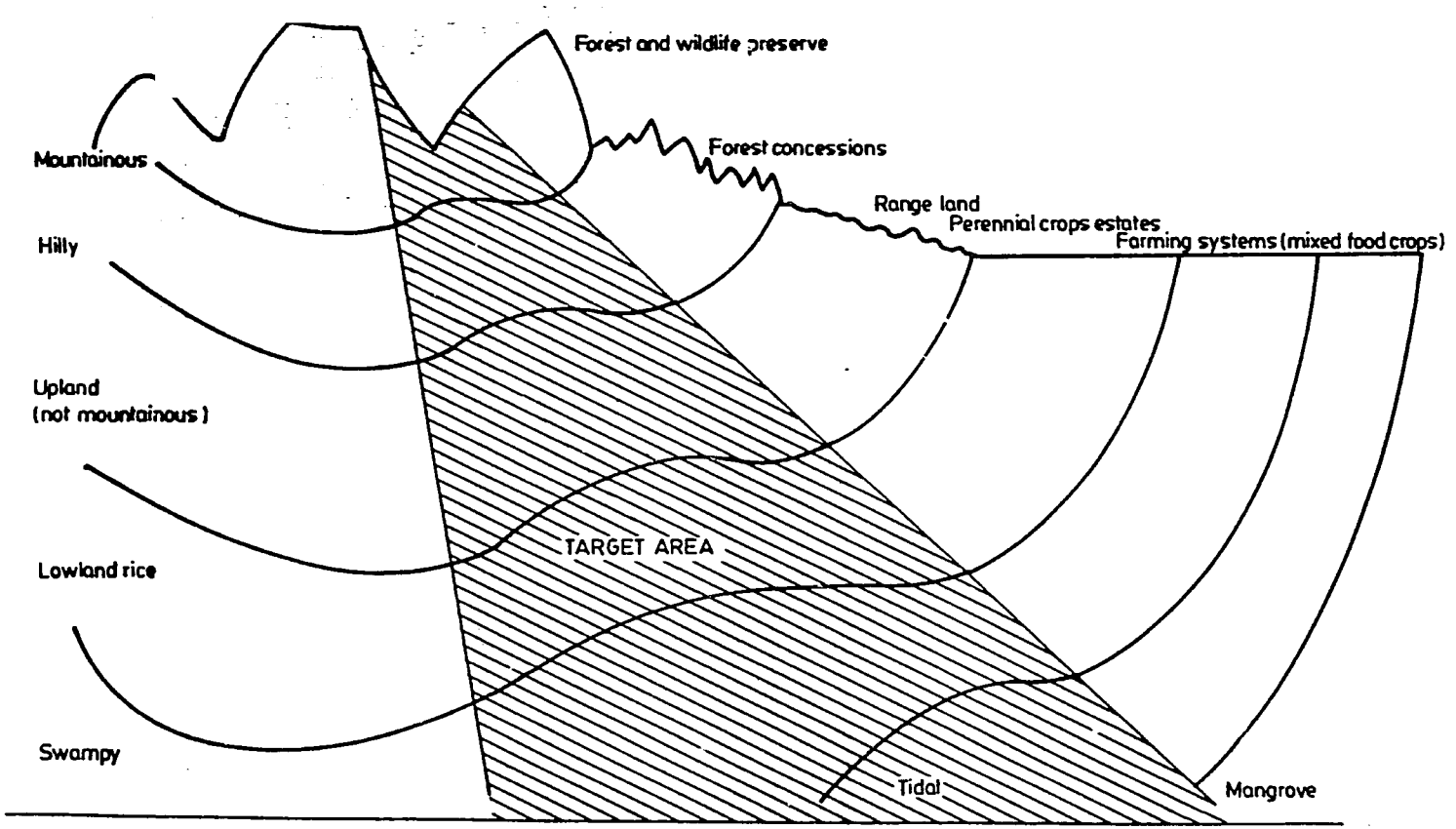


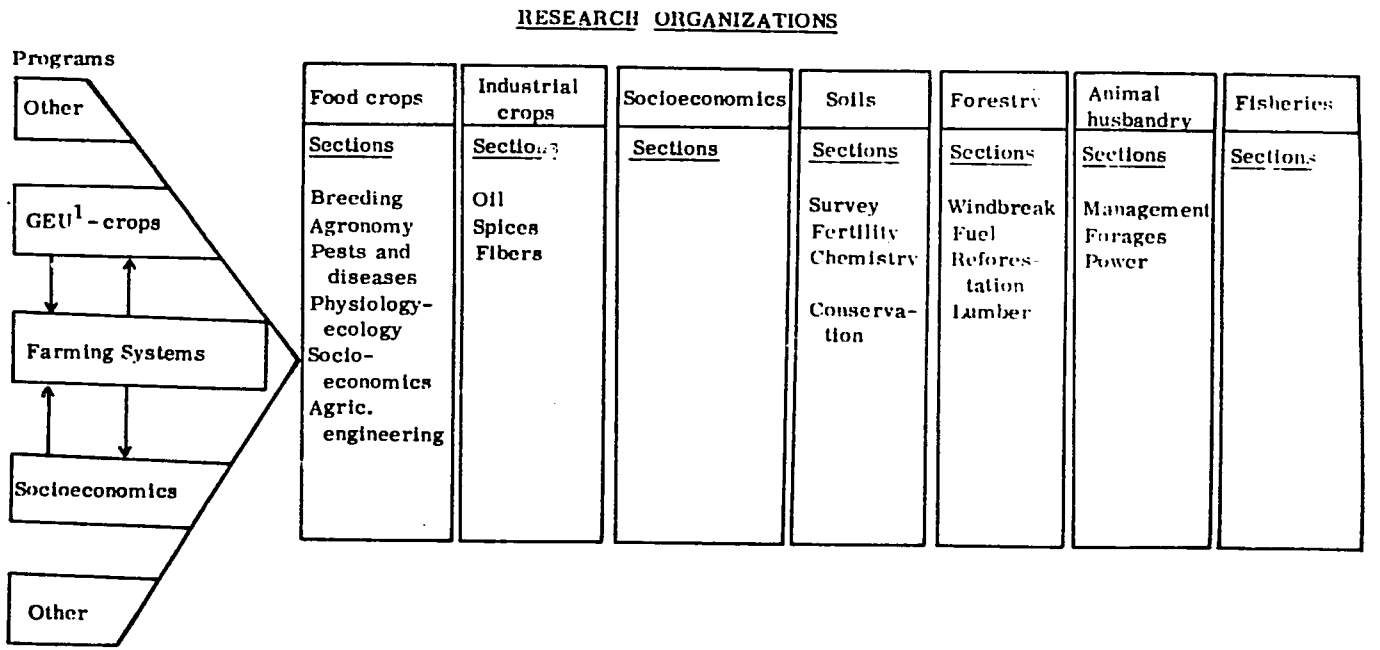

Figure 3. Identification of a "developmental target area" and examples of land use that may exist due to edaphic conditions and soil, slope, and elevation.

usually government enterprises or if privately owned, are closely associated with the Directorate General of Animal Husbandry. Each of these kinds of land use activity requires few people. Usually enough land exists for workers who are associated with the management of such activities to grow some food for their own use. Furthermore, they have employment and some expectation of help in times of emergency.

To a certain extent these conditions apply for estate crop enterprises also, but more labor is usually required for estate crops and, consequently, more people are involved. The management and ownership may be centralized and the laborers dependent upon daily or contract wages. When either production or prices are low the laborers may not have enough money to buy food. Furthermore, if food is scarce, even if the workers have money, food may not be available for them to buy. Two approaches have been suggested and in some instances have been tried to solve these problems. The easiest solution is to provide land, either solely for food crops production or in intercrop combination with the estate crop. The other approach has been to develop nucleus estates in which farmers own the land -- some for their homesites and food production and some cooperatively in a contiguous unit for production of an estate crop such as rubber, oil palm, or perhaps rice. Consequently, a situation for mixed farming research exists. Other areas with land suitable for cultivation will be used solely by small farmers for their farm enterprises. These are the areas where farming systems research is most needed and will be covered in greater detail in this book.

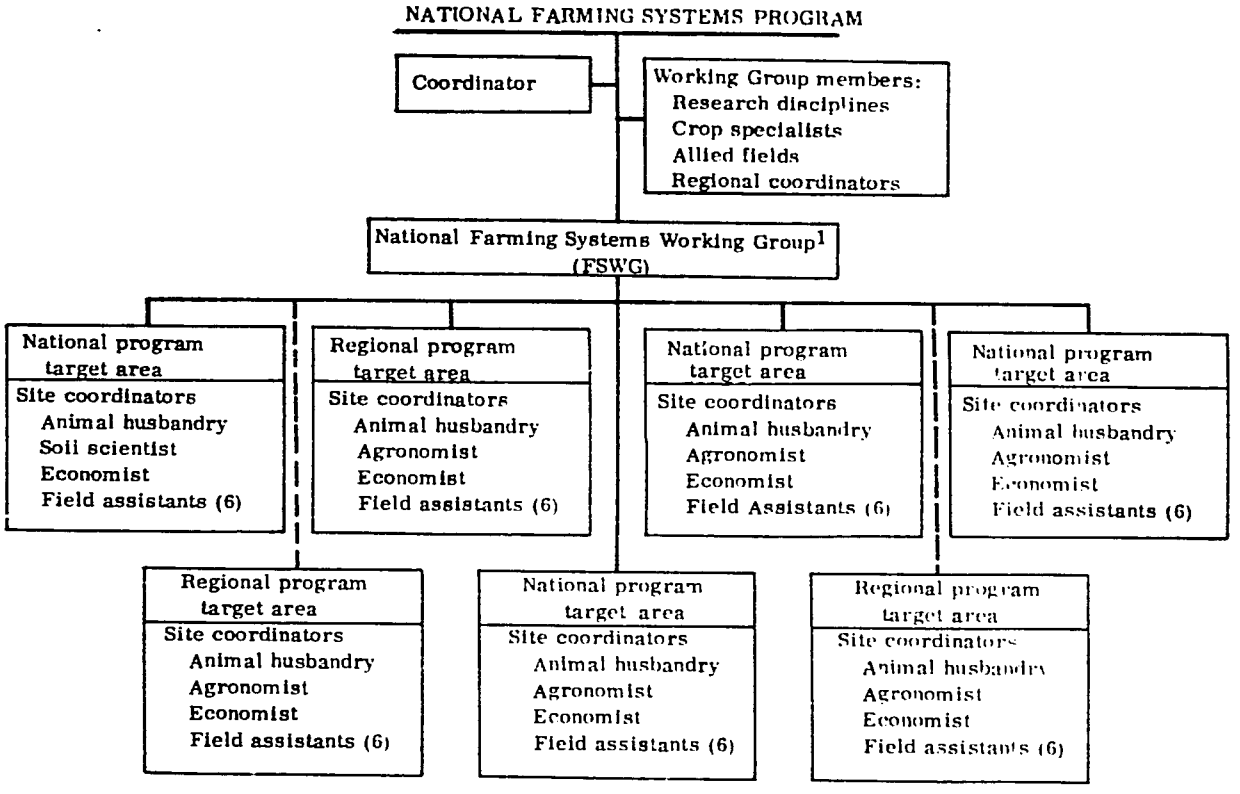
## Site Selection and Description

These activities are carried out as soon as possible after a target area for farming systems research has been selected (Fig. 1). The survey and data collection teams consist of interdisciplinary groups of scientists and extension workers who will be involved in later stages of the program. Figure 4 illustrates how a farming systems program interacts with other systems programs and commodity -- and discipline-oriented activities. Staff and expertise would come from the various research organizations to form a Farming Systems Working Group (FSWG) of scientists (Fig. 5).




[1]GEU, Genetic Evaluation and Utilization, refers to systematic cultivar improvement studies for food crops such as rice, corn, legumes, etc.

Figure 4. Research in a farming systems program (FSP) interacts with other systems, programs, and traditional commodity and discipline-oriented research activities.




[1]Regional programs would be the administrative responsibility of the regional research institute, but hopefully in collaboration with the national program. There would likely be more than one site within a target area, and different technical expertise may be needed for different areas.

Figure 5. Possible organizational chart and staffing requirements for a farming systems program.

## Site Selection

At this point the FSWG will have formulated general objectives for the research and will have designated a coordinator. All problems and conditions existing in the target area cannot be tackled at once. A preliminary survey of the land and water resources and collection of secondary data from government offices and group interviews usually provide enough data to permit the development of an agro-economic profile of the area for use in site selection.

## Site Description

Generally, data collection from government offices and inspection of the prospective area are sufficient for site selection. A better data source is needed for (1) designing and conducting in-depth research and (2) transfer of technology to other areas having similar conditions. Table 1 gives an outline for site description that has been useful for most conditions.

**Agro-economic reconnaissance surveys.** The data collected should comprehensively describe the site, including the institutional, social, economic, and relevant aspects of the physical environments. There should be sufficient scope to permit identification of some of the constraints to higher production that might preclude alternative farming systems strategies that may be considered for the target area. The data collection must be completed in a minimum of time (2-3 days per site) and the report written in a concise manner within 2 weeks after returning from the field. Many times, unfortunately, too many irrelevant data are collected, and months pass before the final report is finished. By this time, the most appropriate planting dates, for example, may have passed, and cooperating scientists have become discouraged. The Appendix gives a detailed outline for carrying out this kind of survey.

Finally, the report should follow a general framework. This permits rapid data collection and reporting from new sites and allows cross-site comparisons for transfer of technology.

**Physical description.** Much of the information needed for this activity can be obtained from secondary sources. Some information may not appear necessary for the research phase of the farming systems project, but it may be very important for

Table 1. Outline for site Description

| Descriptive elements | Data use | Source |
|---|---|---|
| I. Integrated environments factors | | |
| Edaphological classification | General land use and quality | Land use maps and soil classification |
| Cropping patterns and farming systems | Crops and cropping potential | Group interviews and soil classification |
| Farm economy | Manageability of land and options | Group interviews |
| II. Socio-economic determinants | | |
| Markets | Vigor of local economy | Random interviews and local government Sources of farm and market prices |
| Infrastructure | Potential and time for development | Census data and local government |
| Farmer responsiveness | Willingness to assume risk and change | Random interviews on land tenture, personal property, education, and mobility. |
| Labor pool | Distribution and availability | Random interviews and census data |
| Ecological determinants | | |
| Soil-water environment | Crop production and soil amendments | Soil classification |
| Climate (rainfall distribution and amount, temperature and solar radiation, cloud cover and wind) | Crops, cropping patterns, and farming systems | Weather data and soil classification |
| Water control (irrigation, flooding, soil water) | Crops and cropping intensity | Irrigation and soil classification |

the transfer of research technology to other places. Soil classification, along with the commonly used chemical analyses for soil fertility, should adequately describe the soil properties associated with plant growth and crop production. The special value of classification by soil taxonomy and related methods will be described later. Monthly rainfall data collected over many years are available for many locations. Usually there is a need to collect new data for specific sites. The long-term data should be used not only for the average rainfall distribution but should also be analyzed for possible changes in the patterns and probabilities for starting and ending of the rainy season. We must know the length of time of water availability from irrigation and when it starts and ends. Solar radiation and temperature data should be collected if not readily available from sources nearby. Finally, location and elevation should be recorded.

## Economic and Biological Component Studies

These activities should be started as soon as possible after selection of the target area and research sites and then continued as long as needed. In newly developed land areas, this phase may precede the farming systems design and testing, while in older developed areas the two phases may proceed simultaneously. Usually the research sites within a target area are under one coordinator, and the research team at each site consists of a team leader (an agronomist), an assistant team leader, and six field assistants. The assistant team leader should be selected on the basis of need for particular expertise in the particular site. If this is not possible, back-up expertise can be made available from headquarters. The field assistants should be evenly divided according to biological and economic research activities. Initial research usually centers on food crop production and self-sufficiency; later research explores options the farmer may employ to increase stability and economic returns.

The economic information needed may be collected from routine government sources but should be determined mostly from continuous recording of farmers' activities. Most of the agronomic studies can be conducted in small plots (3 x 5 $m^2$) by the team leader and his assistants in farmers' fields.

## Economic Data Collection and Farm Recording

Monitoring of the farmer cooperators and surrounding farm families must be started as early as possible. The data collection must be specific and the analysis quick, and the information should be used in designing and testing of farm operations.

**Income.** The amount and distribution of a farmer's income determines his attitude toward the acceptance of new technology. Farming systems may be designed which require different levels of economic input. The farmers may first accept new technology with low inputs and then, with time and success, be willing to accept technology with higher inputs.

**Labor.** The amount and distribution of labor required for different systems must be determined. Surveys of labor supply and demand in the surrounding areas will be needed.

**Market prices.** The selling and buying prices at the farmers' market level are needed on a weekly basis.

## Problem-focused Surveys

Broad-based surveys tend to be inefficient and difficult to conduct and analyze, particularly in situations where the staff has had little experience in dealing with them. Rather than try to collect all the data thought needed in one large survey, it is better to focus on specific issues as they arise.

## Component Technology Studies

These studies may involve all disciplines in the biological sciences. Mostly these would consist of studies of components of the system made at the time of the year and in the sequence they would it into the cropping patterns or farming systems to be tested.

**Cultivar trials.** Many times adapted plant materials are not available for new target areas. The cropping systems program should not become a breeding program, but some testing of new and introduced plant materials is appropriate.

**Fertilizer responses.** Response curves for the macronutrient elements are needed to determine agronomic and economic thresholds. Depending upon conditions, these trials may be conducted with and without addition of lime and trace elements. They should be carried out as uniformly as possible so that soil and climatic factors across the country (or region) may be better understood in relation to crop production. Care should be taken to locate the trials on soils representative of the area so the results can have wide application.

**Crop combinations.** Different mixed crop and intercrop combinations may be evaluated just as for cultivar trials. These field studies usually show the need for more detailed research concerning light, competition for nutrients, spacing, and economics. The latter studies can usually be conducted more efficiently in the experiment stations. This is a useful way to involve more disciplines and more research colleagues in basic research studies that can directly contribute to development.

**Mixed farming.** Evaluation of farm forestry, animal husbandry, and fishery options for inclusion into farming systems should be undertaken.

**Other biological sciences.** Guidelines for pest and disease management must be developed. Field studies can usually be carried out by superimposing treatments over cropping patterns being tested without undue interference.

## Designing and Testing of Farming Systems

Generally, in this approach simply looking at the existing farming systems is the first step in the research phase. Together with preliminary survey data, enough information will be available to begin the design process. The first priority is for food self-sufficiency. Once this requirement is assured by production or other means, the research may be broadened to study other components of the farming systems. All systems to be tested should be subjected to an ex-ante analysis for capital and labor required and production and income expected over time.

## Partition of the Target Area

There are some natural and man-made economic and environmental factors that have a dominating influence on the appropriateness of cropping patterns and farming systems within a site, and the main idea is to partition the area into management units that reflect these conditions. Sometimes for practical reasons land areas with different soils and climates may be managed alike. On the other hand, land areas with similar soils and climates may require different farming systems because of eocnomic and marketing reasons. The examples that follow from the Indonesian program illustrate the procedures for partitioning of a site within an edaphological classification.

**All sites.** Market accessibility must be considered as a dominating factor influencing cropping pattern design and proportions of individual crops in both the patterns and ultimately, the farming systems. For example, in remote areas far from roads and markets, food crops are grown mostly for subsistence. This is especially true for crops such as cassava which are difficult to store and transport. On the other and, if the fields are near starch factories and good roads, cassava would likely be the most profitable crop. The proportion of cassava for cropping patterns in remote areas would likely be much less than that for cropping patterns near markets, even within a cropping systems target area. If food crops are not extensively grown in remote areas, strategies which include perennial crops, animal husbandry, fisheries, and forestry must be included along with food crops for subsistence in mixed farming systems. The examples which follow emphasize strategies for development of stable cropping systems. As the systems are developed, constraints to production and options for alternatives -- including other kinds of crops and animal -- are examined.

**Upland sites.** A generalized systematic approach for partitioning of a site within an upland target area would be useful, since so far we have relied mostly upon the judgment and experience of our staff. The following example illustrates how expertise has developed to deal with a major upland area in Indonesia. Although specific objectives may differ, this same general approach may be used for mixed farming systems research.

The target area selected was transmigration settlements on upland red-yellow podzolic soils of southern Sumatra. An old transmigration scheme in Central Lampung, Sumatra was picked

as the site for cropping systems studies. A government transmigration program had been carried out in this location about 20 years earlier, and the area had been given a high priority for further development. The Orthoxic Tropudult soil found in the site is similar to the soils of about 46 million ha or slightly more than one-fourth of the total land area of Indonesia. Furthermore the rainfall, which exceeds 200 mm for 6 months and falls below 100 mm for only 3 months, is sufficient for year-round crop production, provided crops such as cassava and cowpea are grown during the driest time of the year. Unfortunately, the soil was low in inherent fertility, which was held largely in the organic component and was soon lost after cultivation. Fertilizer inputs were not available. As a result, this large agro-climatic zone was underdeveloped for agriculture.

It was estimated that there were about 20 million hectares of this soil suitable primarily for upland agriculture which were not effectively used. Traditionally, farmers had used shifting cultivation and an extensive type of agriculture to avoid the soil fertility problem. The transmigration schemes, however, were committed to sedentary agriculture, and farmers in older transmigration settlements were having difficulty producing enough food to sustain their families. Our job was to develop cropping patterns and soil management practices (cropping systems) that would enable the farmers to produce enough food for their families and have some surplus to sell. The original basis for partition of the area into categories was dependent upon present and past land use as follows:

| | | |
|---|---|---|
| Category I | - | Area set aside for lowland rice |
| Category II | - | Land opened for more than 3 years |
| Category III | - | Land newly opened from alang-alang and brush |

Even though this target area was for upland agriculture, farmers tried to grow lowland rice wherever possible. Furthermore, within the area, an irrigation scheme was being developed which would provide water enough for only one rice crop. Upland crops, on the other hand, could be grown throughout the year. The cropping systems program was flexible enough to include lowland rice areas in the research.

The research in Central Lampung has reached the implementation phase. The most recent research is being conducted in new transmigration projects on land newly opened from forests or Imperata. Even though most of the land could be used for

food crop production, there is some land within this "development target area" that may be used only for pasture or forests. This land has rolling to hilly topography and should not be used intensively for food crop production unless soil conservation practices are used. Based on these conditions and our past experiences, we are now using the following criteria for partitioning these target areas for farming systems research:

| | | |
|---|---|---|
| Category I | - | Relatively level land on hill tops |
| Category II | - | Sloping land that must be terraced |
| Category III | - | Land newly opened from forests (compared to land opened from Imperata) |

Figure 6 shows how research categories may be related to each other in a developmental target area. A farmer may have land in more than one of these delineated categories, particularly if the land is hilly and has short slopes. The distance from Category I to Category IV in Figure 6 may be no greater than 150 m. We would develop appropriate technologies for each category in early phases of the research and then combine the developed technologies into relevant farming systems. The use of the land in each category would vary according to the farmer's preference, but usually certain patterns or land uses tend to be common in an area -- the differences usually being due to intensity of land use -- as follows:

| | | |
|---|---|---|
| Category I | - | Home lot (pekarangan) and food crops. |
| Category II | - | Terraced land with rotation of food crops and pasture.<br>Leguminous trees would be planted on terrace bunds.<br>Perennial cash crops such as clove, coffee, and fruit trees would be planted on the steeper land. |
| Category III | - | Same as II, but some management adjustments would have to be made to accomodate the method used for land clearing. |
| Category IV | - | Small ponds may be built to hold water for family, fish, and livestock use. |

**Lowland rice areas.** These areas are dependent upon the reliability of irrigation water and rainfall in sufficient quantities to permit flooding and puddling of the soil as well as maturity of a rice crop. Water availability determines the length of time the soil can be flooded and when and how many rice crops can be planted in 1 year.

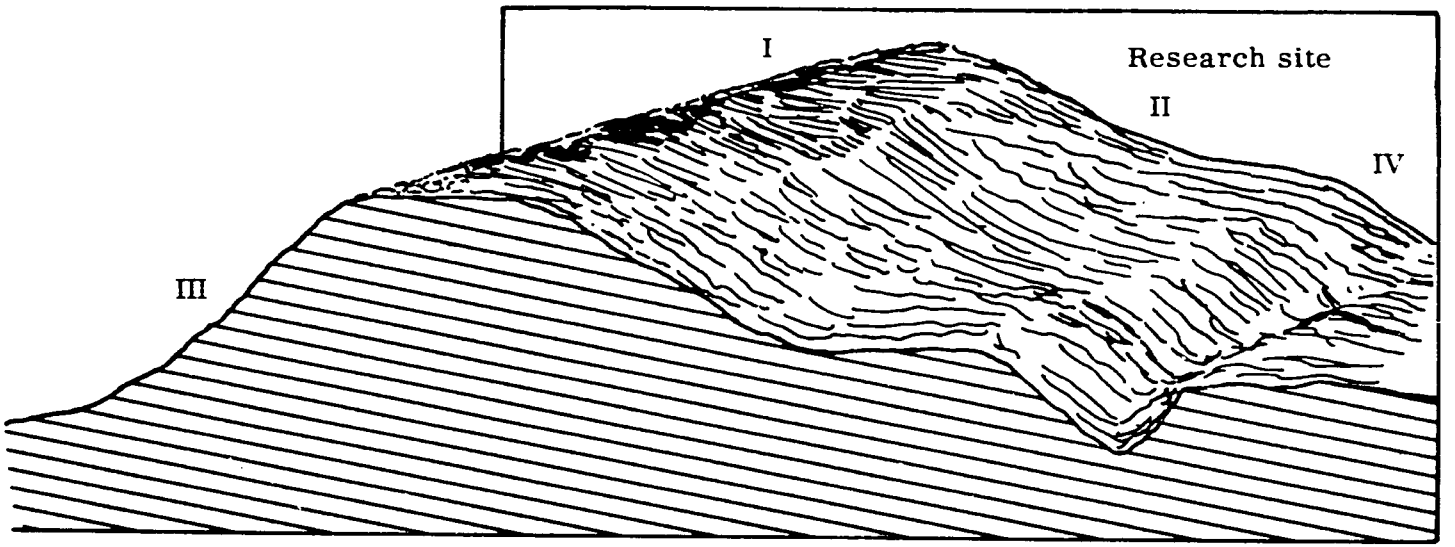



Figure 6. Partitioning of a site into categories for farming systems research in an upland area.

The classification of irrigated lowland rice areas into technical, semitechnical, and simple irrigation areas provides little help to cropping systems research efforts. For example, one target area in Indonesia located in Indramayu, West Java is characterized by relatively level topography, alluvial clay soils, 3-4 wet months with rainfall greater than 200 mm, and a long dry season (Typic Tropaquepts). There are problems with water control -- flooding during the rainy season and partial irrigation during the dry season. The area was partitioned (Fig. 7) into three categories based on present conditions that are mostly dependent on water and which determine cropping intensities and patterns as follows:

Category I - Area with 10 months irrigation
Category II - Area with 7-9 months irrigation
Category III - Area with 5-7 months irrigation

Vast areas of nonirrigated land in Southeast Asia are used for rice production. The land surface may vary from almost level to very steep, and the crop is dependent upon rainfall and some movement of water (surface and subsurface) by gravity from field to field. The fields are usually leveled and the soil puddled before planting rice. The basis for rainfed rice production within an agroclimatic area is mostly dependent upon the ease of flooding and maintaining the water level, so the position of the field on the slope, internal and surface drainage, and depth of water table are dominant determinants for the following partitions of the target area (Fig. 8).

Category I - Poorly drained
Category II - Easily flooded but well drained
Category III - Difficult to flood and excessively drained

## Concepts for Cropping Pattern Design in a Farming System

In some instances, cropping systems research is simply the testing of many cropping sequences in farmers' fields under different environmental conditions. The approach used in Indonesia has emphasized the testing of patterns designed on the basis of concepts. The actual crop sequences used for each conceptual pattern depend upon the level of technology sought or available.

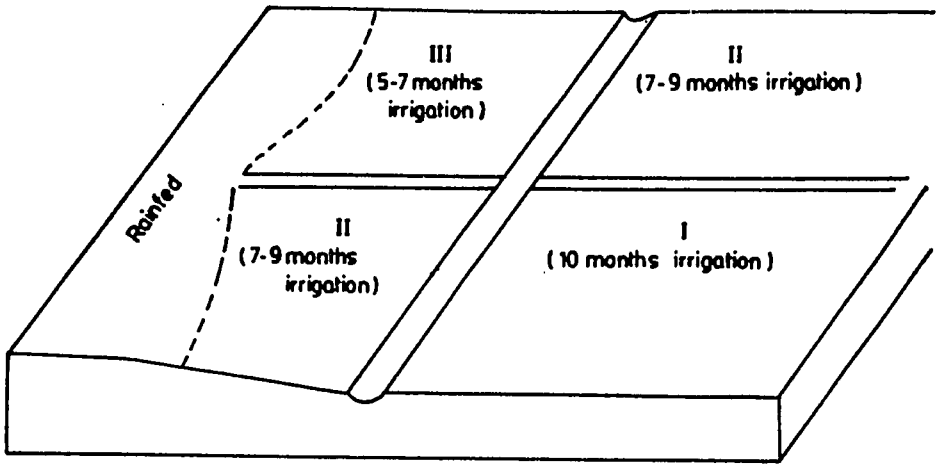



Figure 7. Partitioning of a site into categories for farming systems research in an irrigated lowland rice area.

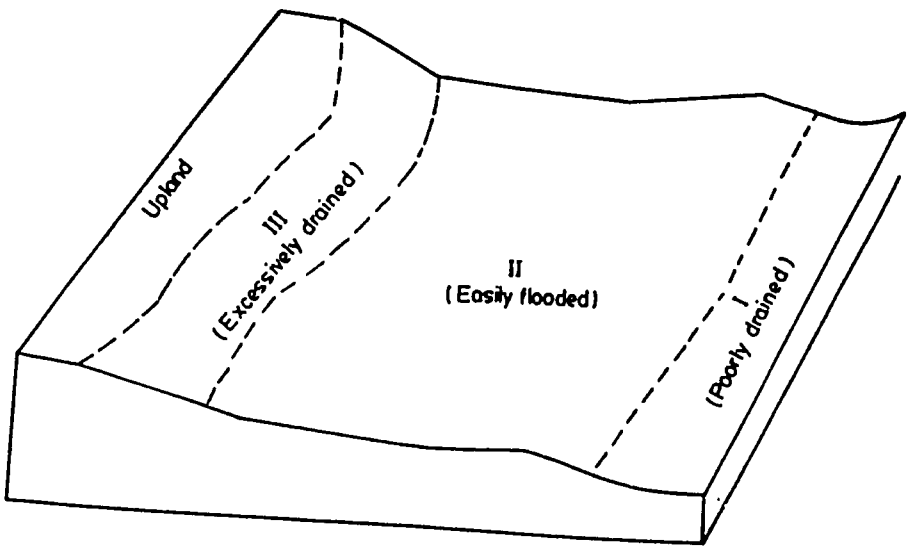



Figure 8. Partitioning of a site into categories for farming systems research in a rainfed lowland rice area.

Three conceptual cropping patterns were tested in each category for each target area when the Indonesian program started in 1975. Each trial was replicated three times but by different farmers (or across farms). The cropping sequences for a pattern tested in each category were not necessarily the same, but were selected on the basis of the same criteria. The criteria for selection of the sequence of crops and management practices for each pattern, plus the rationale for each criterion, were as follows:

Criterion A. Farmer's present cropping pattern.
Rationale: To establish a base-line check for comparison.

Criterion B. Farmer's choice of cropping pattern if input and market constraints were removed.
Rationale: To evaluate the farmer's level of competence and managerial skill and perhaps uncover hidden socioeconomic constraints.

Criterion C. Our introduced cropping pattern with input and market constraints removed and technical assistance provided.
Rationale: To determine production and economic potential and our ability to remove constraints.

The use of these criteria for design of cropping patterns has been successful. It has allowed us to be objective, and we do not get bogged down in evaluating small differences in results from using different species of legumes or cultivars of rice in testing many different cropping sequences. Those refinements are very valuable but are the kinds of component studies that are never finished.

In our studies, we have been made aware of the severe economic stress faced by many Indonesian farmers. Most simply do not have money they can use for material inputs; and if they do, they are afraid to take the risk. This is particularly true for farmers who have seldom worked with the extension service. We feel we must develop low input patterns for new adopters. If the technology is good and shows evidence of being profitable, the farmers will soon learn how to use more inputs. We now recommend the following criteria for design of cropping patterns:

Criterion A. Farmer's present cropping patterns (monitor only).
Rationale: To establish a base-line check for comparison.

Criterion B. Farmer's cropping pattern with inputs and optimum management.
Rationale: To evaluate the farmer's pattern without input and managerial constraints.

Criterion C. Our introduced pattern with low inputs.
Rationale: To induce the farmer to gradually try new technology.

Criterion D. Our introduced pattern with input and market constraints removed and technical assistance provided.
Rationale: To determine production and economic potential.

## Strategies for Design of Introduced Patterns in a Farming System

The impression that evolves from accumulated survey, soil classification, climate, and market data and from observations of farmers' patterns is the best guide for cropping pattern design. If nothing appears obvious to the Farming Systems Working Group after this exercise it would probably be better to work somewhere else. Among the techniques used by cropping systems scientists to intensify cropping and increase production there is a thread of commonality. The techniques used for the lowland rice-producing areas of Asia are shown in Table 2.

These specific examples are useful in understanding how the issue of intensification can be tackled. More generalized guidelines for pattern design may be useful for situations where less is known.

**Selection of crops grown.** New or exotic crops are likely to be unsuccessful when first introduced, so the initial phases of a cropping systems program will be dependent upon the use and improvement in production of familiar and marketable crops. The gradual introduction of new crops can be one of the most important strategies for cropping systems research. Agronomic adaptation is an important consideration for the selection of crops to be included in new cropping patterns. The crop must fit the

Table 2. Common strategies for crop intensification in lowland rice areas.

Fully irrigated · Go from two to three crops per year.

- Plant earlier in the crop year.
- Use earlier maturing cultivars.
- Reduce turn-around time between two consecutive crops.
- Tailor inputs to soil, climate, and crops.

Partially irrigated and rainfed. Synchronize plantings to permit an extra crop per year.

- Plant earlier in the crop year by use of minimum tillage and direct seeding.
- Reduce turn-around time between two consecutive crops.
- Plant earlier maturing cultivars of rice and other crops.
- Plant upland crops other than rice during the dry season after harvest of lowland rice.
- Plant early maturing upland crops at the beginning of the rainy season before there is enough water for lowland rice.
- Use year-round crop production and soil management practices. This will reduce the labor needed for tillage and weeding and will ultimately contribute to crop intensification.

prevailing rainfall or irrigation pattern during the time of the year it is to be grown. Usually, food crops receive the highest priority for government support in developing countries. Of these crops, rice is the most valued in Asia and, consequently, is grown if possible. Maize is usually the next highest valued crop and can be grown under drier conditions than rice. Sorghum and millet are usually more drought tolerant than maize or rice, but are often not as adapted to acid soil conditions. The versatility of upland rice, in this respect, has not been fully exploited. The root crops -- sweet potato and cassava -- can fit into most patterns for upland areas. These are usually high-valued, fresh-market crops near cities and subsistence food crops in remote areas. Cassava is an especially stable crop in drier regions and times of the year. Legumes usually grow well at the beginning of the rainy season when disease and insect problems are fewer; many of the legumes are photoperiod sensitive, though, and this must be taken into consideration. In irrigated areas, legumes are usually catch crops to utilize residual soil moisture after lowland rice. Seeds produced at the beginning of the rainy season in adjacent upland areas may be used for planting the lowland areas. Seed viability is a problem, particularly for soybean, the value of which as a protein source must be given high priority, particularly in remote upland areas where sweet potato, cassava, and other starchy food crops make up a major portion of the diet.

The market and market potential are also important factors. Farmers grow food crops both to feed their families and to sell, but the first priority is for food. The incentive to grow extra crops for marketing purposes depends upon the profit the farmer can make. In most developing countries there are government policies to keep food prices low. These policies benefit the large number of consumers in the cities and towns but hinder efforts to increase agricultural production. These problems have been recognized by most government, and attempts are being made to establish and maintain minimum market prices.

Since rice is the preferred crop in Southeast Asia, it is usually the most profitable crop to grow. Other crops (unfortunately referred to as secondary crops) may be much less profitable, especially if they cannot be easily processed within the country or exported. Maize, cassava, soybean, mungbean, and peanut usually offer the widest range of market potential.

**Management of cropping sequences.** The prevailing farmers' cropping patterns usually give the best clues to the opportunities and constraints faced by farmers. Good surveys can help pinpoint and clarify many socioeconomic as well as agronomic conditions that affect the farmers' decisions. The concept of risk minimization is especially important in remote or newly opened areas where the farmer must be self- sufficient and can expect little help from government agencies. These are the conditions under which farmers many times use complex mixed cropping combinations and little material inputs. In partially irrigated areas farmers are reluctant to grow a second crop of rice, and if they do they usually reduce fertilizer and labor inputs. These evidences of the farmer's understanding of risk must not be ignored. We design and test improved patterns which require low levels of material inputs. At the same time, similar patterns are designed and tested with what we expect to be agroeconomic optimum levels of inputs. In this way we can develop technology with a broader base and gradually introduce it at a level farmers can more readily accept.

The minimization and distribution of labor are significant factors. Power for land preparation is a major constraint to increased crop production through intensification in upland areas; a farm family can prepare only about 0.5-0.6 ha of land by hand labor at the beginning of the rainy season. Labor is also a constraint in partially irrigated and rainfed areas, where time is a factor in getting the land prepared for planting rice at the beginning of the rainy season. The design of cropping patterns to utilize available water can also be an effective technique to save labor. The introduction of extra crops usually induces more land cultivation and more competition for weeds. The farmer benefits by the reduction in the labor requirement for land preparation and weeding per crop and by the opportunity for gainful employment during times of the year when the family would otherwise be idle.

New cropping patterns must take into account the farmer's cash flow situation. In newly opened upland areas farmers usually have less money available for purchase of inputs than farmers in lowland rice-producing areas. In either case there is generally financial stress. Recommendations for larger inputs are not likely to be adopted unless the new technology is gradually introduced and arrangements are made for credit. Even then, farmers who have never had much cash are not usually willing to make use of credit when it is first offered. Gradual introduction of technology represents one strategy to overcome this

reluctance. Consequently, in addition to "optimum patterns", cropping patterns should be designed for developing low and intermediate levels of technology. If the lower levels of technology are adopted by farmers and found beneficial, the farmers will likely be willing to assume the responsibility for more credit and more resultant inputs.

Cropping patterns which involve more crops and harvests usually provide for better labor distribution and even out the cash flow for production costs and the income from the sale of marketable produce. The farmer may have less money for short periods of time but some money over a longer period. He is more likely to have some money for food and for production inputs when needed.

## Testing Cropping Patterns in A Faming System

The cropping systems approach to research has developed for several reasons, but some of the original work was done to study two basic questions in tropical agriculture -- how to utilize more efficiently the tremendous energy, land, water, and labor resources available, and how to get farmers to adopt the technology developed.

### Rationale for Systems Research

The physiological, agronomic, and technical aspects relating to the first question may be studied in laboratories and research stations. The potential for production is evident from this kind of research even if the technology is often inappropriate for adoption by small farmers of the less developed countries of the tropics. The contrasting situations between the developed and less developed areas of the world must be recognized even if there is a problem of oversimplification. In developed countries, where farmers are likely to be better educated and economically stronger, published and disseminated research information may be sufficient to meet their needs. The farmers are more able to apply a technology, assume the risk, and evaluate the technology on their own. In developing countries, however, farmers are usually under-educated, financially weak, and afraid to assume the financial risk and peer pressures associated with change. A technology must be developed and tested systematically and extended to the farmers in a simplified form.,

Production programs have been developed and financed to solve some of these problems. Technological packages with credit facilities have been made available to farmers through such programs as Masagana 99 in the Philippines and BIMAS in Indonesia, and production has been increased for individual crops. These steps forward have been very successful even though many farmers have not greatly benefitted from the efforts and many have not continued to participate, because the basic problems of development and adoption of appropriate technology by farmers have not been solved by the production programs.

Before these programs for crop commodities and cropping systems reach the stage of implementation, they should be preceded by target area specific research conducted under conditions approximating those of the farmers. The first step, as has been described in this book, is to conduct preliminary research in farmers' fields under the researcher's management in order to get some idea of crop performances and production potential within the target area. If this looks promising the cropping patterns that have been designed should be further tested in farmers' fields as much as possible under the prevailing conditions.

## Methodology Used

Using this approach, the Indonesian cropping systems program has been effective in West Java, Lampung, South Kalimantan, and Southeast Sulawesi in developing and implementing research. A team composed of a coordinator, an agronomist, and an economist was stationed in each target area. A team leader and field assistants for agronomy and economics were put in charge of the field work and data collection for input-output within each site in the target area (Fig. 5). A system for collecting daily farm records for all farm buying and selling activities was implemented in cooperation with farmers (about 30) in each target area in order to get a larger base for socioeconomic evaluation.

The organization of the research and the research team should be as simple and self-contained as possible. The coordinator should have flexibility in implementing the research once the general guidelines for trials, patterns, organization, and staffing are decided upon. He should have mobility so that he

can visit the sites and research plots frequently, talk with the farmer cooperators, and develop cooperation with the extension services and local government officials. He should assume the responsibility for summarizing and preparing a draft report of the research results. Most of all, he should, in consultation with his staff, critique the research in progress and prepare a tentative project proposal for the following year. The involvement of those close to the field research activities is the key to successful and relevant research and staff development.

The Indonesian program has usually replicated the field trials across farmers' fields. This has been successful primarily because the target area was stratified by partitioning it into categories. For each cropping pattern tested, three farmers within a category were randomly selected as cooperators after screening based on criteria relating to land tenure, size of farm, cropping system, location, and desire to cooperate. Each farmer agreed to permit 0.1 ha of land to be used for the research; he provided the labor, and the project provided the necessary inputs. The farmer was compensated for any losses and extra labor caused by the project. All data concerning labor and costs of inputs were collected. The cash flows of the agronomic farmer cooperators and of the other farmer cooperators for economics were monitored. The data were reported in terms of yields, gross returns, labor costs, material costs, and net returns for each pattern in each category. The data from economic farmer cooperators were summarized in the same way to establish more precisely the economics of the farmers' cropping patterns and to understand their farm operations.

## Pilot Production Projects

In many countries pilot production projects are an integral part of the technology delivery process. Sometimes a pilot project is considered a research function and sometimes exclusively extension. In Indonesia, as Figure 1, Phase IV indicates, this activity has been a legitimate research component, particularly for new research target areas. But it is recognized that in most instances it is largely an extension activity.

## Pre-production Testing

We would normally expect that the technology developed and tested by a research organization would be adopted by farmers with only dissemination of the information by extension workers and by development of production programs. The latter step is usually not necessary in developed countries, where the agricultural economy may be strong. Even in less well developed countries, technology for new cultivars and management practices for crop commodities may be directly and easily introduced. But for cropping systems research implementation, there will likely be a need for an additional research phase. This phase may be described as pre-production testing, but the research is more complex than indicated by this terminology. It is an evaluation not only of the appropriateness of the technology but also of the infrastructure. The weak links in the infrastructural chain should be identified and strengthened to absorb the new technology. This process can be best illustrated by an example from the Indonesian program.

**Methodology used.** Research was begun in both Indramayu, West Java and Central Lampung, Lampung in 1973. Results from the first two years in Indramayu showed the feasibility of increasing crop production by introduction of high-yielding and early-maturing cultivars and inclusion of an extra crop either before or after the main crop season. In Lampung, the results showed the potential for crop production and stable agriculture on the region's red-yellow podzolic soils under rainfed-upland conditions. The research in these two areas was expanded in 1975 to include on-farm testing of farmers' and introduced cropping patterns in three main irrigation catagories of Indramayu (10 months, 7-9 months, and 5 months of water availability) and for partially irrigated (5-6 months water availability), "newly opened", and "old opened" areas in Central Lampung. This research was conducted in close cooperation with the extension service and local government officials in hopes that the research results could be smoothly and quickly adopted by the farmers. During the third year (1977-78), the trials were not replicated but were consolidated into one contiguous area for each irrigation or land use classification (an embryonic Phase IV in Fig. 1). The idea was to test the introduced patterns in plots large enough to cover several farms and minor differences in soil and water availability and to gain visibility among farmers and extension workers.

**Constraints identified.** The data and experiences from the 1977-78 research verified previous findings. We felt there was sufficient evidence to support the development of production (BIMAS) programs in these two target areas for cropping patterns rather than for individual crops as has been done in the past. The BIMAS program would help remove the credit, input, and perhaps market constraints faced by farmers. But in order to be successful, all components of the production system would have to be synchronized, including choice of cultivars, insecticides, planting and harvesting dates, time of arrival and termination of irrigation water, and local government activities. These infrastructural considerations are not so important when new cultivars, insecticides, or other single-faceted technologies are introduced, but for cropping pattern changes the constraints that have prevented the farmer from modifying his systems in the past must be identified and removed. Furthermore, the new problems that arise from implementing new cropping patterns must be anticipated and removed. For example, increased production will cause marketing problems and overloading of the existing agri-business community. We felt that an expanded Phase IV is needed in the sequence of site selection, agro-economic potential, designing and testing, and implementing new cropping systems technology for a target area (Fig. 9). But we also recognize that this activity must be an integrated endeavor with other government agencies.

**Institutional constraints.** The pre-production or pilot production phase (Phase IV) should cover one or more of the smallest governmental units (desa in Indonesia) within the target area. The planning could be coordinated by the Ministry of Agriculture in cooperation with the provincial planning agency (BAPPEDA in Indonesia) so that all relevant governmental agencies are involved. In this way, the institutional constraints that might arise from introduction of the new technology can be identified (and removed) before wide-scale implementation is attempted. The coordination of research, extension, irrigation, and local governmental agencies is vital if pre- and post-production constraints are to be removed. This idealized kind of on-farm research would have been useful as a follow-up to the embryonic efforts we made to solve these problems in Indramayu and Lampung -- two target areas which differ greatly in their stages of development and kinds of agriculture. However, if the site descriptions are accurate and sufficiently detailed, research results can be applied (transferred) to other areas with similar agro-climatic conditions.

| | Research and Implementation Phases | | | | | |
|---|---|---|---|---|---|---|
| Target Area selection | I<br>Site description | II<br>Economic and biological potential | III<br>Design and test | IV<br>Pilot production program | V<br>Implementation | Technology transfer |
| CSWG[1] | CSWG | CSWG | CSWG | CSWG | CSWG | CSWG |
| Extension<br>Local government<br>National government | Extension<br>Local government | Extension<br>Farmer<br>Local government and Bureau of Statistics | Extension<br>Farmer<br>Local government | Extension<br>Farmer<br>Directorate of Production<br>Local government | Extension<br>Farmer<br>National production program<br>Local government | Extension<br>Other national government agencies |

[1]CSWG = Cropping Systems Working Group, which is the multi-disciplinary research group that coordinates and carries out the research plans of cropping systems program in a target area.

**Figure 9.** Schematic representation of the research-extension workload distribution and interaction with farmers and other government agencies in different phases of cropping systems research and implementation.

### Test Farms

The research approach used for test farms does not necessarily differ from that described in this book. The land tenure arrangement represents the major difference: The land on test farms is under the control of the researchers and, consequently, the researchers are more sheltered from the public and will likely conduct research more in line with tradition. But the security offered by a test farm arrangement -- we prefer the term "field laboratory" -- permits development of research facilities, quarters, and longer term experiments. The technology generated should finally be tested directly in farmers' fields.

## Implementation Through Production Programs

Experience with government-sponsored production programs has in general been good. Acknowledgment of the need for support to small farmers for development of appropriate technology, credit, production inputs, technical services, and markets has been made, and this is a step in the right direction for developing countries. The prospects for this kind of governmental activity affect the research processes and the technologies developed. If the farmers in a developing country are economically weak (and they likely will be) and the government is indisposed to support production programs, the agricultural research effort should be directed mostly toward low-input technology. This places a great constraint upon research options. Not much can be done to increase total agricultural production, but some techniques can be developed to conserve the soil and stabilize production. Research should be directed to identify these constraints and develop technologies that are within the economic grasp of the individual farmer. The methodology that has been described can be used for these different situations.

Experiences with production programs in the Philippines and in Indonesia have been described in several publications. The important question is how to make the programs more effective from a technical point of view. It is recognized that initially production increases each year after implementation of a program. Then production begins to level off. It is at this stage that cropping systems research can be most useful. The technology developed for specific target areas permits more specific recommenda-

tions and higher production possibilities for these areas. This technology then becomes more acceptable and allows for transfer of technology to similar agroclimatic and economic regions. The transfer of appropriate technology may reduce the research time required in new target areas by 2 or 3 years (Fig. 10). Production packages can be tailored to better meet the requirements for increased production and farmers' needs.

## TECHNOLOGY TRANSFER

Farming systems research within a target area provides the framework for the testing and adaptation of various components of the farm systems for a particular environment. In the process technologies are developed that may be used fully or partially in other places with similar conditions. The technology flow within the bureaucracy and from the target area to other areas with similar conditions is a vital objective of this kind of research. The rate of flow of the technology depends upon developing active linkages among research, extension and other governmental agencies. The rate of flow also depends upon the ability of the researchers to describe and then identify other areas where the new technology would likely fit. The technology transferred must be tested in place by researchers or by their colleagues working in production and extension programs. Consequently, the key to smooth and successful technology transfer depends on the development of institutional linkages and adequate site descriptions.

### Technology Flow

Improving the flow of technology (transfer of technology) is simply a way of using research funds, personnel, and time more efficiently. The concept is useful in that it urges scientists to consider the application and integration of new technology as a legitimate part of a research effort. This approach has not been fully exploited in most agricultural research nor in development activities that apply directly to farmers.

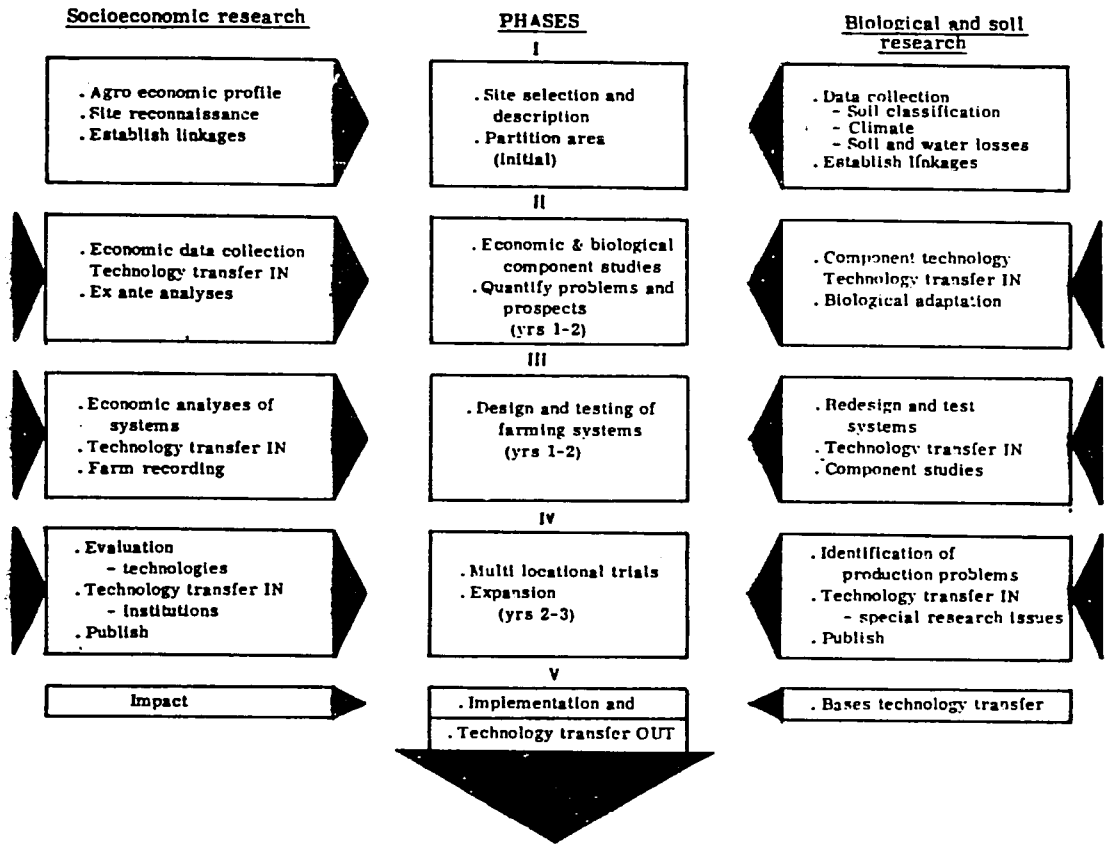



Figure 10. Time frame for research and implementation phases of a Farming Systems research program with significant inflow of technology from research in areas with similar site descriptions. This technology transfer may reduce the research time in a target area by two more years.

### Vertical Flow

One objective of a farming systems program is to use existing information by bringing it together and testing it in a specific environment. Technology of this kind usually comes from the experiment stations of national and international institutes and is fragmented according to crop commodities and disciplines. The technology is then transferred to the government bureaucracy and finally to the extension service. This is a kind of vertical transfer of technology. The information is disseminated by the extension service in a "trickle-down" fashion.

### Horizontal Flow

Basic studies in soil science, biochemistry, plant physiology, and related fields are usually well described and documented, and the technology developed can be transferred from place to place horizontally as well as vertically. The technology of the applied agricultural sciences (such as agronomy, horticulture, and forestry, which directly affect farmers' welfare) usually consists of well-documented studies of small parts of a larger system. The bits of research information can be absorbed directly by farmers in both developed and developing societies, but many times farmers in less-developed countries cannot make use of this technology. The missing pieces of the research puzzle for a particular target area can be identified and studied by cropping/farming systems research. Further testing and complementary research provide the appropriate technology for use through production programs and horizontal transfer of technology. A comparison of Fig. 1 and Fig. 10 illustrates how research time and effort can be saved by transfer of appropriate technology from one target area, horizontally, to another.

## Descriptive Basis for Technology Transfer

It is theoretically possible to describe the ecological and socio-economic environment of a target area completely. The agrotechnology developed for the area would then be suited for an area with an identical (or similar) description. Some on-site research could be conducted to further verify the appropriateness of the technology transferred in. In practice, though, it is difficult - if not impossible - to find identical areas for research based on purely technical reasons.

The question then is how or to what extent can agrotechnology be transferred from one area to another when there are differences as well as similarities between the two areas. What are manageable levels of diversity among the socioeconomic and biological determinants that describe a target area for cropping systems?

In Table 1, descriptive elements of a target area (summarized from the text of this book) were listed along with a statement of intended use and expected sources of information. These were given to provide a basis for futher discussion and were not intended to be comprehensive. The purpose was to illustrate how data can be collected and used to characterize a target area, as exemplified in the following pages.

## Descriptions of Initial Target Areas

Two major target areas were selected in 1973 by the Indonesian Cropping Systems Working Group, one in Indramayu, West Java and the other in Bandarjaya, Central Lampung. These two areas met the criteria for selection that were being developed by the Cropping Systems Working Group (listed on page 11). The availability of technology for transfer in was very limited. We expected that seeding rice directly and planting earlier maturing cultivars were technologies that could be used to intensify cropping patterns in the partially irrigated Indramayu area. Using fertilizers and crop residues to improve soil fertility and more systematically arranging farmers' cropping patterns were technologies that could be used to improve production and stabilize agriculture in the upland transmigration areas of southern Sumatra. Cropping systems studies were begun in 1973. The target area descriptions are summarized in Table 3.

The descriptions are used basically for two purposes. Initially, the data were used to provide bases for selection of the research sites within the target areas, for problem identification, and for design of cropping patterns to be tested. Later, the descriptions were used as bases for transfer of relevant technology between or among (transfer out) selected target areas. There is no attempt to match descriptions precisely as a basis for technology transfer. The real task is to identify and match the dominant factors in each environment that control the socioeconomic and biological processes.

Table 3. Descriptive data for sites in target areas

| Descriptive elements | Indramayu | Bandarjaya |
|---|---|---|
| I. Integrated environment factors | | |
| Edaphological classification | Partial irrigation for lowland rice | Upland crops and *Imperata cylindrica* |
| Cropping patterns and farming systems | Lowland rice - lowland rice - fallow<br>Lowland rice - palawija - fallow | Partially irrigation for lowland rice<br>Maize - upland rice - cassava<br>lowland rice - fallow |
| Farm economy | Government designated minus area land idle | Government designated minus area, low production |
| II. Socioeconomic determinants | | |
| Markets | Good potential | Good potential |
| Infrastructure | Good | Good |
| Farmer responsiveness | Good | Good among transmigrants |
| Labor pool | Sufficient | Seasonal |
| III. Ecological determinants | | |
| Soil-water environment | Vertic Tropaquepts | Orthoxic Tropudults |
| Climate | | |
| Rainfall distribution and amount | Dec-Feb >200 mm<br>Jul-Oct <100 mm | Nov-Apr >200 mm<br>Aug-Sep <100 mm |
| Temperature and solar radiation | $6^{o}$ 20'S latitude at ± 5 m elevation | $4^{o}$ 40'S latitude at ± 40 m elevation |
| Cloud cover | Litlle effect | Significant effect on disease problems |
| Wind | Significant in dry season | Not Significant |
| Water control | | |
| Irrigation | Full<br>Partial - 5-7 and 7-9 months<br>Rainfed | 5 month intermittant irrigation in limited area<br>Predominantly rainfed upland |
| Flooding | Hazard in partially irrigated areas | No hazard |
| Soil water | High water table and good storage soil water | High water table in irrigated area but poor storage soil water in upland |

Markets and availability of inputs (as affected by the infrastructure) are dominating economic factors in vast regions of Indonesia. Water availability from irrigation and rainfall (and its reliability) dominates lowland rice production. Rainfall is the dominant factor for upland crops. Soil, as it exists and as a consequence of its formation, interacts with water availability and plant nutrition in both instances to greatly affect crop production, cropping patterns, and agrotechnology transfer. Consequently, the comprehensive nomenclature incorporated in the taxonomic units embodied in Soil Taxonomy provides one source of information needed to characterize the biological and environmental aspects of a site or target area for appropriate soil and crop management. The Family category of that system of soil classification has been hypothesized to be appropriate for these purposes. Many times the Sub-group is adequate (Table 3) if there is sufficient practical and research experience within the area. Information that can be derived from the Soil Family name which is useful for crop and soil management purposes can be illustrated by using the dominant soils found in our two target areas.

**Indramayu example.** The most likely classification for the soil in sites of the Indramayu target area would be clayey, montmorillonitic, isohyperthermic Vertic Tropaquept. This refers to immature soils that have no horizons of accumulation of clay and aluminium. The natural drainage is poor, and groundwater stands close to the surface during some part of the year. These soils are found in tropical regions of relatively low elevations and were likely formed from marime deposits. They are relatively fertile clay soils that are dry enough in most years to crack deeply. But the surface soil has considerable organic matter that ameliorates the effects of the clay and provides favorable conditions for cultivation. The effects of the dry period reduce weed growth, loosen the surface soil, and permit shallow cultivation and preparation of a seedbed for direct-seeded rice at the beginning of the rainy season. The relatively high water-holding capacity and water table moderate the effects of brief dry periods after seeding. Likewise, near the end of the rainy season sufficient soil water and intermittant rain permit upland crops to grow after harvest of rice provided the surface water is drained away.

**Central Lampung example.** The most likely classification for soil in sites of the Central Lampung target area would be fine loamy, kaolinitic, isohyperthermic Plinthic Tropudult. The name indicates this is a highly weathered tropical soil with some

plinthite in or below the argillic horizon. It is low in inherent fertility and likely has a perched water table at some time during the year. The udic moisture regime permits year-round crop production provided drought tolerant crops are grown during the drier times of the year and soil management practices for fertilizer and crop residue recycling are used. This soil must be managed carefully to prevent erosion and rapid loss of soil organic matter. On the other hand, this soil tends to be very responsive to small increments of phosphorus fertilizer application and is easily cultivated. The surface horizon is well drained and the clay particles aggregated so that the soil can be cultivated soon after a rain. This soil is responsive to intensive management and is well suited for farming systems that include animal components as well as food, forage, and perennial crops. It is best suited for management in small units by family farm type operations.

## Descriptions of Subsequent Target Areas (1978-80)

The cropping systems research in Indonesia started in Indramayu, West Java and Lampung, Sumatra in 1973 with Indonesian sources of funding. In 1975 this research received supplemental support from the International Development Research Centre (IDRC) of Canada. Later, cropping systems (farming systems) sites were established in other places in Sumatra, Java, Sulawesi, and Kalimantan and the research was funded by the national program through usual sources and by other national agencies with support from international funding institutions. The initial research efforts in Indramayu and Lampung were terminated in 1978, but with continued support from IDRC two new research sites were established -- one in Madura, East Java and the other in South Kalimantan -- covering upland rainfed and tidal swamp areas.

**Madura, East Java.** Soils within this target area vary from one research site to another. The soils are derived from uplifted calcareous rock, shale, and beach sands. The classifications for soil in the different site categories are given in the following paragraphs.

In Category I - upland rainfed area, the most likely classification for soil is sandy, mixed, isohyperthermic Lithic/Typic Dystropept. Although these soils are not extremely acid they are low in plant nutrients and subject to drought during the dry season because of shallowness of the soil and excess drainage.

These soils have some 2 : 1 clays, but the surface soil is not influenced by pyroclastic materials. An udic moisture regime characterizes these soils, and in some cases the lithic subgroup prevails where there are steep slopes and a shallow soil mantle. Crops grow well on these soils during the rainy season if adequate amounts of phosphorus and nitrogen fertilizer are used. Management practices should include row applications of phosphate and return of crop residues and barnyard manure to the soil. These soils are easily managed even during the wettest time of the year and are well suited for upland cropping patterns provided soil fertility and conservation management practices are carefully followed.

The research site is located in Blega, Madura, East Java and has 5 months with rainfall more than 200 mm, 3 months with 100-200 mm, and 4 months with less than 100 mm. The common cropping pattern of this area (farmer's cropping pattern) is upland crop - upland crop - upland crop (usually corn and peanut).

In Category II - rainfed lowland, hilly area, the most likely classification for soil is clayey, kaolinitic (mixed), isohyperthermic Lithic Eutropept. These brownish-red soils overlay limestone rock within 50 cm of the surface. The surface soil has more than 35% clay, and a base saturation of more than 60%. These soils are fertile, but crop production is constrained by the steep slopes. Terracing and impounding of water during the rainy season, however, permit production of high yields of lowland rice. Most upland crops grow well during the early part of the dry season following the rice crop. The gradual onset of the rainy season permits early maturing crops like maize, mungbean, and some soybean cultivars to be grown before lowland rice.

This research site is located in Blega, Madura, East Java and has 2 months with rainfall more than 200 mm, 6 months with 100-200 mm, and 4 months with less than 100 mm. The common cropping pattern of this area (farmer's cropping pattern) is lowland rice - upland crop.

In Category III - rainfed lowland, low lying area, the most likely classification for soil is clayey, montmorillonitic, isohyperthermic Typic Pelludert. These soils have a dark gray to black surface horizon and have sufficient clay to permit cracking to a depth of 50 cm during dry periods. The soils are found in low areas and are level. They are well suited for lowland rice production and for soybean during the dry season provided surface drainage is implemented.

There are two research sites in this category, one located in Blega and the other in Jrengek, Madura, East Java. The Blega site tends to have more rain, with 3-5 months with more than 200 mm and only 4 months with 100 mm or less. Jrengek, on the other hand, has 3 months with rainfall more than 200 mm, 4 months with 100-200 mm, and 5 months with less than 100 mm. The common cropping pattern of these areas (farmer's cropping pattern) is lowland rice - upland crop.

**South Kalimantan.** Two major edaphological conditions were studied in this province -- upland areas similar to those in Sumatra and the drained tidal swamps similar to many of the new transmigration areas in tidally affected lands.

The most likely classification for soils in the upland rainfed areas is fine loamy, kaolinitic, isohyperthermic Typic Tropudult. These soils are similar to many of the upland soils in southern Sumatra, and in general they are rolling but less disected and less fertile than similar soils in southern Sumatra. These soils are very responsive to phosphorus fertilizer, are erosive, and are mostly dependent upon available nutrients contained in organic matter. Successful soil management is dependent upon strategies to maintain organic matter, prevent erosion, and recycle crop residues. The udic moisture regime and physical nature of the soil permit year-round crop production, but stable and sustainable land use is dependent upon developing mixed farming systems. These systems should be designed to provide sufficient food products for subsistence, but most of the land should be devoted to perennial and pasture crops to provide cash income and stabilize the soil.

The research site is located about 12 km from Tanah Laut (Pleihari) and 65 km from Banjarmasin in South Kalimantan. The average slope and altitude of this area are 3-15% and 20-50 m above sea level, respectively. The average annual rainfall is 2438 mm, with 6 months with more than 200 mm and 4 months with less than 100 mm. The common farmer's cropping pattern of this area is maize + upland rice - maize.

The most likely classification for soil in the drained tidal swamps is clayey, mixed, isohyperthermic Histic-Sulfic Tropaquept. Water control in these soils has been imposed through a system of drainage that removes surface water but provides sub-surface irrigation at high tide. The distance to the water table at high tide varies between 100 and 50 cm depending upon the variation in elevation within the area. During the rainy

season impoundment of rainwater permits flooding and production of lowland rice. These soils are covered with a mantle (< 50 cm) of peaty material. The underlying mineral soil, upon exposure to oxidative conditions, has sufficient sulfurous materials to develop strongly acidic conditions. It is not uncommon for the floodwater in rice fields to have a pH of 3 or less. Consequently, successful use of the soils requires good water control and maintenance of anaerobic conditions. Overdrainage can lead to serious crop production problems, and strategies to insure flooded or nearly flooded conditions are necessary. Also, strategies to promote flushing of the soils with rainwater or other sources of nonacidic water enhance crop production and soil productivity. Systems of bedding to promote favorable conditions for upland crops on the raised bed and improved chances for flooding the lower bed have been used successfully by indigenous farmers.

This research site is located about 40 km north of Banjarmasin, along the Barito River. Its topography is flat, with an altitude of 1-3 m above sea level. The soil is derived from alluvial materials, and the general area is overlain with 30-80 cm of peat. The area has been drained by a series of canals after the herring-bone design of Gadjah Mada University. The average annual rainfall is 2500-3000 mm, with 6 wet months with more than 200 mm and 3 dry months with less than 100 mm. After opening of the land the farmers gradually develop land management techniques similar to the sorjan system commonly found in other places in Indonesia where there are water control problems. The farmers commonly grow maize - maize + cassava (and eventually perennial crops) on the raised beds and plant photoperiod sensitive rice cultivars in the lower area (one crop per year). The local cultivars grown in the lower bed are usually transplanted into successively larger areas through a series of three transplantings as the floodwaters recede, and they require 8-9 months from initial seedbed to harvest.

## Technology Development and Implementation for Initial Target Areas

Descriptive research through socioeconomic surveys and collection and evaluation of soil, climatic and biological data from sites in the target area is a necessary and vital phase of the cropping/farming systems research methodology. It provides the basis for experimentation through studies involving the components of the cropping and farming systems and through the

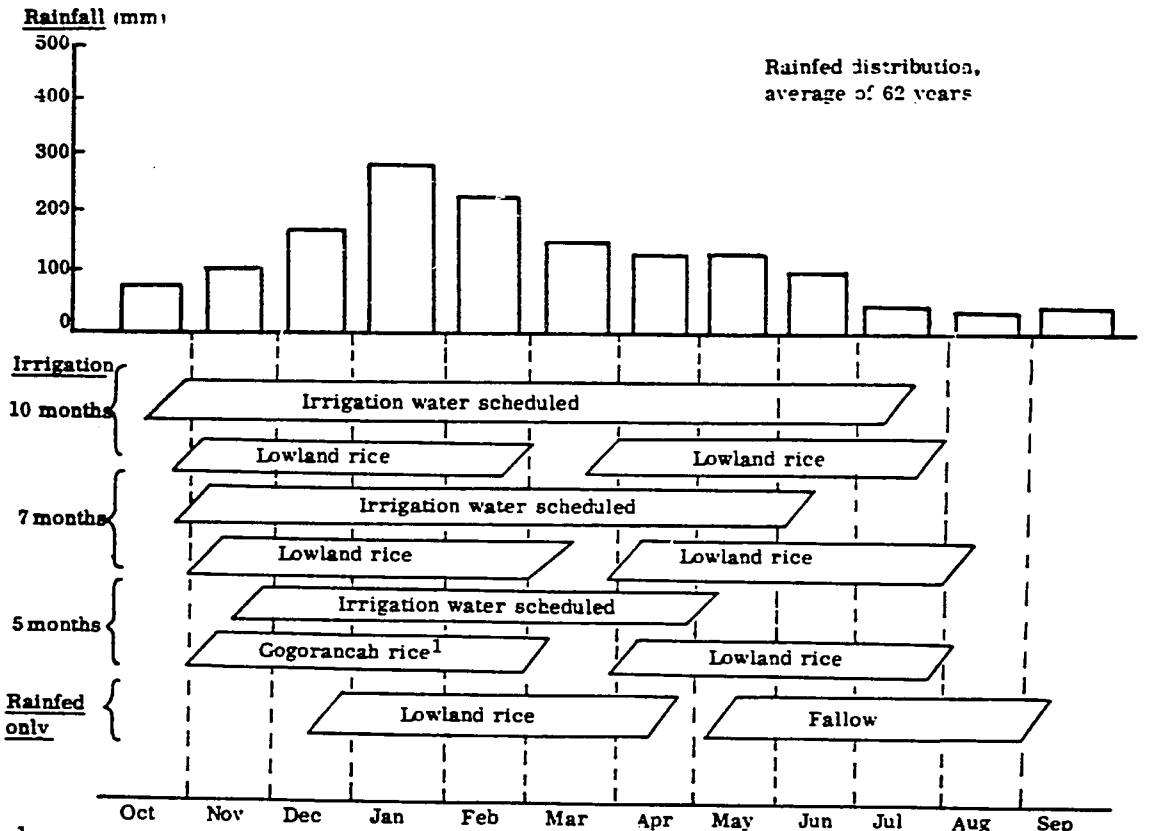
designing and testing of new systems. The initial research in the target areas involved studies of the crop components of the farming systems. These cropping systems studies were not intended to develop technologies that would preclude other agricultural enterprises on the individual farms but were simply studies of the crop components of the whole farm. For irrigated rice and new transmigration areas this research included most of the production aspects of the farm enterprises. The highlights of the systems research that is discussed in the following pages does not include results from numerous studies of the individual components of the cropping systems because these studies are similar to others carried out by scientists for the various crop commodities and are not uniquely part of cropping systems research.

**Indramayu**

Figure 11 shows the predominating cropping patterns used by farmers in the Indramayu area at the time research was begun in 1973. When existing farmer practice is compared with the long-term rainfall data and irrigation capabilities, some basis for cropping pattern redesign can be seen. Consequently, the following observations are not looked upon as problem identification but as potential for increased crop production, and improved farm economy.

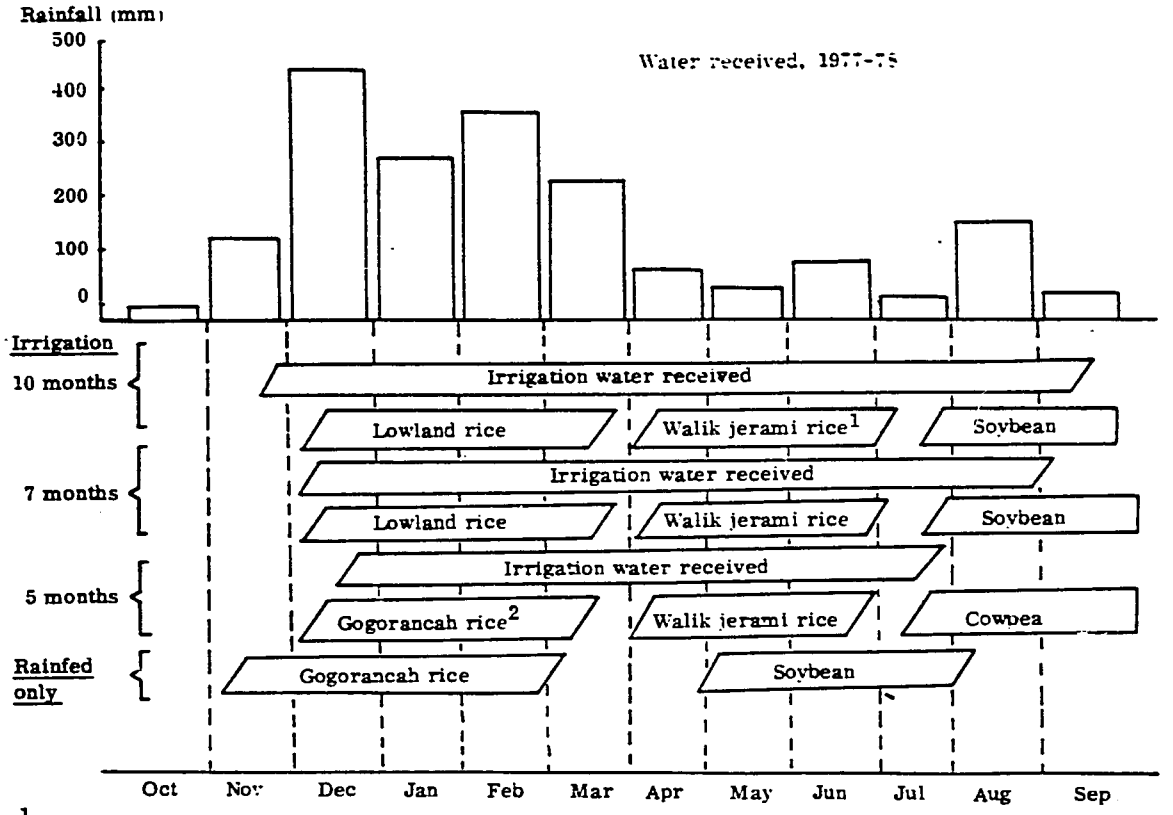
The second rice crops in the partially irrigated areas were not receiving water long enough to meet their requirements adequately. Practically no food crops other than rice (palawija crops) were grown. Direct seeding of rice by broadcasting or dibbling seed on aerobic soils (gogorancah) was practiced on a limited scale by farmers in partially irrigated areas and even less in rainfed areas. Lands were not being fully utilized and there were food shortages; yet labor, markets, agronomic potential, and time existed to permit increased crop production; and earlier maturing rice cultivars (less than 120 days) had been developed.

Figure 12 shows patterns that were tested in 1977-78 along with the rainfall distribution and irrigation water available for that crop year. These patterns had been tested as introduced patterns in the two previous crop years. Table 4 shows a summary of the results of testing farmers' and introduced cropping patterns for 3 years. The pre-production test plots (1977-78) were subjected to extreme weather conditions in that year: the




[1]Dry seeded rice that is later flooded.

Figure 11. Working calendar of farmers' cropping patterns, Indramayu, West Java, 1973.




[1]No tillage
[2]Dry seeded and later flooded

Figure 12. Working calendar of introduced cropping patterns, Indramayu, West Java, 1977-78.

Table 4. Comparison of average yields and economic returns from farmers' and introduced cropping patterns, CRIFC Cropping Systems Project, Indramayu, West Java, 1975-78.

| Cropping patterns | Irrigation Category | | |
|---|---|---|---|
| | 10 months | 7-9 months | 5-8 months |
| Farmers' cropping patterns[1] (1975-77) | | | |
| Lowland rice - (kg/ha) | 5,560 | 5,334 | 3,628 |
| Lowland rice - (kg/ha) | 5,820 | 2,758 | 2,250 |
| Net returns | $ 897.22 | $ 589.64 | $ 308.65 |
| Introduced cropping patterns[2] (1975-77) | | | |
| Lowland rice - (kg/ha) | 5,314 | 5,647 | 4,781 (GRR) |
| Walik jerami rice - (kg/ha) | 5,032 | 4,578 | 4,630 |
| Legume - (kg/ha) | 768 | 944 | 541 |
| Net returns | $ 893.16 | $ 993.50 | $ 524.40 |
| Introduced cropping patterns[3] (1977-78) | | | |
| Lowland rice - (kg/ha) | 6,915 | 7,195 | 3,451 (GRR) |
| Walik jerami rice - (kg/ha) | 4,910 | 4,550 | 2,901 |
| Soybean - (kg/ha) | 462 | 610 | -- |
| Cash surplus[4] to rice | $ 1,242.17 | $ 1,230.82 | $ 483.62 |

[1]Farmers' patterns as shown in Fig 11. Yields were measured by sampling from 100 $m^2$ plots. There were 3 replications/treatment per year for the 2 years, 1975-77.

[2]Introduced patterns as shown in Fig 12. Walik Jerami rice is directly planted after the preceding rice crop has been harvested without plowing the land. Gogo rancah rice (GRR) is rice directly seeded on aerobic soil at the beginning of rainy season, it is flooded later.

[3]Yields were measured by sampling from contiguous areas of approximately 3 ha for each irrigation category for pre-production test trials, 1977-78.

[4]Cash surplus is gross returns minus cash costs for materials and labor, while net returns is gross returns minus costs for all materials and labor, including farmers' labor.

rains were unusually late and began abruptly with high intensity in December; flooding was severe in the rainfed and partially irrigated areas; and unusually heavy rainfall continued through the dry season of 1978 so that it was more difficult to grow palawija crops during this period. Nevertheless, crops in the introduced cropping patterns performed well, particularly in the partially irrigated areas, when compared to the average results of the farmers' patterns tested the previous 2 years. The yield of the second rice crop in the 5-7 months irrigated area was reduced during 1977-78 in comparison to the first crop because of stem borer and unusual weather conditions. Nevertheless, the overall data showed that technology to improve rice yields, grow an extra crop per year, and increase net returns for these areas under these conditions was available. The new technology was dependent upon availability of earlier maturing and adapted cultivars of rice and on suitable soil and climatic conditions for gogorancah (dry seeded rice) and walik jerami (no tillage second rice crop).

These characteristicts and management techniques are shown in Photographs 1-6.

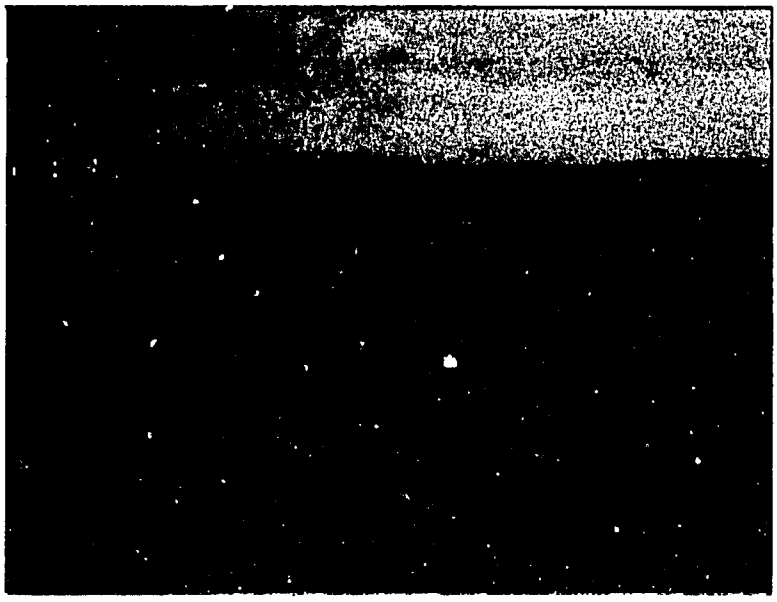
Implementation over an extended area is considered to be dependent upon the synchronized activities of government agencies (research, extension, irrigation, and local government) to regulate the use of water, cultivars, and cropping patterns in an appropriate irrigation or agroclimatic complex. Efforts to transfer the technology, fully, or in part, have been successful experimentally in Serang, West Java; Madura, East Java; and most notably in Nambah Dadi, Central Lampung (see Fig. 13). The last example will be discussed in the next section.

## Central Lampung

Figure 13 shows the predominating cropping patterns used by farmers in the partially irrigated lowland areas in Nambah Dadi village and the upland areas of Central Lampung. The farmers had become dependent upon the irrigation water in Nambah Dadi and grew only one rice crop per year in their irrigated fields, while they grew crops throughout the year in their upland fields. This is an unfortunate example of overdependence upon irrigation. Although it had not been our intention to work in an irrigated area, because of our experiences in Indramayu and observations that the land was underutilized, we established one site in Nambah Dadi.

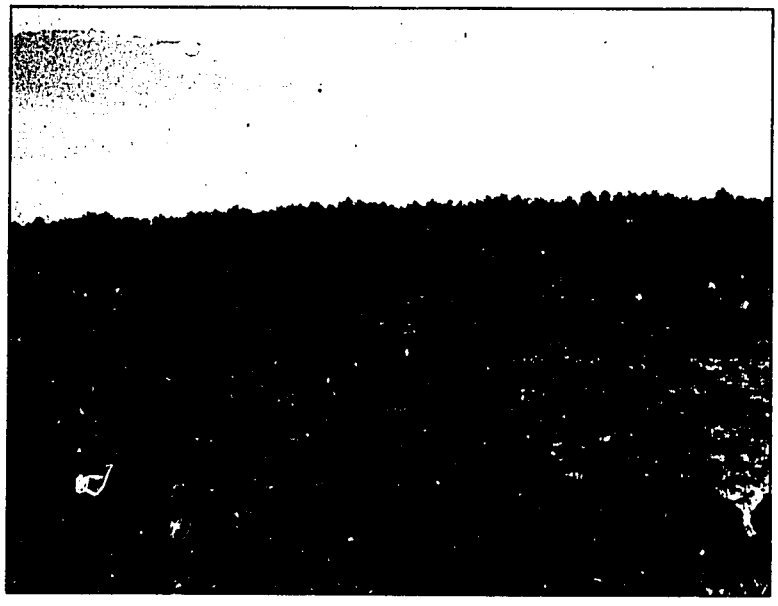
Lowland rice areas may be partially or fully irrigated or only rainfed. Where water control was a problem in Indramayu, the farmers usually grew only one crop of rice.

Constraints to more intensive crop production included flooding in rainy season and extreme dryness during dry season. Direct seeding of rice at the beginning of the rainy season on aerobic soil was one way to plant earlier and increase cropping intensity.

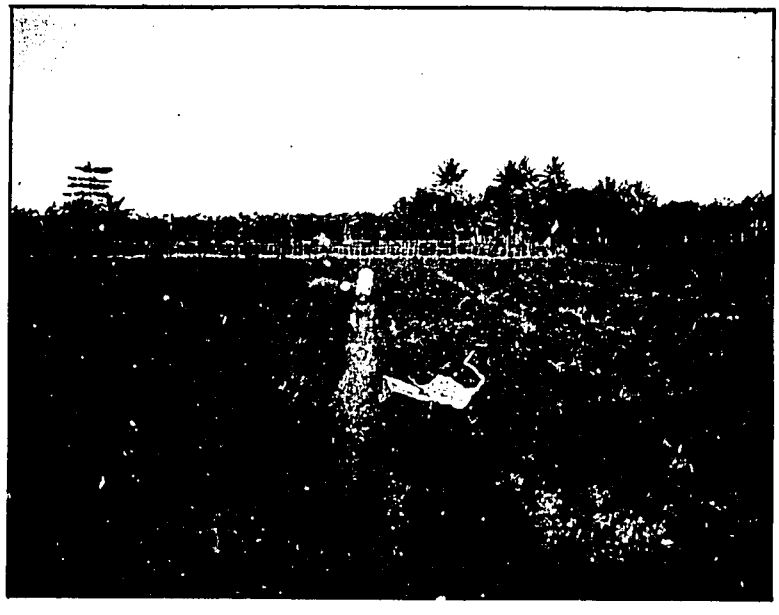


Rice direct seeded (gogorancah) at the beginning of the rainy season (right) grows like upland rice until rain or irrigation water floods the fields. Transplanted rice on left is suffering from water stress.

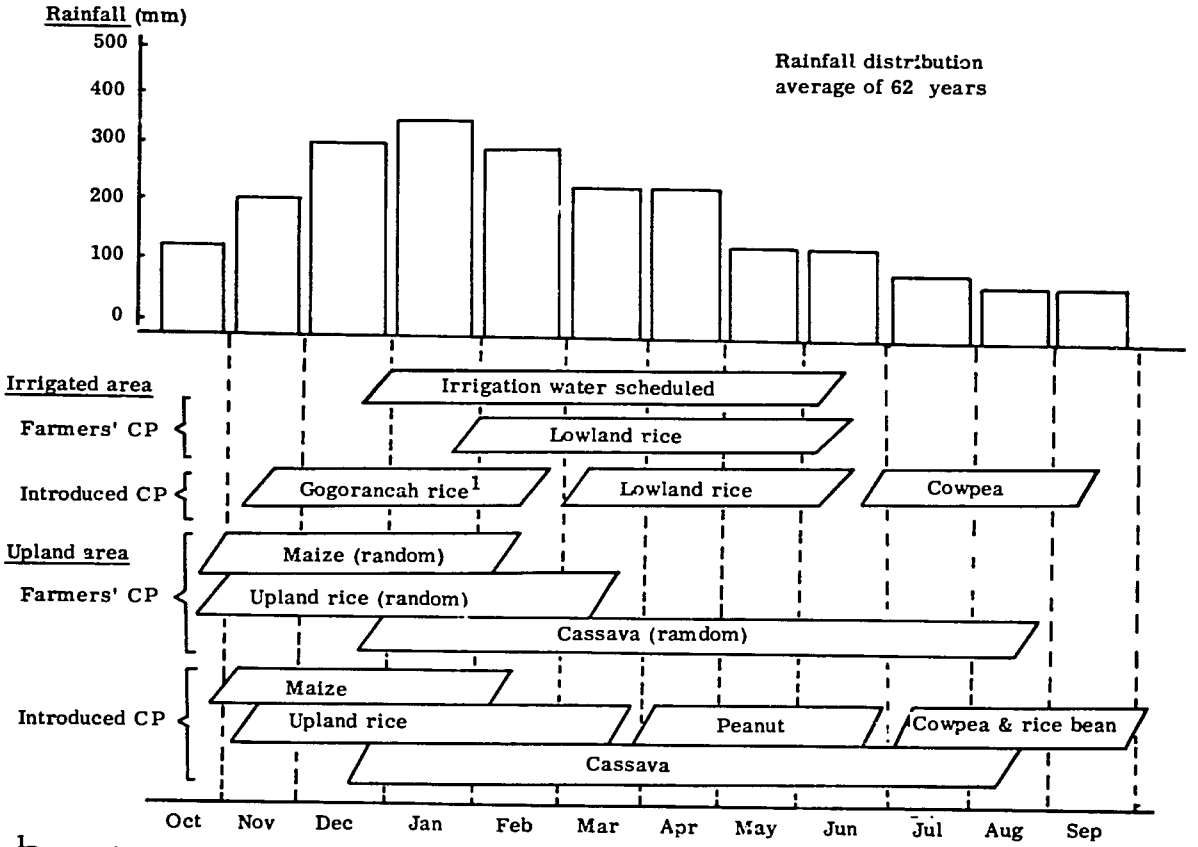
Also, earlier planting helps the first crop escape flooding in the middle of the rainy season in poorly drained areas and flood prone areas.



Reduction in turn around time between the first and second rice crops can be accomplished by directly transplanting into the mud without plowing (walik jerami).



Good drainage and earlier planting permits production of legume crops after two rice crops.




[1]Dry seeded rice that is later flooded

Figure 13. Working calender of farmers' and introduced cropping patterns (CP) Central Lampung, Lampung, 1977-78.

**Partially irrigated areas.** Our first attempts to improve the cropping patterns in this area consisted of introducing earlier maturing rice cultivars, reducing turn-around time between planting of rice crops in the wet season, and growing secondary crops during the dry season. We found that the supply of irrigation water was less dependable than anticipated and that we could not save enough time to get two lowland rice crops per season. But there appeared to be potential for growing legume crops during the dry season after the rice crops. We had tried gogorancah (direct seeding of rice on aerobic soil that will be flooded later) in some small plots and found that even though the rats and birds ate the rice because it was out of phase with the surrounding crops, the vigor of the crop of rice appeared good. The soil was considerably different from the alluvial clay soils of Indramayu (see Table 3), but other factors made the area suitable for this method of rice culture. First of all, the rainfall gradually increases over time (more than 2 months) to reach a peak suitable for flooding and rainfed lowland rice culture. This may be seen by comparing rainfall distribution data in Figures 11 and 13. Furthermore, there was sufficient rainfall to permit establishment of an upland crop. However, if the rainfall is high, aerobic conditions to permit continued cultivation of upland crops is possible only if these conditions are provided by extensive drainage facilities. Gogorancah rice, on the other hand, can be directly seeded on aerobic soil and then flooded. The usual benefits of flooding for control of weeds and improved nutrient availability result. Generally, in well-drained soil such as that existing in Nambah Dadi, excess drainge hinders gogorancah rice production. Furthermore, since the soil is not puddled when this cultural method is used, downward percolation of water and leaching of plant nutrients are excessive. Fortunately, because of the level topography of the partially-irrigated rice fields and the gradual raising of the water table with irrigation water and rainfall within the system, this problem did not occur. Table 5 shows the yields and economic returns from farmers' and introduced cropping patterns in this partially-irrigated area when the gogorancah technology was used in the improved pattern. The plots were about 3 ha in size and included fields of several farmers. This pre-production trial was sufficient evidence to many farmers to spontaneously adopt the technology. Thus, the technology was transferred from Java successfully and within the Nambah Dadi area. Considerable research effort and time were saved.

**Upland areas.** The other two sites were located in upland fields that were being newly opened (Komering Putih) and that had been opened several years before but had been allowed to

Table 5. Comparison of yields and economic returns from farmers' and introduced cropping patterns in pre-production trials in partially irrigated areas with 3 ha plots, CRIFC Cropping Systems Project, Nambah Dadi, Central Lampung, 1977-78.

| Cropping patterns[1] | Yield[2] (kg/ha) | Gross returns ($/ha) | Material cost ($/ha) | Hired labor cost ($/ha) | Cash surplus ($/ha) |
|---|---|---|---|---|---|
| Farmers' cropping pattern | | | | | |
| Lowland rice | 3,743 | 307 | 40 | 119 | 148 |
| Fallow | -- | -- | -- | -- | -- |
| | | | | Total | $ 148 |
| Introduced cropping pattern | | | | | |
| Gogo rancah rice | -5,563 | 617 | 72 | 207 | 338 |
| Walik jerami | -2,873 | 236 | 57 | 99 | 90 |
| Cowpea | 679 | 120 | 12 | 10 | 98 |
| | | | | Total | $ 516 |

[1]Farmers' and introduced patterns are diagrammed in Fig. 13. Gogo rancah rice is rice directly seeded on aerobic soil at the beginning of the rainy season; it is later flooded. Walik jerami rice is directly planted after the preceding rice crop, without tillage.

[2]Yields were measured by sampling from farmers' fields and from within the 3 ha of contiguous plot area. Cash surplus means gross returns minus cash costs of materials and labor only.

revert to Imperata (Bandar Agung). Figure 13 shows the predominating cropping pattern used by the farmers, which appeared to be well adapted to the existing soil, climatic, and market conditions, but the probability of increasing production by use of fertilizer, improved management practices (planting in rows), and introduction of more legumes into the systems appeared to be good. Research had begun in 1973 to evaluate these ideas. Tables 6 and 7 illustrate some of the dramatic results that were obtained. Yield and net return data show the advantage of planting in rows compared to random planting as practiced by the farmers. This was especially important for crops other than cassava when fertilizers were used. The data also show that the farmers' practice of growing combinations of crops was more productive and profitable than growing crops separately in sequence. Most of all, these data show the importance of improving soil fertility through use of fertilizer. This is further illustrated in Table 7, where the yield data for the intercropping patterns

Table 6. Average yield of crops and approximate net returns for check and full treatment plots, CRIFC Cropping Systems Project, Bandarjaya, Central Lampung, 1973-1974[1]

| Fertility Treatment | -----Dry grain (kg/ha)---- Maize | Upland rice | Peanut | Rice-bean | Fresh cassava t/ha) | Approximate net return ($/ha) |
|---|---|---|---|---|---|---|
| Mixed cropping | | | | | | |
| Check | 467 | 690 | 161 | 55 | 12.7 | 157 |
| Full treatment + mulch | 1,165 | 1,358 | 356 | 248 | 28.3 | 318 |
| Intercropping | | | | | | |
| Check | 455 | 769 | 222 | 93 | 14.6 | 219 |
| Full treatment + mulch | 1,350 | 2,724 | 567 | 627 | 23.2 | 639 |
| Sequential planting | | | | | | |
| Check | 606 | 850 | - | 153 | - | (-14) |
| Full treatment + mulch | 2,935 | 3,536 | - | 723 | - | (178 |

[1] Yields have subsequently varied somewhat due to pests and variable management practices but have remained basically the same.

Table 7. Calories and protein produced per ha from year-round cropping patterns with no and full fertilizer treatments, CRIFC Cropping Systems Project, Bandarjaya, Central Lampung, 1973-74.

| Cropping pattern | No treatment Yield (kg/ha) | Calories[1] (MCal/ha) | Protein (kg/ha) | Full treatment Yield (kg/ha) | Calories (MCal/ha) | Protein (kg/ha) |
|---|---|---|---|---|---|---|
| Maize + | 455 | 1,615 | 42 | 1,350 | 4,792 | 124 |
| Upland rice + | 769 | 1,840 | 52 | 2,724 | 6,521 | 185 |
| Cassava + | 14,600 | 17,520 | 102 | 23,200 | 27,840 | 162 |
| Peanut - | 222 | 1,003 | 51 | 567 | 2,563 | 145 |
| Rice bean | 93 | 308 | 23 | 627 | 2,075 | 157 |
| Total | | 22,286 | 276 | | 43,791 | 773 |
| Gabah[2] equipment (kg/ha per year) | | 9,325 | 4,060 | | 18,323 | 11,371 |

[1] Calories = Food calories or kilogram calories and MCal = Mega food calories

[2] Gabah x. 665 = milled rice and average value of 6.8% protein used for conversion from protein to gabah.

are expressed in terms of calories, protein, and rice (gabah equivalent). Thus, if properly managed, the total production per hectare on these nonirrigated and underutilized uplands can exceed that of the irrigated and fertile lowland areas of Java.

Extensive and systematic cropping systems studies were started to test this technology in farmers' fields under different conditions within the target area. In 1975, sites were established in Bandar Agung and Komering Putih, Central Lampung. In succeeding years, sites were established in Way Agung, North Lampung; Baturaja, South Sumatra; and Tajau Pecah, South Kalimantan (Fig. 14). These sites were similar in many respects to the description given for Bandarjaya in Table 3.

Characteristics of these areas and management techniques used for the introduced patterns are shown in Photographs 7-12.

Yield and economic data are shown in Tables 8, 9 and 10. Tables 8 and 9 show the data from the first and second years, respectively, for the sites mentioned above. Basically, the same cropping patterns and management practices that were used in Bandarjaya were transferred intact to those sites. The data show dramatically the increased production and economic returns that could be expected by use of the introduced technology. But the data also show that usually there were general improvements in cropping pattern performances during the second or succeeding years in a site. This kind of fine tuning is to be expected and probably indicates improvement in management techniques. Not only do the researchers improve their techniques but more importantly, the neighboring farmers gradually adopt low-input practices such as planting in rows, using improved cultivars, and using small amounths of fertilizer. An example of this took place in Komering Putih in 1976-77 (Table 9), where farmers' crop yields and economic returns increased compared to the previous year (Table 8). Furthermore, provincial extension agents began to disseminate technology through conversations with farmers before production programs were initiated. With the fragile local economy, and given the economic status of the farmers, technologies that require considerable money for inputs such as fertilizer, insecticides, and legume seeds are not readily adopted.

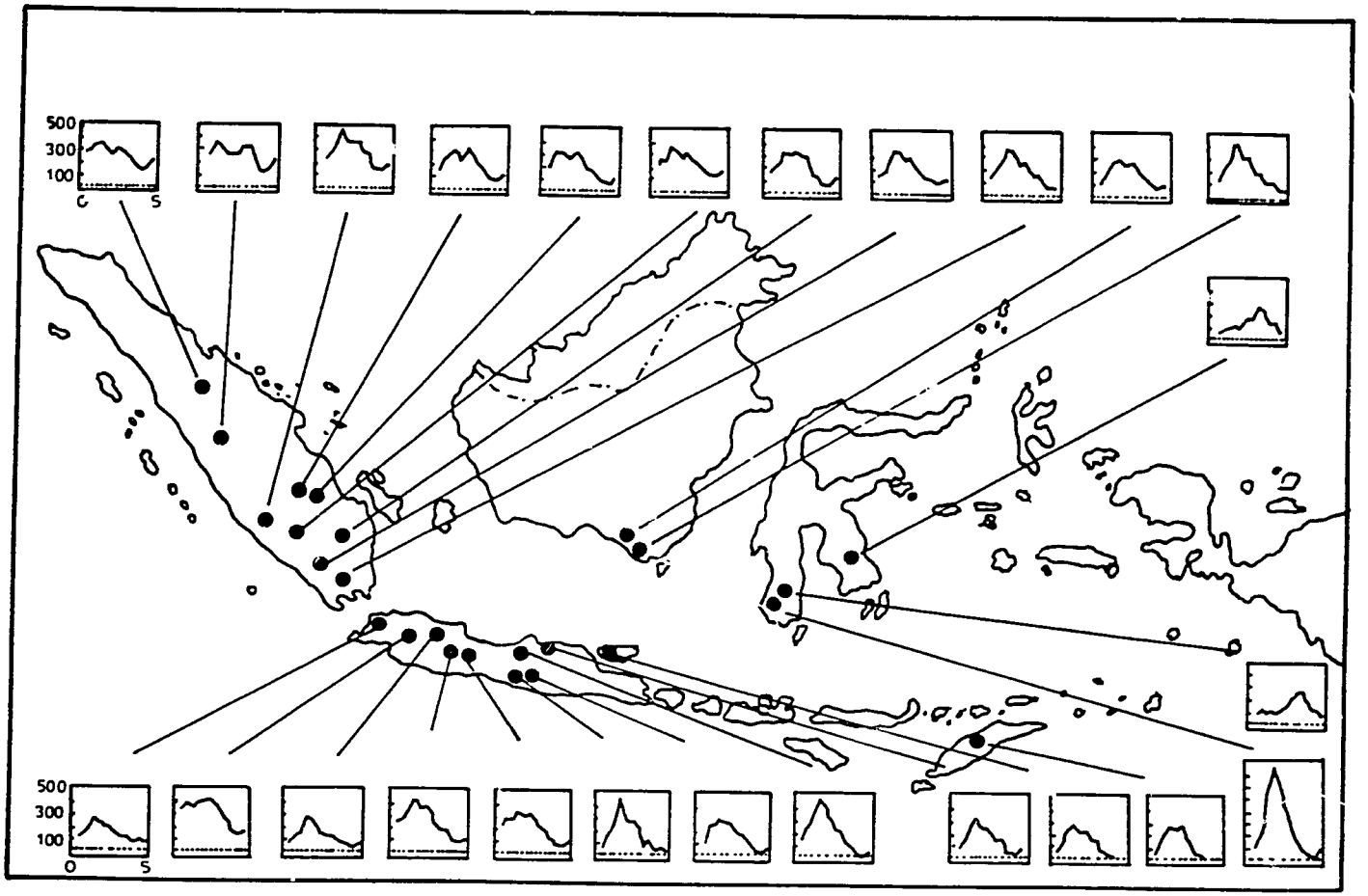
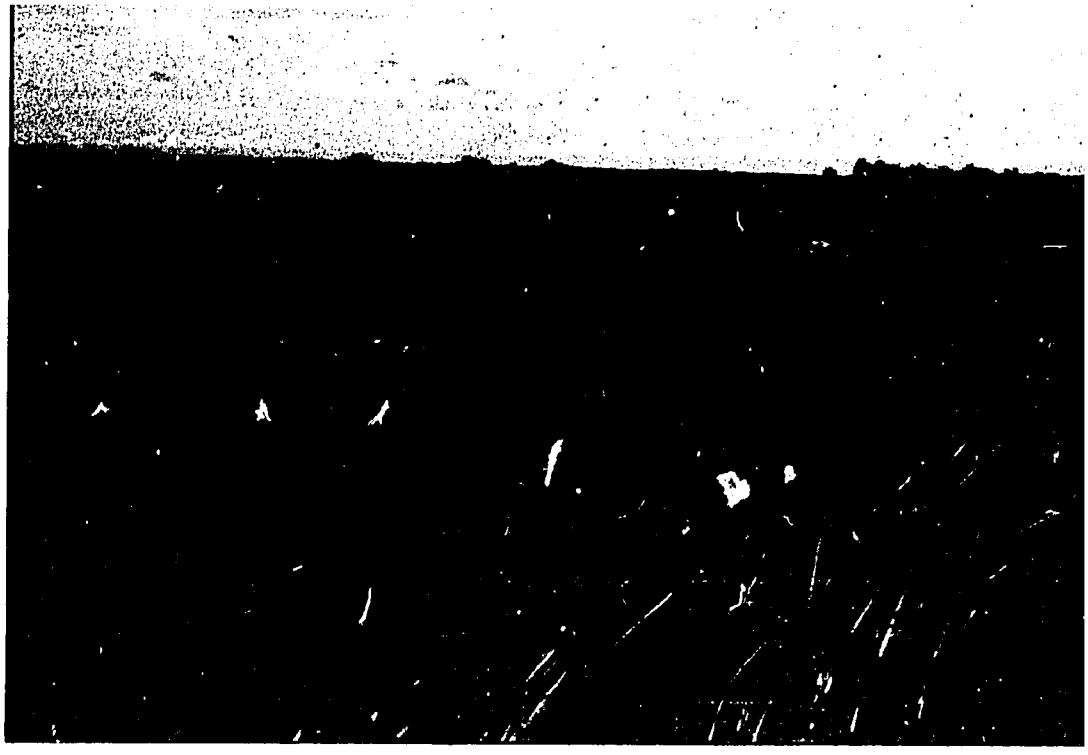



Fig. 14. Location and rainfall pattern of cropping systems projects in Indonesia. 1981.



Even though upland areas covered with Imperata cylindrica are not very productive, they are well protected from erosion.

Opening land from Imperata takes place during the dry season. The tops are cut, the ground dug and the rhyzomes dried and removed.

While opening land from forests, care must be taken to minimize damage to the soil.

Early maturing crops like maize and rice are planted together at the beginning of the rainy season. Cassava is interplanted in the corn rows.

After corn harvest the cassava grows up through the rice. The rice is soon harvested and is not seriously affected by the cassava.

After harvest of maize and upland rice legumes are interplanted between the cassava rows and the rice straw is used as mulch. The cassava eliminated turn-around time in this efficient year around system.

Table 8. Comparison of yields and economic returns from farmers' and introduced cropping patterns for first year results from different locations, (CRIFC) Cropping Systems Project, Lampung, South Sumatra, and Kalimantan, 1975-79.

| Cropping patterns | Yields (kg/ha) and net returns | | | | |
|---|---|---|---|---|---|
| | Bandar Agung (1975-76) | Komering Putih (1975-76) | Way Abung (1976-77) | Batu Raja (1976-77) | Tajau Pecah (1978-79) |
| **Farmers' cropping pattern** | | | | | |
| Maize + | 235 | 287 | 569 | 332 | 3,000 ears |
| Upland rice + | 722 | 461 | 1,975 | 1,043 | 1,030 |
| Cassava + | -- | 7,975 | 9,767 | 5,890 | -- |
| Peanut[1] | (M) 793 | -- | -- | 329 | 8,270 ears |
| Net returns | $ 55.17 | $ 78.61 | $ 280.61 | $ 183.29 | $ 81.53 |
| Gabah rice equivalent (t/ha per year) | 2.24 | 4.87 | 7.66 | 5.94 | -- |
| **Introduced cropping pattern** | | | | | |
| Maize + | 1,798 | 2,140 | 1,169 | 1,877 | 698 |
| Upland rice + | 1,094 | 1,231 | 1,858 | 746 | 1,665 |
| Cassava + | 11,151 | 9,933 | 22,200 | 16,649 | 7,200 |
| Peanut[2] - | -- | -- | 567 | 499 | (CP) 332 |
| Rice bean | -- | -- | 228 | 531 | -- |
| Net returns | $ 180.05 | $ 144.34 | $ 348.49 | $ 269.48 | $ 357.93 |
| Gabah rice equivalent (t/ha per year) | 9.33 | 9.36 | 16.07 | 13.52 | -- |

[1] Occasionally maize (M)
[2] Occasionally cowpea (CP)

Table 9. Comparison of yields and economic returns from farmers' and introduced cropping patterns for second year's results from different locations, (CRIFC)Cropping Systems Project, Lampung and South Sumatra, 1976-78.

| Cropping patterns | Yields (kg/ha) and net returns | | | | |
|---|---|---|---|---|---|
| | Bandar Agung (1976-77) | Komering Putih (1976-77) | Way Abung (1976-77) | Batu Raja (1977-78) | Lahat Tebing tinggi (1977-78) |
| **Farmers' cropping pattern** | | | | | |
| Maize + | 759 | 337 | 924 | 405 | None |
| Upland rice ≠ | 2,018 | 1,562 | 1,905 | 1,877 | None |
| Cassava ≠ | -- | 18,333 | 9,788 | -- | None |
| Peanut[1] | (M) 806 | -- | -- | 525 | None |
| Net return | $ 260.84 | $ 374.68 | $ 295.91 | $ 311.76 | |
| Gabah rice equivalent (t/ha per year) | 4.33 | 11.23 | 8.16 | 3.46 | |
| **Introduced cropping pattern** | | | | | |
| Maize + | 1,977 | 2,080 | 2,553 | 1,626 | 2,440 |
| Upland rice ≠ | 1,689 | 1,022 | 3,688 | 1,076 | 2,822 |
| Cassava ≠ | 21,125 | 26,110 | 19,888 | 14,710 | 14,867 |
| Peanut[1] | (M) 1,739 | 385 | 580 | 573 | 551 |
| Rice bean[2] | (CP) 328 | -- | 290 | 544 | 284 |
| Net returns | $ 509.63 | $ 475.01 | $ 964.10 | $ 415.39 | $ 889.00 |
| Gabah rice equivalent (t/ha per year) | 18.22 | 17.88 | 18.89 | 12.67 | 15.29 |

[1] Occasionally maize (M)
[2] Occasionally cowpea (CP)

Table 10. Comparison of yields and economic returns from farmers' and introduced cropping pattern in pre-production trials in upland area with 3 ha plots, (CRIFC) Cropping Systems Project, Bandar Agung, Central Lampung, 1977-78.

| Cropping patterns[1] | Yields and Cash Surplus | | | | |
|---|---|---|---|---|---|
| | Yield (kg/ha) | Gross return ($/ha) | Material cost ($/ha) | Hired Labor cost ($/ha) | Cash surplus ($ /ha) |
| Farmers cropping pattern | | | | | |
| Maize + | 396 | 65.22 | 48.80 | 80.81 | 272.59 |
| Upland rice | 1,418 | 336.93 | - | - | |
| Gabah rice equivalent (t/ha per year) | 2.0 | | | Total | $ 272.59 |
| Introduced cropping pattern | | | | | |
| Maize + | 1,105 | 182.00 | - | - | -- |
| Upland rice + | 2.965 | 704.62 | - | - | -- |
| Cassava + | 29,331 | 107.04 | 148.35 | 176.92 | 900.90 |
| Maize - | 2,653 | 210.25 | - | - | - |
| Cowpea | 86 | 22.26 | - | - | - |
| Gabah rice equivalent (t/ha per year) | 23.16 | | | Total | $ 900.90 |

[1] Farmers' and introduced patterns are variants from Table 8. Farmers in this area have jobs on nearly plantations. They have develop a reasonably good market for maize and are just beginning to see the value of cassava.

## Technology Developed for Subsequent Target Areas (1978-80)

The methodology for cropping systems research was well developed by 1978, and technologies developed in Indramayu and Lampung were directly applicable to new areas with similar site descriptions (see Fig. 10). Consequently, the time required for each phase of the cropping systems methodology could be reduced considerably and the total time required to complete the research phases in similar target areas could be reduced from 3-5 years to 2-3 years. This was the situation for rainfed areas (both lowland and upland) in Madura, East Java and Tajau Pecah, South Kalimantan.

In addition to cropping systems, studies were made to develop relevant component technologies for each crop in the patterns. The results of these studies are not included because of the routine nature of the methodology as well as the results.

**Madura, East Java**

Madura has an old culture, and the land has been intensively cultivated for many years. Production of rainfed upland crops has been constrained by low soil fertility and by drought conditions. Crop removal and erosion have exacerbated the soil fertility problems. To reduce drought risk and soil fertility problems farmers use early maturing cultivars of maize (± 65 days) and intercrop with other food crops, particularly peanut. They frequently plant three crops of maize + peanut per year. Cropping patterns and fertilizer management strategies used in earlier studies offered good possibilities for increased and stable crop production.

The rainfed lowland areas have been more stable and productive. The usual practice has been to transplant rice after sufficient rain has fallen to permit flooding and puddling of the soil, and there was usually not enough time and rainfall prior to planting the rice to permit production of upland crops; nor was there enough time and water after the rice harvest to grow another crop. Furthermore, farmers were not using the most recently released early maturing rice cultivars particularly IR 36. Consequently, the strategy of direct seeding early maturing cultivars of rice on aerobic soils (gogorancah) offered the possibility of getting a good harvest of rice plus a subsequent upland crop or perhaps even another rice crop.

The results from the first year's studies were affected by the inexperience of the staff in carrying out research in farmers' fields. Problems identified the first year were corrected, and the results of the second year, which are included here, were satisfactory.

**Category I - Upland rainfed area.** The cropping intensity of the farmers' existing pattern was already high. They planted the intercrop combination of maize + peanut three times per year. The farmers' cropping pattern was evaluated under the reseachers' management (I A2) and was compared with results from farmers' management (I A1), as shown in Figure 15.

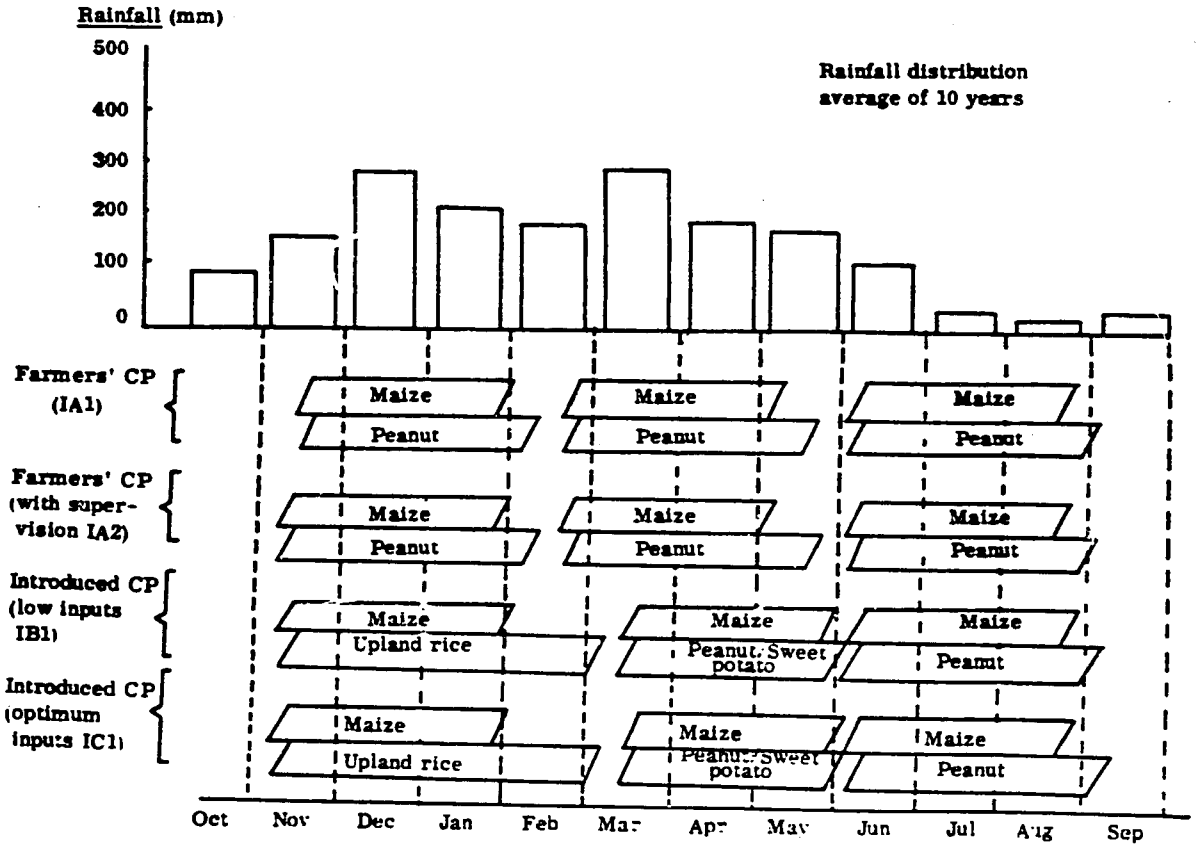



Figure 15. Rainfall distribution and cropping patterns (CP) tested in rainfed upland areas (Category I), Blega, Madura. 1979-80.

Cropping pattern (CP) A2 apparently gave the highest net return among the patterns tested (Table 11). The net returns from CP A2 were almost double those from the same pattern but under farmers' management (CP A1). In CP A2 more emphasis was put on peanut, which has higher economic value than maize. The yield of maize in CP A2 was lower compared with the yield from CP A1 because of a lower maize population, but the peanut yields in CP A2 were much higher than those from CP A1. The net returns from the introduced patterns with low and high inputs (CP B1 and CP C1) were also higher than those from CP A1. The higher returns in the introduced patterns were mostly due to the high yields from upland rice. However, CP A1 had the highest ratios of returns to labor and material costs because of lower total variable costs compared with those from the introduced patterns. Consequently, without government support programs, farmers are often not inclined to increase fertilizer and labor inputs and adopt cropping systems which require higher investments.

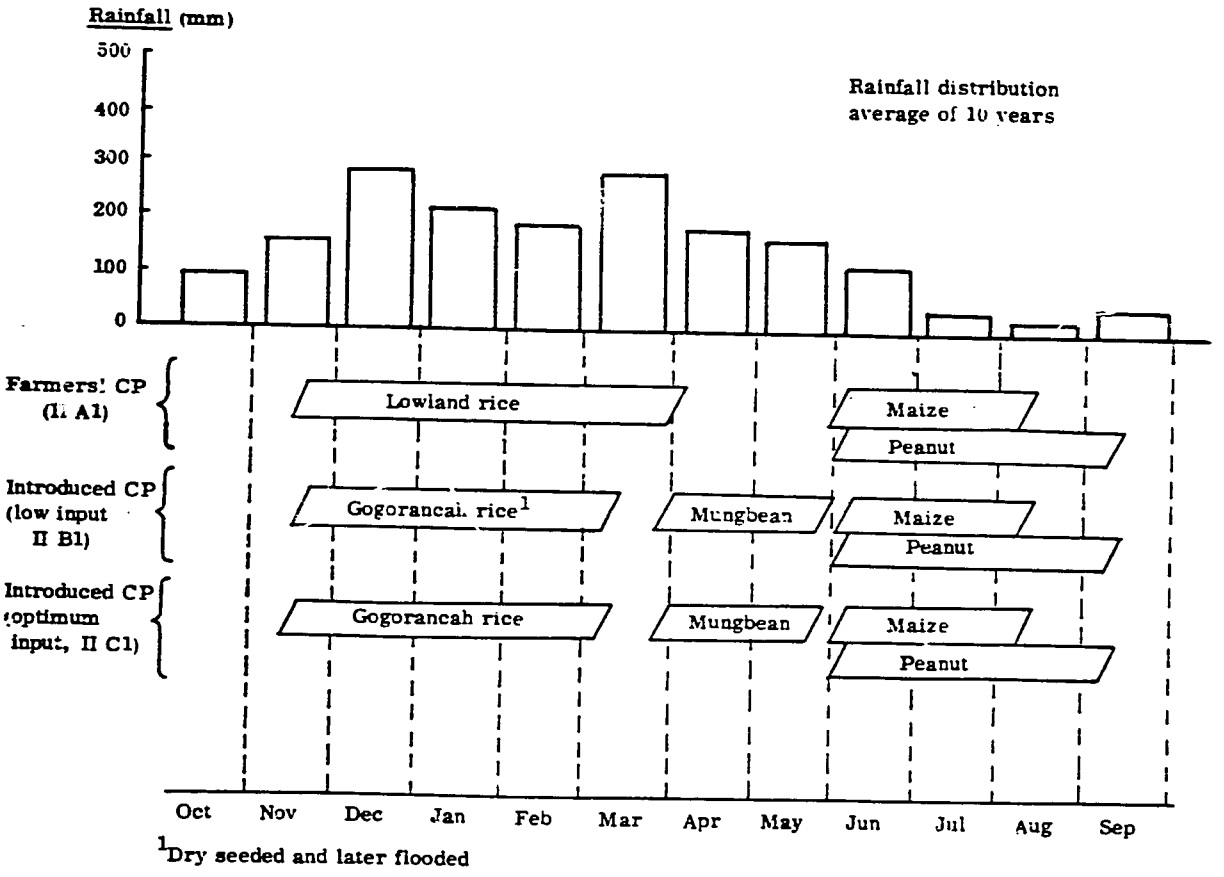
**Category II - Rainfed lowland, hilly area.** Because of the undulating landscape, run-off and percolation rates are high and there is not enough water to grow two rice crops. The farmers' cropping pattern included only one rice crop followed by a maize + peanut intercrop (Fig. 16). The introduced pattern involved only one rice crop as gogorancah (direct seeded), followed by mungbean and the maize + peanut intercrop. The returns obtained from the introduced patterns (both with low and high inputs) were higher than those from the farmers' pattern (Table 12), but there were only small differences between the low and high input introduced patterns, suggesting the need for further studies to determine optimum input levels. The data also suggested that production programs with low input costs could be quickly developed to implement new technologies, which happened the following year with support from the Provincial Agricultural Services.

**Category III - Rainfed lowland, low lying area.** Cropping patterns were tested in this category in two locations, Blega (Fig. 17) and Jrengek (Fig. 18), Madura. The highest net return in Blega was obtained from the introduced cropping pattern (CP C2, Table 13). The sequence involved in this pattern was direct seeded (gogorancah) rice - transplanted (walik jerami) rice - maize + mungbean. The return was about 3.5 times that from the farmers' pattern. By using peanut instead of mungbean in CP C1, lower returns were obtained, but they were still more than two times those from the farmers' pattern. The farmers'

Table 11. Summary of the results of cropping patterns[1] tested for the upland rainfed areas (Category I), Blega, Bangkalan, Madura, 1979-80.

| Observations | Farmers' CP[2]A1 (usual) M+PNT-M+PNT-M+PNT | Farmers' CPA2 (supervised) M+PNT-M+PNT-M+PNT | Introduced CPB1 (low input) M+ULR-M+PNT-M+PNT | Introduced CPC1 (optimum input) M+ULR-M+PNT-M+PNT |
|---|---|---|---|---|
| **Crop yields (t/ha)** | | | | |
| Maize 1 | 0.51 | 0.38 | 0.58 | 0.83 |
| Maize 2 | 0.51 | 0.44 | 0.28 | 0.31 |
| Maize 3 | 0.27 | 0.13 | 0.78 | 0.12 |
| Peanut 1 | 0.57 | 1.33 | 0.64 | 0.73 |
| Peanut 2 | 0.68 | 1.35 | 0.78 | 0.81 |
| Peanut 3 | 0.45 | 0.54 | - | - |
| Upland rice | - | - | 4.50 | 5.10 |
| Sweet potato | .. | - | - | - |
| **Economic evaluation** | | | | |
| Labor costs ($/ha) | 297.92 | 461.29 | 491.28 | 572.62 |
| Material costs ($/ha) | 74.99 | 185.98 | 147.26 | 238.35 |
| Total variable costs ($/ha) | 372.92 | 647.28 | 638.54 | 811.00 |
| Gross returns ($/ha) | 1,037.66 | 1,942.05 | 1,521.73 | 1,704.50 |
| Returns to labor costs | 3.2 | 3.8 | 2.8 | 2.6 |
| Returns to material costs | 9.9 | 8.0 | 7.0 | 4.8 |
| Net returns ($/ha) | 664.75 | 1,294.77 | 883.19 | 893.50 |

[1]M = maize, PNT = peanut, ULR = upland rice
[2]CP = Cropping Pattern.




[1]Dry seeded and later flooded

Figure 16. Rainfall distribution and cropping patterns (CP) tested in rainfed lowland - upper areas (Category II), Blega, Madura, 1979-80.

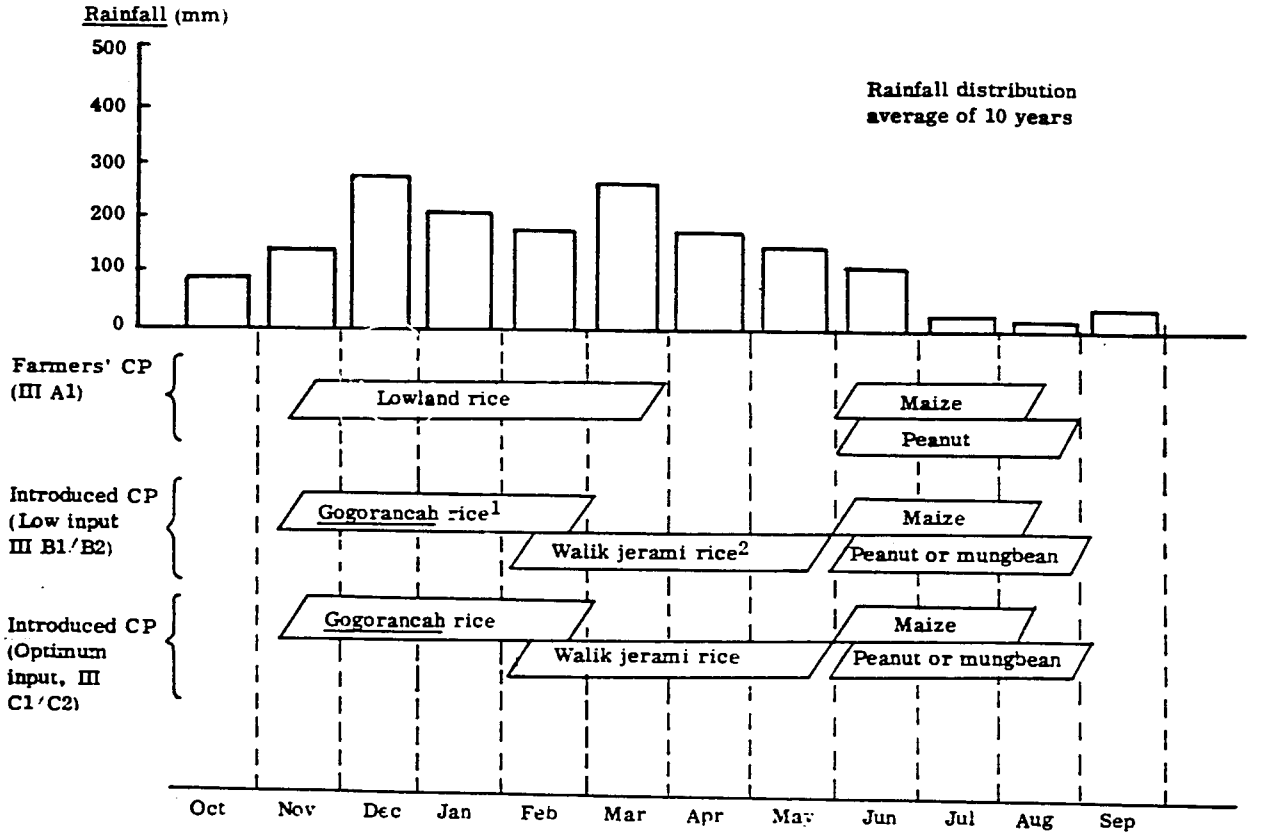
Table 12. Summary of the results of cropping pattern[1] study for the rainfed upper (hilly topography) areas (Category II), Blega, Bangkalan, Madura, 1979-80.

| Observations | Farmer's CP[2] A1 (usual) LLR-F-M-PNT | Introduced CP B1 (low input) GRR-Mb-M-PNT | Introduced CP C1 (optimum input) DSR-Mb-M-PNT |
|---|---|---|---|
| Crop yields (t/ha) | | | |
| Rice | 2.90 | 4.40 | 4.70 |
| Maize | 0.33 | 0.23 | 0.26 |
| Peanut | 0.44 | 0.85 | 0.94 |
| Mungbean | - | 0.11 | 0.19 |
| Economic evaluation | | | |
| Labor costs ($/ha) | 233.44 | 271.68 | 313.70 |
| Material costs ($/na) | 58.86 | 134.10 | 198.82 |
| Total variable costs ($/ha) | 292.30 | 405.78 | 512.52 |
| Gross returns ($/na) | 703.38 | 1199.74 | 1336.67 |
| Returns to labor costs | 2.8 | 4.0 | 3.6 |
| Returns to material costs | 8.0 | 7.0 | 5.1 |
| Net returns ($/ha) | 411.08 | 793.96 | 824.15 |

[1]LLR = lowland rice, F = fallow, M = maize, PNT = peanut, Mb = mungbean, GRR = gogorancah rice, DSR = dry seeded rice.

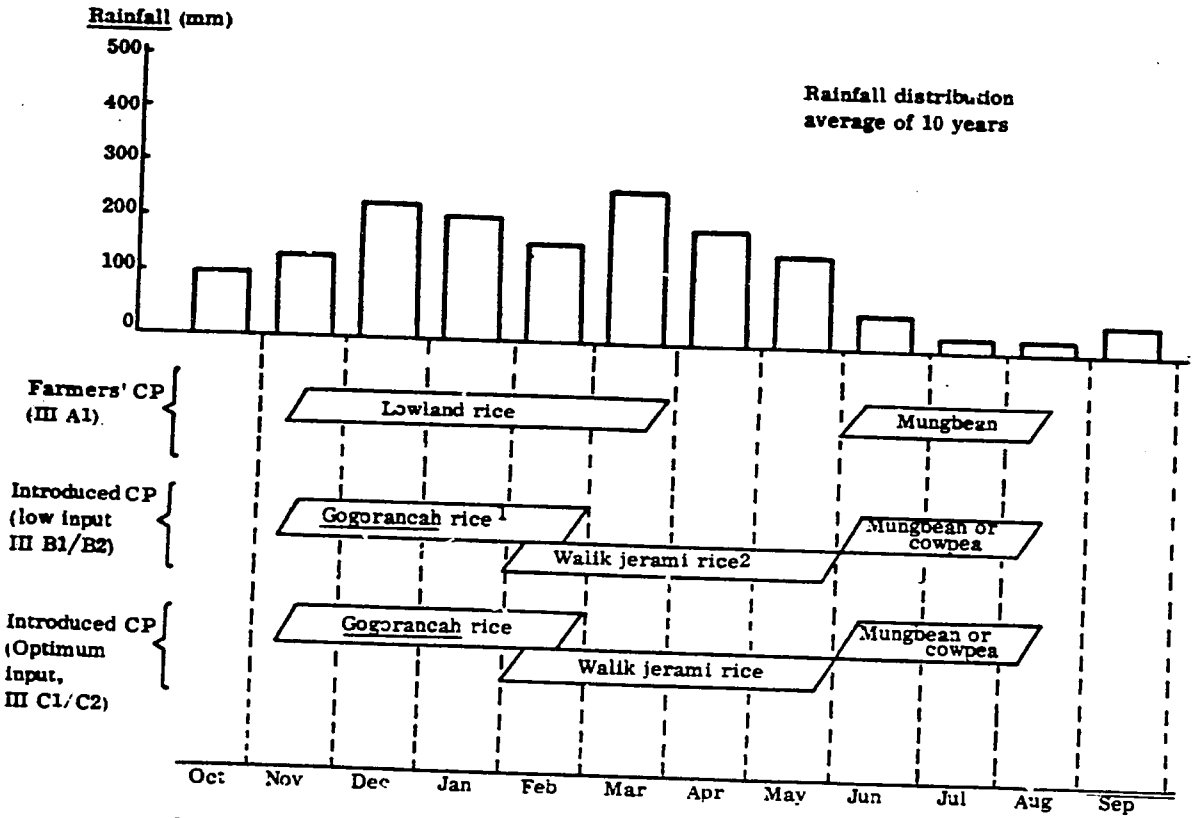
pattern included only one rice crop followed by maize + peanut intercrop. The other introduced patterns (CP B1 and CP B2), which were lower input versions of CP C1 and CP C2, also included two rice crops followed by maize + peanut or maize + mungbean intercrops and gave net returns higher than those from the farmers' pattern. CP B1, which was a low input version of CP C1, gave about the same net return as CP C1. This was due to the lower peanut yield from CP C1 compared with that of CP B1. Mostly, however, these results show that great improvements can be made in the farmers' pattern by the introduction of gogorancah (direct seeded) rice as the first crop.

Results from patterns tested (Fig. 18) in the same category in Jrengek (Table 14) also show the benefits of introducing gogorancah in the cropping pattern. All of the introduced patterns gave higher returns than those from the farmers' pattern, and there were no consistant and marked differences between the introduced patterns that received low and high inputs, suggesting that increasing inputs (fertilizers, insecticides) does not necessarily give significant increases in net returns.




[1]Dry seeded and later flooded
[2]No tillage

Figure 17. Rainfall distribution and cropping patterns (CP) tested in rainfed lowland – lowlying areas (Category III), Blega, Madura, 1979–80.




[1]Dry seeded and water flooded
[2]No tillage

Figure 15. Rainfall distribution and cropping patterns (CP) tested in rainfed lowland - lowlying areas (Category III), Jrengek, Madura. 1979-80.

Table 13. Summary of rhe results of cropping patterns[1] tested for the rainfed lowland, lowlying areas (Category III), Blega, Madura, 1979-80.

| Observations | Farmers CP[2] A1 (usual) LLR-F-M+PNT | Introduced CP B1 (low input) GRR-WJR-M+PNT | Introduced CP B2 (low input) GRR-WJR-M+MB | Introduced CP C1 (optimum input) GRR-WJR-M+PNT | Introduced CP C2 (optimum input) GRR-WJR-M+MB |
|---|---|---|---|---|---|
| Crop yields (t/ha) | | | | | |
| Transplanted rice | 2.80 | 2.43 | 2.43 | 3.63 | 3.63 |
| Dry seeded rice | - | 4.40 | 4.40 | 5.53 | 5.53 |
| Maize | 0.37 | 0.18 | 0.26 | 0.41 | 0.26 |
| Peanut | 0.50 | 1.17 | - | 0.42 | - |
| Mungbean | - | - | 0.80 | - | 1.38 |
| Economic evaluation | | | | | |
| Labor costs ($/ha) | 244.80 | 454.33 | 454.33 | 490.79 | 493.83 |
| Material costs ($/ha) | 54.72 | 152.30 | 120.82 | 257.90 | 221.92 |
| Total variable costs ($/ha) | 299.52 | 606.63 | 575.15 | 748.69 | 715.75 |
| Gross returns ($/ha) | 725.30 | 1664.18 | 1513.45 | 1863.73 | 2193.18 |
| Returns to labor costs | 2.7 | 3.3 | 3.1 | 3.3 | 4.0 |
| Returns to material costs | 8.8 | 7.9 | 8.8 | 5.3 | 7.7 |
| Net returns ($/ha) | 425.78 | 1057.55 | 938.30 | 1115.04 | 1477.43 |

[1] LLR = lowland rice, F = fallow, M = maize, PNT = peanut, GRR = gogo rancah rice
WJR = walik jerami rice, MB = mungbean

[2] CP = Cropping pattern.

Table 14. Summary of the results of cropping patterns[1] tested for the rainfed lowland, lowlying areas (Category III), Blega, Madura, 1979-80.

| Observations | Farmers CP[2] A[1] (usual) LLR-F MB | Introduced CP B[1] (low input) GRR-WJR-MB | Introduced CP B[2] (low input) GRR-WJR-CP | Introduced CP C[1] (optimum input) GRR-WJR MB | Introduced CP C[2] (optimum input) GRR-WJR-CP |
|---|---|---|---|---|---|
| Crop yields (t/ha) | | | | | |
| Transplanted rice | 2.75 | 4.80 | 4.80 | 5.10 | 5.10 |
| Dry seeded rice | - | 3.50 | 3.50 | 3.80 | 3.80 |
| Mungbean | 0.46 | 0.41 | - | 0.48 | - |
| Cowpea | - | - | 0.14 | - | 0.18 |
| Economic evaluation | | | | | |
| Labor costs ($/ha) | 230.79 | 478.93 | 464.52 | 532.95 | 517.65 |
| Material costs ($/ha) | 34.82 | 113.32 | 125.10 | 203.22 | 215.00 |
| Total variable costs ($/ha) | 265.61 | 592.25 | 589.62 | 736.17 | 732.66 |
| Gross returns ($/ha) | 674.33 | 1482.48 | 1321.20 | 1604.72 | 1421.60 |
| Returns to labor costs | 2.8 | 2.9 | 2.6 | 2.6 | 2.3 |
| Returns to material costs | 12.7 | 8.9 | 6.9 | 5.3 | 4.2 |
| Net returns ($/ha) | 408.72 | 890.23 | 731.58 | 868.55 | 688.94 |

[1]LLR = lowland rice, F = fallow, MB = mungbean, GRR = gogorancah rice, WJR = walik jerami rice, CP = cowpea.
[2]CP = Cropping pattern.

## South Kalimantan

The studies and the results in the upland rainfed areas were very similar to those from Lampung. The studies in the drained tidal swamp areas, however, were initial efforts. The experiences of farmers in the target areas as well as some previous work by Gadjah Mada University provided some bases for the cropping pattern design.

**Upland rainfed area, Tajau Pecah.** Based on rainfall distribution three cropping patterns were designed and tested for two years, 1978-80 (Fig. 19). Data for 1979-80 are shown in Table 15.

In Cropping Pattern A (farmers' pattern), priority was given to upland rice planted at the start of rainy season, and maize was intercropped after the rice was 1 month old. Planting the upland rice crop early caused stand establishment problems (only about 74%) due to insufficient and poor distribution of the rainfall at the beginning of the rainy season.

In Cropping Patterns B and C (Introduced patterns), maize was planted at the beginning of the rainy season and upland rice was planted when the amount and distribution of rainfall were sufficient to sustain its growth. In both these patterns cassava was interplanted in the maize and rice. The cassava provides high calorie food (Table 15) during the dry season as well as some excess to sell. These two introduced patterns were similar in all respects except for levels of inputs and management. CP B represented an intermediate level of management, while CP C represented a higher level.

From the yields and economic analyses it appears that the intermediate level of technology is more appropriate at present, most likely due to the lack of well adapted cultivars of crops that are responsive to higher management, even though the introduced patterns (B and C) with four crops (maize + upland rice + cassava + peanut) in the rainy season gave about twice the gross returns of CP A. Total calories produced in CP B and C were about three times higher than for CP A (Table 15).

Among the crops that can be planted after upland rice, maize involves the least risk and can be sold easily. Because the farmers usually plant late maturing cultivars of upland rice, peanut planted after upland rice is likely to be severely infested

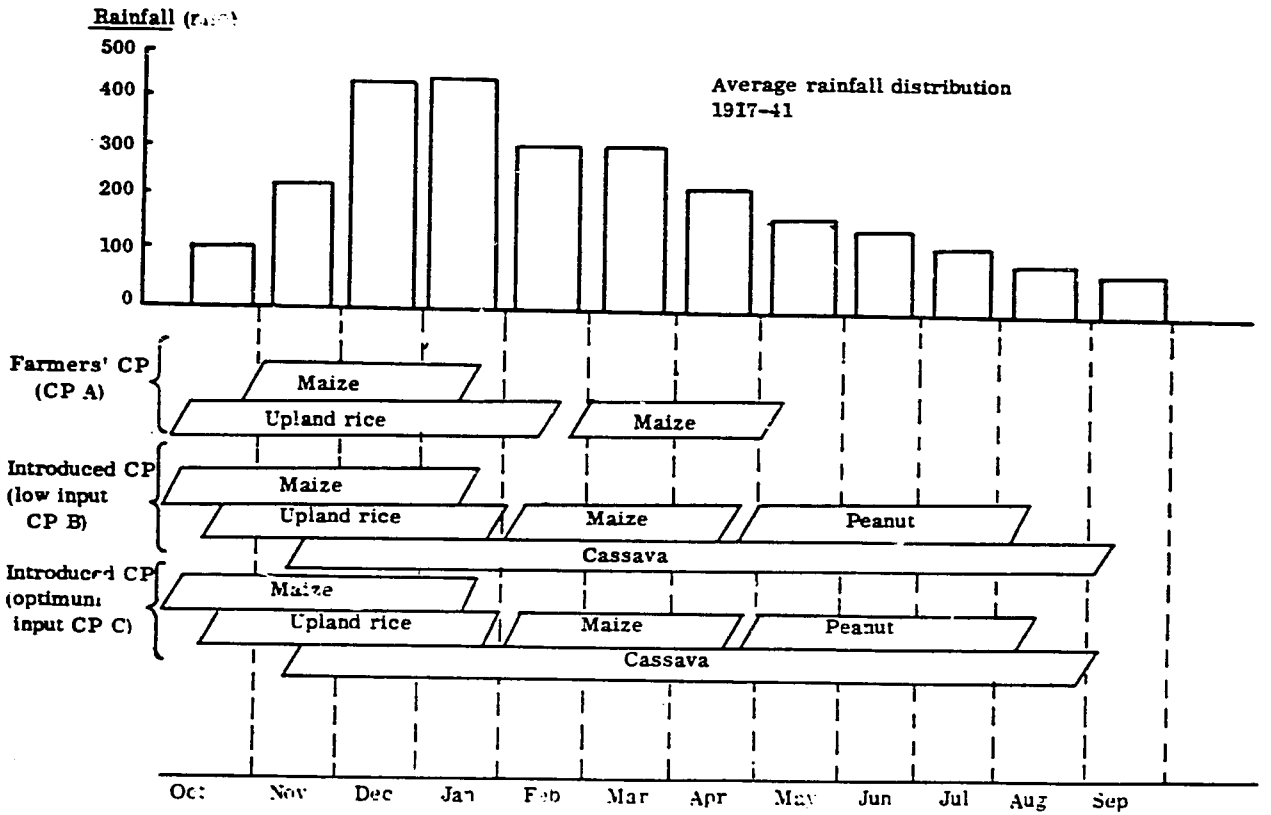



Figure 19. Rainfall distribution and cropping patterns (CP) tested in upland rainfed area, Tajau Pecah, South Kalimantan, 1978–80.

Table 15. Average yield, value, calories, and protein per ha in upland rainfed area, Tajau Pecah, South Kalimantan, 1979-80.

| Cropping pattern | Yield (t/ha) | Gross returns ($/ha) | Net returns ($/ha) | Calories (M Cal/ha) | Protein (kg/ha) |
|---|---|---|---|---|---|
| Farmers' CP[3]A | | | | | |
| Upland rice + | 1.48 | 295.41 | | 3.530 | 100 |
| Maize - | 0.25[1] | 39.14 | | 870 | 20 |
| Maize | 0.31[1] | 49.63 | | 1.100 | 30 |
| | | 384.18 | 120.73 | 5.500 | 150 |
| Equivalent in rice (t/ha) | | | | 2.30 | 2.21 |
| Introduced CP B (low management) | | | | | |
| Maize + | 0.64 | 101.60 | | 2.250 | 60 |
| Upland rice ≠ | 1.07 | 213.97 | | 2.560 | 70 |
| Cassava ≠ | 7.33 | 293.01 | | 8.790 | 50 |
| Maize - | 0.29[1] | 46.50 | | 1.030 | 30 |
| Peanut | 0.11 | 89.80 | | 510 | 30 |
| Total | | 743.88 | 393.84 | 15.140 | 140 |
| Equivalent in rice (t/ha) | | | | 6.33 | 3.53 |
| Introduced CP C (high management) | | | | | |
| Maize + | 0.66 | 105.44 | | 2.340 | 60 |
| Upland rice ≠ | 1.18[2] | 236.61 | | 2.830 | 80 |
| Cassava ≠ | 7.83 | 313.33 | | 9.400 | 60 |
| Maize - | 0.26[1] | 42.09 | | 921 | 20 |
| Peanut | 0.12 | 99.36 | | 560 | 30 |
| Total | | 796.82 | 344.89 | 16.051 | 250 |
| Equivalent in rice (t/ha) | | | | 6.70 | 3.68 |

[1] Harvested and marketed as green maize; price fluctuates by season.
[2] Serious neck blast.
[3] CP = cropping pattern.

by pod borers. Consequently, farmers were reluctant to plant peanut following early rice cultivars and maize was planted between cassava crops. Although the population of maize in the introduced patterns was 75% of farmers' pattern, the yields were about the same. Legumes planted in the dry season will provide additional income and, of course, a source of protein. But these crops may serve a more useful function as cover crops and sources of organic matter to improve the physical properties of the soil. Drought tolerant legumes such as rice bean and cowpea are likely better suited than peanut for this purpose.

Summary data for these patterns all indicate the increased productivity and profitability of CP B. CP C is inappropriate until more efficient and productive cultivars of upland crops are available.

**Drained tidal swamp.** In this first effort to conduct cropping systems research in the tidal swamps, care was taken to minimize confounding effects. The research was carried out in an area that had been drained, was not subjected to flooding (although sub-surface water remained within 50 cm of the surface) was overlain with less than 1 m of peat, and was populated with transmigrants from Java. These conditions are similar to those of many other transmigration projects in the tidal areas of Kalimantan and Sumatra, and the results from Barambai should apply to other sites with similar conditions.

Because the water table at high tide may still be as much as 20 cm below the land surface, the farmers have used a raised and furrow bed system of agriculture (sorjan) similar to that used by many indigenous farmers in tidal affected areas (Fig. 20). The furrow bed, which may be 10 m wide, is used to grow lowland rice. The raised beds, which may be only 1 m wide, are used initially to grow upland crops in an interculture combination with perennial crops.

Characteristics of these areas and management techniques for the new technologies are shown in Photographs 13-18.

These systems are simple and economical to develop. They can be developed slowly or quickly in response to the farmers' needs. The low lying area (furrow bed) tends to be "scalped", however, to provide soil for the raised bed. Water collects from rainfall in the furrow bed, and the reduction processes tend to ameliorate the acidity that develops from the underlying and surfurous mineral soil. Usually one crop of photoperiod sensitive lowland rice is grown in the furrow bed during the rainy season. However, there is sufficient time to grow two rice crops if there is a normal rainfall duration and if early maturing cultivars are used. Upland rice and other upland crops such as maize, legumes, and cassava are usually grown in an interculture combination with coconut, clove, and coffee on the raised beds. The crop combinations for food crops are usually the same as for other upland areas.

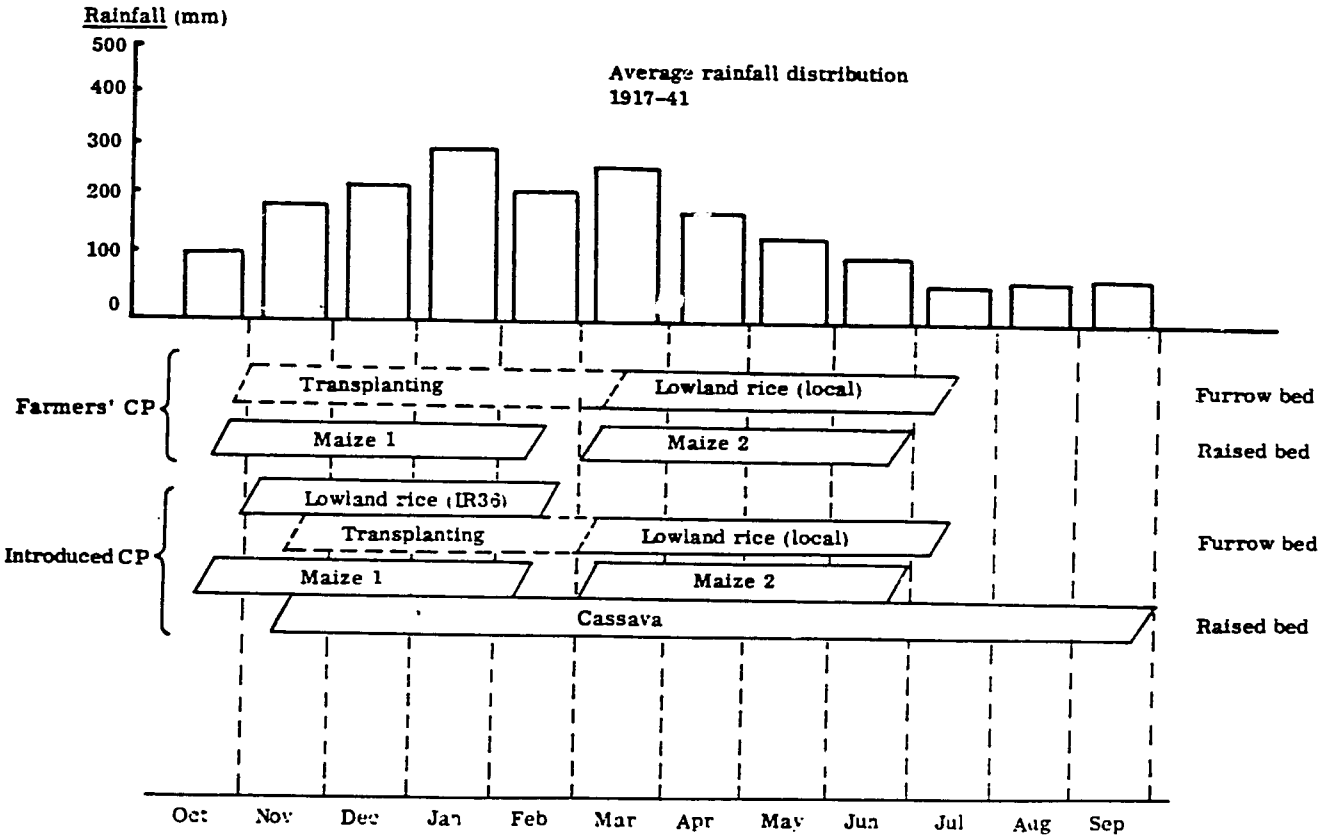
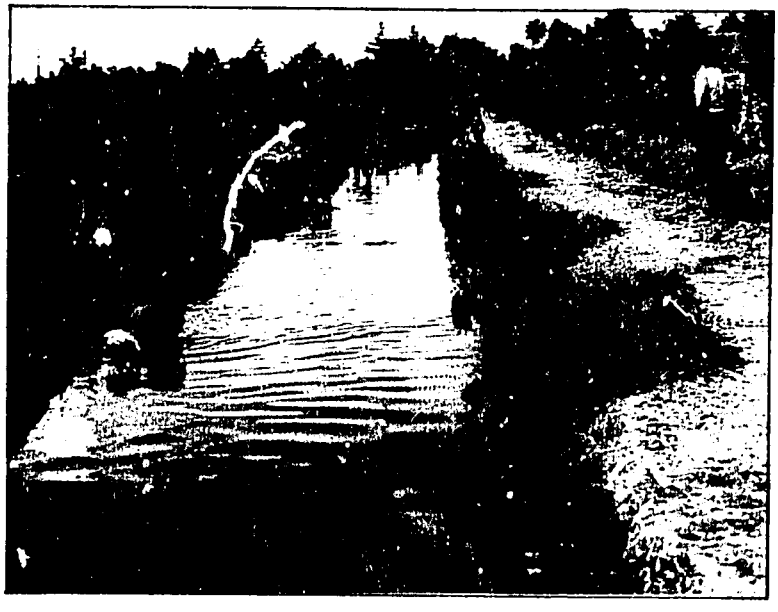


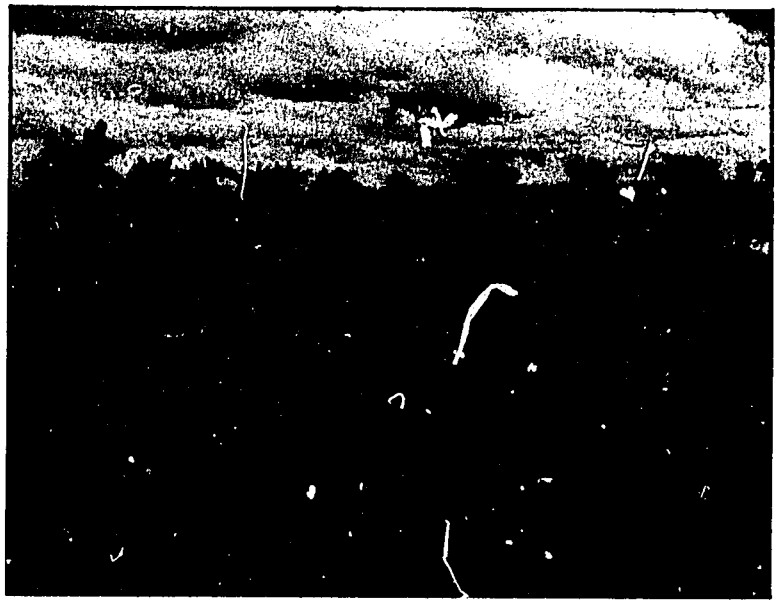

Figure 20. Rainfall distribution, cropping patterns (CP) tested, and bedding arrangements for cropping systems research in drained tidal swamp, Barambai, South Kalimantan, 1979–81.

There are vast areas of tidal swamplands that could be drained and used more effectively for agriculture.



A network of canals must be carefully built to prevent flooding but at the same time avoid excessive drainage.

Traditionally, farmers have planted photoperiod sensitive cultivars that require 3 transplantings and 9 months to mature.



Two crops of photoperiod insensitive rice can be grown and then followed with a legume crop.

A raised bed-lowered bed arrangement had been patterned after the farmers' systems to permit lowland rice, upland crops, and perennial crops to be grown simultaneously.

Eventually the pcrennial crop canopy closes and only a small crop of rice may be grown under the trees.

The soil in the raised beds may become quite acidic due to oxidation of sulfur-containing compounds. These compounds are found mostly in the subsoil but are also present to varying degrees in the surface soils used to make the raised beds. The subsoils are inherently low in mineral nutrients for crop production and become extremely acidic as the soils become aerated during the dry season and the sulfur compounds oxidize to sulfate.

By using fertilizers and improved cultivars of early maturing rice and palawija crops, we have been able to produce some good yields. Yields and economic returns from the cropping patterns tested (Fig. 20) at different levels of management are shown in Table 16. These data show only the production of food crops. It is expected that the net income and stability of production will increase as perennial crops such as coconut, clove, and coffee come into production.

There thus appears to be considerable potential for increased crop production in these areas. It is expected that farmers will initially prefer the low input technology, since yields and net income can be doubled by these practices. Further increases in inputs and labor increased yields, but at a much lower rate of return (Table 16). Better cultivars and further amelioration of soil conditions are needed. However, we think these drained tidal areas can be productively and profitably used for agricultural purposes. The slow but systematic conversion of the land into a 2 : 1 ratio of lowland to upland appears to be a logical management technique. With further development, narrow and sufficiently deep drains adjacent to the raised beds are needed to carry away the leaching and acid-producing sulfate compounds. Before this final and equilibrium situation is reached, the raised beds will have to be widened each year by adding soil to their sides. Oxidation of the exposed and aerated sulfur compounds to sulfates would permit these acid-producing materials to leach into the furrows and be carried away by the tidal flow. More time and study are needed to test these hypotheses.

Table 16. Cropping patterns, yields, costs of production, and economic evaluation for cropping systems research in drained tidal swamp, Barambai, Kalimantan, 1978-81.

| Cropping patterns[1] | Yield (t/ha) | Gross return ($/ha) | Labor cost ($/ha) | Input cost ($/ha) | Net return ($/ha) | Benefit/ cost | Marginal rate of return % |
|---|---|---|---|---|---|---|---|
| Farmers' cropping pattern | | | | | | | |
| FB : Rice | 2.51 | 502.00 | 183.60 | 24.66 | 293.74 | | |
| RB : Maize 1 - | 0.22 | 35.20 | 6.00 | 9.58 | 19.62 | | |
| Maize 2 | 0.22 | 35.20 | 6.00 | 9.58 | 19.62 | | |
| | | 572.40 | 195.60 | 43.82 | 332.98 | 2.39 | |
| Introduced cropping pattern (low input) | | | | | | | |
| FB : Rice 1 - | 2.74 | 548.00 | 171.60 | 33.60 | 312.80 | | |
| Rice 2 | 2.33 | 466.00 | 165.60 | 18.48 | 281.92 | | |
| RB : Maize 1 ≠ | 0.25 | 40.00 | 18.00 | 13.58 | 8.42 | | |
| Cassava ≠ | 4.36 | 101.64 | 7.20 | 11.14 | 86.30 | | |
| Maize 2 | 0.07 | 11.20 | 14.40 | 10.38 | -13.58 | | |
| | | 1,169.84 | 376.80 | 37.18 | 705.86 | 2.52 | 166.05 |
| Intriduced cropping pattern (standard) | | | | | | | |
| FB : Rice 1 - | 3.18 | 636.00 | 164.40 | 61.36 | 410.24 | | |
| Rice 2 | 2.51 | 502.00 | 156.00 | 59.25 | 286.75 | | |
| RB : Maize 1 ≠ | 0.29 | 46.40 | 24.00 | 13.30 | 9.10 | | |
| Cassava ≠ | 4.94 | 118.56 | 7.20 | 24.08 | 87.10 | | |
| Maize 2 | 0.10 | 16.00 | 19.20 | 11.71 | -14.91 | | |
| | | 1,318.96 | 370.80 | 169.70 | 778.28 | 2.44 | 94.90 |

[1] FB = furrow bed, RB = raised bed in a sorjan arrangement.

## SUMMARY AND CONCLUSIONS

The historical development of the current research strategy has followed a logical evolutionary path. The cropping systems focus grew out of a recognition that farmers typically grow several food crops in a given year, either in combination or in sequence. Consequently, commodity-focused research that ignores the interrelationships among all the food crops grown fails to meet farmers needs. Farming systems research builds upon this philosophy at a more comprehensive level recognizing that in mixed farming systems not only food crops but all interrelated enterprises must be considered.

Figure 21 depicts in a general way the development, dissemination, and adoption of new technology from agricultural research in a target area. Research in phases I and II closely parallels that carried out in conventional commodity and discipline oriented research. The designing and testing of farming systems through on site research and multilocational trials that is implied in phases III and IV is the distinguishing feature of systems research. However, even with this kind of research farmers are not likely to be aware of much appropriate technology that is available. Many farmers do not adopt technology even if they are aware of its usefulness. Within Indonesia, implementation of new technology, even for monoculture rice, is dependent upon the support and subsidies of production programs. Even with implementation under these circumstances, the gap between farmers' use of technology and that which is available is still too large. Perhaps with researchers working more closely with farmers, extension workers, and local government officials, a research and extension system more responsive to farmers' needs will be developed. Furthermore, the need for inputs cannot be eliminated, but low input farming systems can be developed that will facilitate farmer adoption. Also, by understanding the socioeconomic and environmental constraints better and by anticipating the input requirements, the implementation of production programs that are more appropriate for an area can be facilitated. The time required for research in an area can be decreased and thereby the number of other sites that can be studied may be increased. In order to do this, more emphasis must be placed on site description and technology transfer.

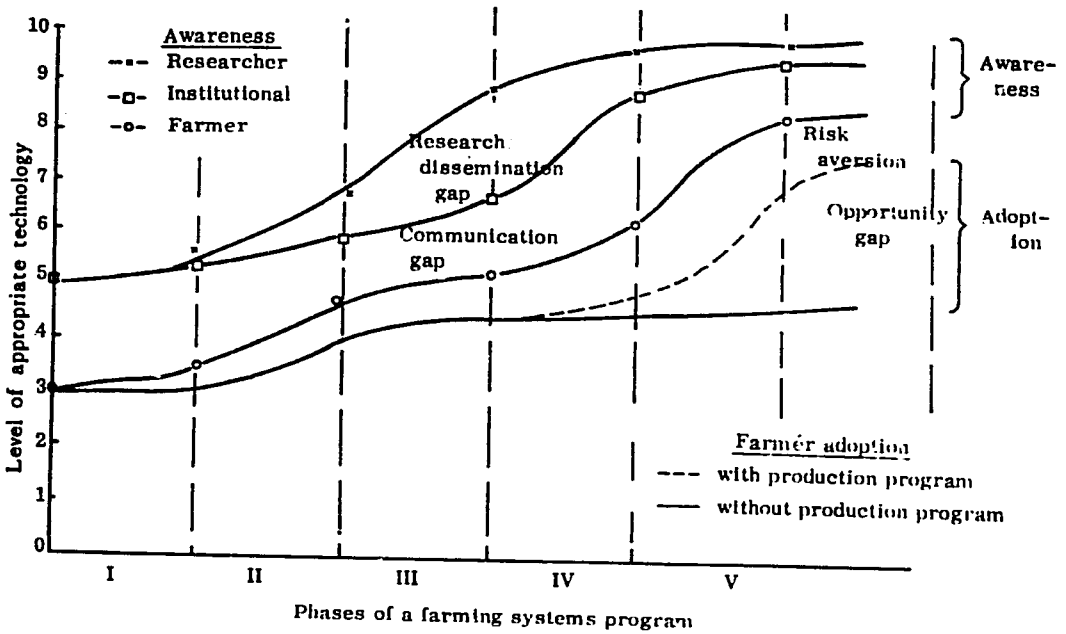



**Figure 21.** Research development, dissemination and implementation with respect to sequential phases of a farming systems project in an underdeveloped target area.

As work proceeds within a target area and technology is developed for more productive and socioeconomically acceptable food production systems, other opportunities and constraints faced by farmers are identified. Consequently, research that is initially food crops based develops into a holistic farming systems program. This is the proper sequence. The initial surveys that are used to describe a target area can be holistic in scope, but the experimentation that is implicit in this kind of research must be focused at early stages on the needs that have the highest priority. Usually that priority is for food crops. When that need is satisfied, either on the farm or by other means, then new priorities can be tackled.

## Lessons Learned

Consideration of past experiences in conducting cropping systems research can provide direction for planning future research. Strategies required for developing a successful program include:

(1) Site selection - Basic aggregate data collected from district and sub-district offices in the target research area may be used to identify more effectively villages representative of the agro-climatic area in which research in farmers' fields will be conducted.

(2) Site description - Rapid rural appraisal techniques may be used to obtain an initial assessment of the farming systems followed in target areas. The agro-economic profile approach in which two or three staff members spend one or two days collecting a basic set of agro-environmental and socioeconomic data provides the required data which can be summarized soon after returning from the site into a report providing background for development of research plans (see Appendix). In addition, the agro-economic profile can be used to identify specific constraints that may require problem-focused surveys in order to obtain more in-depth understanding of the problem. In addition the site description must include internationally accepted soil and climate classifications.

(3) Staff assignment - At all field sites, a site supervisor and support staff must be assigned as permanent residents. This permits close supervision of field work and enables the staff to understand better the technology problems and needs of the client farmers.

(4) Interdisciplinary teams - The problems facing farmers fall into the domain of several different disciplines. In order to solve these problems, scientists from all relevant disciplines must work together in planning, conducting, and evaluating research results.

(5) Compensating farmer cooperators - Farmers cooperators should not be paid for their labor input, but only should be provided the recommended inputs. This allows the researcher to obtain a more realistic estimate of labor inputs required to utilize the new technology. There may be extenuating circumstances or yield losses due to the research which will require compensation.

(6) Farmers field trials - Trials in farmers' fields must include comparisons of farmers' patterns (either directly by trials of farmers' patterns or by monitoring) with introduced cropping patterns and component technology trials. These introduced patterns should include two or three input intensity levels and/or crop combinations. The technology component trials focus on single factors (fertilizer, pest control, management practices, cultivars) with the results used to increase the productivity of the introduced cropping patterns. Both pattern and component trials are needed in order to identify the best technology for each environment.

(7) Data analysis - Simple procedures must be used that allow the on-site staff to complete most of the analysis at the site. These field staff are most familiar with the data and are best able to interpret the results and use them in planning the next seasons's trials.

(8) Economic analysis - All biological trials must be analyzed economically to determine the changes in income that can be expected if farmers adopt the new technologies. For data record-keeping, net returns analysis is appropriate, and for component technology trials, marginal benefit cost analysis is required.

(9) Reporting format - One of the purposes of conducting research throughout the country is to enable the researchers to identify cross-site determinants to better understand the potential and constraints for transferring a technology to similar areas. Research results can best be compared across sites if a uniform analytical and reporting format is used at all sites.

(10) Long-term site commitment - Due to variability in environmental factors and the need to refine results of initially tested patterns and trials, experimentation must be continued for at least 2-3 years before extending the new technology to farmers. In some instances, particularly in newly opened areas, longer trials may be needed to address specific research issues such as soil conseravtion, fertility, and perennial crops.

In planning farming systems research, these lessons should be taken into consideration and incorporated into the research strategy to maximize research efficiency and impact.

## Challenges to be Faced

Cropping systems research in Indonesia has been conducted within a single agency (CRIFC), mostly by staff who had participated in the IRRI-sponsored six-month cropping systems training program. Consequently, it has been easy for the research team to develop a close relationship with each other and a common understanding of the research strategy. As we move into an integrated farming systems program for all of AARD, several problems can be expected to arise, since researchers from many institutes and backgrounds will be required to work together towards a common goal. In order to provide good working relationships, special efforts must be made, including:

(1) Staff training - It will be necessary to conduct intensive interdisciplinary staff training to help all the researchers understand the philosophy and techniques of applied farming systems research.

(2) Research coordination - Both at the research sites and across sites, efforts will have to be made to maximize the flow of communications among researchers

from the several participating institutes. It is important to plan jointly the various trials to be conducted by each institute in order to generate results that are complementary and which can be implemented by farmers at the sites.

(2) Program development - All production activities require farmer owned/supplied resources. In order to develop farming systems production packages, results of each institute's research must be integrated, taking into consideration available farmers resources. Unless this is done, farmers will be unable to implement recommended farming systems packages.

## From Researchers to Farmers

Efforts to increase the adoption of farming systems technology must focus on remedying constraints that prevail in target areas. Strategies that will guide these activities include:

(1) Widespread testing - Once the researcher has developed a farming systems package that is biologically viable, profitable, and compatible with farmers' resources - it must be tested on a wider scale over the targeted agro-climatic area. At this point, the appropriate agency to conduct these tests is the Directorate of Agricultural Production (Bina Produksi) in collaboration with the Provincial Agricultural Services staff. With data collected from the trials, the technology must be evaluated, both in terms of technical and economic appropriateness, and modified if necessary.

(2) Diagnosing institutional constraints - In each target area, institutional requirements for adoption must be clearly specified. The existing situation must be compared to the required conditions to identify the institutional constraints to adoption of the technology package. In many areas, these will be primarily factors such as lack of seed and credit for purchase of fertilizer and insecticides, need for redistribution of irrigation water, understaffed extension service, and limited markets.

(3) Removing institutional constraints - Once institutional weaknesses are identified, plans must be developed to remove each of these limiting factors. A comprehensive approach is required involving research, extension, production programs, irrigation, and local government authorities, because if only one of these enities is considered, it may be impossible for farmers to adopt the technology package.

(4) Multiple-focused extension - Since a holistic farming system is many times comprised of several crop and livestock enterprises, extension agents must be able to diagnose a wide variety of problems facing the farmers and to identify appropriate solutions. In order to do this, extension agents must be taught a wider variety of skills (or perhaps less intensive training in one area). With a broader base, extension agents will be better able to give advice that is compatible with the farmers' needs in terms of the whole farming system.

(5) Research support - After farming systems sites are established, there will be a need to develop new technology as new problems arise. To meet these second generation needs, field laboratories may be useful for generation of more in-depth technology for the major land areas and climate conditions in Indonesia. These research laboratories should be under the control of the researchers and should be large enough to permit testing of new farming systems models, to conduct commodity research to backstop systems trials, and to produce seed. These research facilities will provide a vehicle for training of research and extension staff in farming systems approaches. In this way, it will be easier to bridge the technology gap between commodity and discipline research and farming systems research, as well as the gap that exists between researchers and implementation personnel.

## The Impact of Systems Research

The ultimate objective of applied research is to develop and introduce to farmers new technologies that may be adopted, thereby improving their welfare. Traditionally, researchers have

been given the responsibility of technology development and the extension service is expected to transfer the technology to farmers. For lowland rice improvement, this model has been effective. Since rice is the staple food crop, the Government has developed over the past 18 years a strong rice-based program (Bimas) that serves farmers throughout the country. Also, since the package of practices for rice production is relatively similar throughout the country, it has been possible to conduct extension training which is narrowly focused. This situation has made it possible to train a corps of extension specialists to serve the rice sector. The availability of new cultivars, seed, government credit, inputs, irrigation, and a strong extension service to deliver the technology to farmers has enabled Indonesia to double her rice output over the past 10 years.

The cropping systems research program has had considerable impact on agricultural research in a short time, including:

(1) The acceptance of a systems approach to research and to increasing agricultural output - This is demonstrated by the increasing demands made on CRIFC and AARD for their services in conducting cropping/farming systems research throughout the country.

(2) The reorientation of commodity research goals - Feedback from cropping systems research activities have resulted in greater emphasis being placed on screening of legumes for tolerance to low pH soils, of maize for resistance to downy mildew, and of upland rice for resistance/tolerance to blast.

(3) Research staff training - Over the past 10 years, over 119 young scientists have increased their capability to conduct research and extension through participation in IRRI-sponsored cropping systems training programs. Five CRIFC staff have earned PhD. degrees in cropping systems and are now heads of research institutes; five others have received M.S. degrees.

(4) Interdisciplinary research teams - As a consequence of the systems emphasis, research at CRIFC now involves teams of scientists trained in soils, entomology, breeding, agronomy, and economics. These teams jointly plan, conduct, and evaluate AARD research throughout the country.

(5) Extension training - With the increased research capacity that has been developed, CRIFC cropping systems staff, organized through CRIFC's Research Dissemination Office, have conducted training for the extension service in cropping systems.

(6) Institutional linkages - In the Transmigration and Provincial Development Projects, where cropping systems work has been conducted, linkages have been developed among planners (BAPPEDA), researchers, and the extension service. This has enabled implementation of cropping systems technology through production programs.

(7) Increasing production and cropping intensity - At cropping systems sites throughout the country, it has been demonstrated that technology exists to increase cropping intensity, yields, and farmers' income. In addition, soil and water erosion can be reduced, and stable and productive cropping systems can be achieved. Considerable spontaneous adoption of technology (in full or in part) has taken place. Production programs have been carried out.

Considering the short time that researchers have been involved in cropping systems research, these achievements are considerable. At the same time, the ultimate objective of the research is to achieve an extensive impact whereby farmers' incomes are increased resulting from higher yields, increased cropping intensity, and/or lower costs. This kind of information can be obtained from impact studies. Impact studies have been carried out by cropping systems economists in Nambahdadi and Way Abung, Lampung and in Baturaja, South Sumatra. The first site is representative of many of the partially irrigated areas of Sumatra, while the latter two sites are representative of the humid upland rainfed areas of Indonesia. Relevant findings show the following: (1) Since 1978, when on-site research was finished in Nambahdadi, Central Lampung (partially irrigated area) the rice - rice cropping pattern that was introduced spread from 30 to 640 ha in 1978-79 and then to 7,000 ha in 1981-82. The local government plans a major production program that will cover 72,000 ha in Lampung province. (2) On the other hand, the adoption of the introduced upland rainfed cropping patterns has been rapid only in transmigration areas where inputs are readily available. In general, the adoption has been much slower than for the partially irrigated areas. The identification and removal

of constraints to adoption are important objectives of these studies. The major constraint appears to be the lack of supporting services for seeds, fertilizers, pesticides, and markets. Thus, widespread impact cannot be achieved by research alone. As has been noted, the highly successful rice program has focused on only one commodity, has evolved over 15 years, and has been supported by extremely large Government investments in credit, seed production, price support, input subsidies, and a nationwide marketing system through BULOG. Furthermore, this major achievement was not accomplished without the input of systems research in breeding (GEU), integrated pest management (IPM), and cropping systems research (CSR). Even then, without seed technology and extension, little would have been accomplished.

In contrast, the cropping systems research program is new, several crops requiring specific management practices are involved, a secondary crop seed production program was only recently initiated, the credit system for secondary crops is only a few years old, and BULOG is authorized to purchase only corn. Furthermore, many of the sites where cropping systems research has been conducted are isolated transmigration areas. While these locations are programmed for infrastructural support, it will take several years before all of the necessary components are in place. Consequently, inputs and credit are often not yet available, and marketing is difficult, because the closet population center is far from the site.

CRIFC's research shows that a viable cropping systems technology that is appropriate for many locations in Indonesia has been developed. Figure 14 shows the diversity of these locations and the magnitude of the research effort. At the same time, it is clear that technology is a necessary, but not the sole condition for agricultural development. The challenge facing cropping systems researchers is to further develop strategies to identify and break the existing bottlenecks to widespread adoption of the systems technology. By specifically focusing on identifying these constraints and by developing strategies to break prevailing bottlenecks, it will be possible to improve adoption of cropping systems research results throughout Indonesia. But finally technologies must be developed for the whole farm system that will not only increase production but also income. Consequently, present FSR involves studies of all the relevant agricultural enterprises on the farm.

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# GLOSSARY

| | | |
|---|---|---|
| Padi gogo | - | upland rice |
| Padi sawah | - | lowland (wetland) rice |
| Lebak | - | swampy area |
| Pasang surut | - | tidal area |
| Kabupaten | - | political unit similar to a county |
| Gogo rancah | - | dry seeded rice that is later flooded, the rice is directly seeded on aerobic soil at the beginning of the rainy season and later flooded |
| Alang-alang | - | Imperata cylindrica |
| Walik jerami | - | no tillage; rice is directly planted after the preceeding rice crop has been harvested, without plowing the land |
| Palawija | - | all non-rice food crops |
| Gabah | - | threshed un-milled rice |
| Sorjan | - | raised and furrow bed system of agriculture |
| Pekarangan | - | home lot with vegetation |
| Desa | - | rural district, village |
| Ulu-ulu | - | village official concerned with irrigation water distribution |
| Reksabumi | - | village official concerned with land tenure |
| Juru tulis | - | village clerk |
| Golongan | - | group |
| Kiosk | - | small store or stall for sale of merchandise |

# APPENDIX

## A Methodology for Constructing Agro-Economic Profile in Cropping Systems Sites[1]

### INTRODUCTION

Before planning the field research program in new cropping systems target areas, basic data must first be collected so that existing agro-climatic and socioeconomic conditions can be considered in the design of component technology and cropping pattern trials. A methodology for constructing an agro-economic profile must meet four requirements. First, the data to be collected should comprehensively describe the selected villages, including the physical, biological, institutional, social, and economic environments, in order to guarantee that important considerations are not overlooked. Second, the effort should enable the researcher not only to describe the existing conditions, but also to understand the system well enough to make research recommendations. In particular, the research report must identify probable constraints to higher yields for specific crops, input intensification, crop intensification, and the adoption of technologies which the research team believes could increase production in the target areas. Third, the data must be collected in a minimum of time, not exceeding 2-3 person days/site. Finally, the report must be short, so it can be completed within a maximum of 2 weeks after returning from the field.

This appendix describes a methodology and data sources for rapidly developing an agro-economic profile to meet cropping systems design needs in Indonesia. These data are collected once research sites have been selected within a targeted agro-climatic area. While this general model will have to be modified in response to the availability of secondary data at the site, the framework herein presented for data collection will reduce the time required to plan the cropping systems research at each new site. In addition, by using the same general research model for appraising all sites, the researcher is better prepared to compare new sites to ongoing research areas, and is thereby able to evaluate the transferability to new target areas of technologies found to be successful at old sites.

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[1]Prepared by Cropping Systems Economists for the Cropping Systems Working Group, AARD, September, 1981, and revised for this book.



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## DATA SOURCES AND DESCRIPTION

Data for developing the agro-economic profile should be collected from sources capable of giving reasonably accurate answers in a minimum of time. In this initial inventory, the objective should be to obtain an overview of the situation in the village, not a set of data that can be analyzed statistically. This inventory can be developed from secondary data that are usually available from such local sources as the village office, extension service, Bureau of Central Statistics, irrigation office, the bank extending production (Bimas) credit, and input dealers. When the required data are not available from these sources, the researcher may rely on a key informant to provide the answers to the questions. Possible key informants include extension officers, village officials, village water officers, and groups of farmers and landless laborers assembled for the purpose of providing the information sought.

The data to be collected are summarized in Table A.1 by subject categories and in Table A.2 according to the sources from which they may be obtained. The researcher may eliminate those items not applicable to a particular site or add additional ones. Yet, in most instances, all the items listed should be considered in the initial inventory. Each item is described in detail in the next section of this appendix in terms of the specific information to be collected, evaluation to be completed with these data, and possible sources from which the information may be obtained. Data forms are available -- but not included here -- which may be used for recording the data in the field and which may be later incorporated into the final report.

Table A. 1 Agro-economic profile data by subject category

Subject category

Physical environment

- Rainfall*
- Soil*
- Topography*
- Land use by type*
- Elevation

Experimental base

- Cultivar trials
- Fertilizer trials
- Pest surveillance
- Demonstration plots

Crop situation

- Hectares in each crop*
- Planting and harvesting dates*
- Yields by crop*
- Current cropping pattern
- Historical cropping pattern
- Cropping intensity

Institutional

- Land ownership
- Tenure
- Landless labor
- Support services
- Credit
- Input sales
- Input availability and timeliness
- Cooperatives
- Irrigation system

Labor

- Employment profile
- Population
- Off and non-farm employment
- Migration of agricultural labor

Farm practices

- Wages
- Power sources
- Cultivar
- Land preparation
- Input use
- Yield constraints
- Constraints to intensification
- Desired crop characteristics
- Desired research
- Soil conservation
- Food consumption

Markets

- System
- Output (crops)

Community

- Transportation
- Markets

*These items should have already been collected before choosing the research village.

Table A. 2 Agro-economic profile data by source

Extension office - District

- Rainfall*
- Soil*
- Topography*
- Land use by type*
- Cultivar trials
- Fertilizer trials
- Pest surveillance
- Demonstration Plots

Extension office - Sub-district

- Hectares in each crop*
- Planting and harvesting dates*
- Yields by crop*

Field extension worker

- Land ownership
- Transportation
- Support services
- Markets
- Power
- Yield constraints
- Constraints to crop intensification
- Input subsidies

Agri-business

- Input sales
- Input availability
- Input prices

Farmer group interview

- Current cropping pattern
- Historial cropping pattern
- Landless labor
- Input availability
- Input prices
- Off-farm employment
- Migration of agricultural labor
- Wages
- Power (animal and tractor)
- Input use
- Yield constraints
- Cultivars
- Planting decision
- Input levels
- Constrains to cropping intensification
- Desired crop characteristics
- Soil conservation
- Desired research
- Food consumption
- Prices received

Middlemen - Buyers

- Support services
- Markets
- Prices

Village office

- Land ownership
- Tenure
- Landless labor
- Support services
- Irrigation profile
- Population
- Transportation
- Cropping intensity

Bank - Unit desa

- Credit

Irrigation office

- Irrigation system
- Rainfall

Landless labor group interview

- Landless labor
- Off-farm employment
- Migration of agricultural labor
- Non-farm employment

* These items should have already been collected before choosing the research village.

# DETAILED DESCRIPTION OF AGRO-ECONOMIC PROFILE DATA

## I. PHYSICAL ENVIRONMENT

### A. Rainfall

Description - Weekly rainfall data (mm) for each of the past 15 years is desirable. Alternatively, monthly data for each of the past 15 years may be collected, but cannot be intensively analyzed.

Evaluation -

1. Make a bar graph profile of monthly rainfall starting with the beginning of the crop year.
2. Count the number and distribution of months with less than 100 mm of rainfall per year.
3. Estimate the probability of less than 100 mm of rainfall during each month.
4. Estimate the cumulative frequency distribution of the onset and end of rains during the crop year (applicable only with daily data).

Sources - Rainfall station located closest to the site (note location and distance from site), information may be obtained from the rural extension office.

### B. Soil

Description -

1. Major soil types found in the area and hectares in each group.
2. Hectares of land in the area classified in each of the land tax classes.
3. Information on known soil problems, (e.g. aluminum toxicity, high pH, zinc deficiency, salinity).

Evaluation - Describe the soil potential with respect to soil fertility, micro-nutrients, problems, and amelioration.

Sources — Rural extension offices, research stations, and Soils Research Institute.

**C. Topography**

Description - 1. Estimate the hectares in each type situation -- flat plain, rolling, greater than 18% slope, and mountains -- and describe associated erosion/flooding problems.

2. Draw a profile of the landscape in the area.

Evaluation - Describe the topography of the land, erosion, and drainage problems.

Sources - Rural extension offices, field observation.

**D. Land Use by Type**

Description - Hectares of land classified as irrigated (full, partial, and simple), upland for annual crops, upland for perennial crops, homelot, fallow, and urban; and changes in land use over the past ten years. Estimate the number of terraced hectares.

Evaluation -
1. Describe the land use pattern.
2. Determine the potential for crop extensification.
3. Determine the potential for crop intensification.
4. Identify changes in land use pattern.
5. Identify extent of terracing.

Sources - Rural extension offices, desa office.

**E. Elevation**

Description - Determine area of land at elevations < 500 m, > 500 m but < 1000 m, and > 1000 m.

Evaluation - Describe land use and existing vegetation.

Sources - Maps from extension offices and home affairs.

## II. EXPERIMENTAL BASE

### A. Previous Research

Description - Location and nature of research; relevant data and results.

Evaluation - Assess the biological potential for crops.

Sources - Research Institute for Food Crops.

### B. Multi-locational Cultivar Trials

Description - Yield data for each cultivar in each replication grown in farmers' fields.

Evaluation -
1. Describe the yield potential of tested cultivars and variability among replications.
2. Identify the best cultivar for the introduced pattern and cultivar component technology.

Sources - Trials organized through the Directorate of Plant Protection and implemented through rural extension offices.

### C. Multi-locational Fertilizer Trials

Description - Yield data for each fertilizer treatment in each replication grown in farmers' field experiments during past 5 years.

Evaluation -
1. Determine the optimum level of fertilizer for introduced cropping patterns.
2. Identify nutrients to be included in component technology fertilizer trials.

Sources - Trials organized through the Directorate of Food Crop Production and implemented by rural extension offices.

**D. Pest Surveillance/Bio-type Monitoring (Integrated Pest Control - IPC)**

Description - All major rice production areas are evaluated weekly (one worker/10,000) for the presence of economic pests. Also, all major rice production areas are evaluated once per season to determine the brown planthopper biotypes present. Visit with the pest fieldman to obtain information about (1) the most important pests in the wet and dry seasons for rice and other crops, (2) bio-types of BPH present, and (3) the most common insecticides used by farmers on all crops.

Evaluation -

1. Describe the major pest problems at the site, by season.
2. Use the data to determine insect control measures to be used in the introduced cropping patterns.
3. Use the data to identify treatments to be used in insect component technology.

Sources - Data collected by staff members of the Bureau of Plant Protection who are located in rural extension offices.

**E. Demonstration Plots**

Description - In many sites, the local extension service conducts trials including cultivar, spacing, fertilizer, and cropping patterns.

Evaluation - Summarize the existing experimental data to determine the factors that might be included in the introduced patterns and component technology.

Sources - Rural extension offices.

## III. CROP SITUATION

### A. Hectares in Each Crop

Description - Total hectares cropped for each of the past 5 years by crop type and area double-cropped.

Evaluation -
1. Identify the most important crops grown in the site and the rice cropping index.
2. Determine changes in the relative importance of these crops over the 5-year period.

Sources - Rural extension offices, desa office.

### B. Planted Area Data

Description Hectares planted to each crop every month during the past 3 years.

Evaluation -
1. Determine the month of planting and time distribution of crop establishment.
2. Estimate the percent of the area double-cropped in rice.
3. Identify the major cropping pattern by observing planting sequences.
4. Timing of farmers' activities may indicate soils problems, rainfall shortages and variability, etc.

Sources - Rural extension offices, desa office.

### C. Crop Calendar

Description - Identify the months during which each crop is generally planted and harvested.

Evaluation -
1. Identify the cropping season for each crop.
2. Determine the existence of double cropping.
3. Identify months when cropping pattern trials should be initiated.

4. Timing of farmers' activities may indicate soils problems, rainfall shortages and variability, etc.

5. Relate the crop calendar to rainfall distribution.

Sources - Rural extension offices, desa office.

**D. Yields by Crop**

Description - Yield of each crop (by season) for past 5 years; yield of rice by production program participation in (Bimas, Inmas) past 5 years; crop cut yield as estimated by Bureau of Central Statistics.

Evaluation -

1. Identify the productivity level of each crop.
2. Identify changes in productivity over the past 5 years.
3. Identify the existence of yield constraints.

Sources - Rural extension offices, desa office.

**E. Current Cropping Pattern**

Description - Typical cropping patterns grown in the area by type of land; also, percent of area allocated to each pattern.

Evaluation - Describe cropping patterns and the relative importance of each.

Sources - Farmer group interviews, desa office.

**F. Historical Cropping Pattern**

Description - Major changes in cropping patterns that have occurred over the past 10 years and causes of these changes.

Evaluation - Identify the dynamic factors that have influenced local cropping patterns.

Sources - Farmer group interviews.

## IV. INSTITUTIONAL FACTORS

### A. Land Ownership Inequality

Description - Hectares of land by type (irrigated, rainfed, upland) owned by size of holding class: 0-0.25, 0.26-0.50, 0.51-0.75, 0.76-1.00, 1.01-1.50, 1.51-2.00, 2.01-2.50, 2.51-3.00, 3.01 or above; and hectares owned by the five largest land owners. Estimate the typical number of parcels operated.

Evaluation -

1. Identify the degree of social inequality existing in the village.
2. Identify the typical farm size, which should serve as a guide in avoiding the selection of atypical agronomic cooperators.
3. Quantify the degree of inequality of land ownership through graphing a Lorenz curve (i.e., percent of land owned by 10%, 20%, 30% etc. of the largest owners) and estimating the Geni ratio of landholding inequality.
4. Determine the degree of fragmentation.

Sources - Field extension workers at desa level or letter C list in desa office.

### B. Tenure

Description - Number of households who are land owners, leaseholders, share tenants, and landless; size of typical holding.

Evaluation -

1. Estimate the percent of cultivators by tenure class to indicate the degree to which farmers are able to independently make input and cropping pattern decisions.
2. Estimate landless laborers as a percent of farming population to indicate the availability of labor and the degree of economic inequality.

Sources - Desa official (reksabumi), farmers group interviews.

**C. Support Services**

Description - Number of extension officers, input dealers, cooperatives, and output wholesalers by crop; and how they function.

Evaluation -

1. Estimate the number of extension workers per hectare as an indication of the adequacy of extension support.
2. Describe the availability of input and output dealers as an indication of input supply and marketing opportunities.
3. Identify problems that may affect production.

Sources - Desa official, field extension workers, dealers, and output middlemen.

**D. Credit**

Description - Determine the number of farmers participating in Bimas and Inmas during each season for each of the past 5 years. Estimate the number of farmers defaulting on government loans during each of past 5 years. Estimate the value of the Bimas package. Describe the informal credit system. Determine the Bimas target and realization.

Evaluation -

1. Estimate the percentage of farmers participating in the government production programs and trends in participation to indicate the degree to which modern technology has been introduced.
2. Determine the loan default rate and trends in default to evaluate the viability of the system.
3. Evaluate the cost of informal credit on farmers' incentive to borrow.

Sources - Banks at the local government level.

**E. Inputs Used and Availability**

Description - Describe the fertilizers, insecticides, and rat poisons most commonly used on rice, prices paid, and transportation costs.

Evaluation -
1. Determine the inputs sold in the Desa.
2. Identify availability as a constraint to input use.
3. Determine input costs for computing crop returns.

Sources - Agri-business dealers and farmer group interviews.

**F. Cooperatives (KUD/BUUD)**

Description - Estimate the number of members in the cooperatives, activities, and volume of purchases.

Evaluation - Evaluate the strength of the cooperatives.

Sources - Desa officials.

**G. Irrigation Water Availability**

Description - Irrigation water schedule over the year and the organizational structure controlling the distribution of water at the village level. Obtain a map for the irrigation system or draw one including the primary, secondary, and tertiary canals. Give a history of construction and problems in supplying water.

Evaluation -
1. Determine the timing of water distribution to evaluate how this will influence cropping pattern design.
2. Determine the months of water to evaluate the potential for crop intensification.
3. Describe the farm level water distribution system to identify the potential for earlier planting and crop intensification (e.g. rotating golongans).

4. Identify water problems.

Sources - Irrigation office, desa office (ulu-ulu, farmer group interviews.

## V. LABOR

### A. Employment Profile

Description - Number of persons engaged in the major occupational categories.

Evaluation - Estimate the degree to which the area is agriculturally dependent.

Source - Desa office (juru tulis)

### B. Population

Description - Present population by age group and sex and number of households; population 10 years ago, by sex; number of permanent in- and out-migrants during the past 10 years.

Evaluation -
1. Describe the sex distribution of the adult population to evaluate the possibility of an out-migration of male workers which would contribute to a shortage of labor for crop production.
2. Estimate the rate of population growth.
3. Evaluate the importance of migration on the labor supply.
4. Evaluate the average household size as an indicator of the availability of labor.

Sources - Desa office (juru tulis)

### C. Off- and Non-farm Employment

Description - Employment opportunities by season for major job types.

Evaluation -
1. Determine the activities for which agriculture provides off-farm employment.

2. Determine when off-farm seasonal labor demand is greatest as a guide for pattern design with respect to seasonal labor requirements.

3. Identify non-farm labor opportunities.

Sources - Landless laborer group interviews.

### D. Migration of Agricultural Labor

Description - Amount and source of non-resident labor drawn to the site, by farming operations and seasons; amount, destination, and wage rate received by residents seeking farm employment outside the desa.

Evaluation - 1. Identify the existence of labor bottlenecks associated with specific operations and seasons.

2. Identify changes in labor migration patterns.

Sources - Farmer group interviews, landless laborer group interviews.

## VI. FARM PRACTICES

### A. Wages

Description - Wages paid over the past 5 years for major farm activities (land preparation, transplanting, weeding, harvesting) and price of rice (gabah) at harvest.

Evaluation - 1. Estimate changes in the real wage rate as an indication of welfare and the existence of a shortage of labor.

2. Identify labor bottlenecks.

3. Estimate the cost of land preparation by power source.

Sources - Farmers group interviews, landless laborer group interviews.

**B. Power Sources**

Description - Determine the number and hectares of land prepared by each power source. Determine if tractors used are associated with season or with environment.

Evaluation - 1. Describe the type of power available for land preparation.

2. Determine the degree of mechanization as measured by kind of land by ha/hand labor, ha/water buffaloes and ha/tractor.

Sources - Field extension workers, desa office, and farmers group interviews.

**C. Cultivars**

Description - Hectares in major cultivars, farmers' evaluation of each cultivar and availability of improved seeds.

Evaluation - 1. Determine types of cultivars used as indicators of the level of existing technology.

2. Determine the acceptability of modern cultivars to the farmers.

3. Identify seed shortages.

Sources - Field extension workers, farmer group interviews.

**D. Land Preparation/Planting**

Description - The guidelines farmers use in deciding when to begin land preparation and when to plant each crop.

Evaluation - Identify constraints to earlier crop establishment.

Sources - Farmer group interviews.

**E. Input Levels**

Description - Input levels used by crop, season, environment, and other factors that may influence input use such as cultivars.

Evaluation - Describe the type of technology used at the site to assist in designing introduced patterns and component technology studies.

Sources - Farmer group interviews.

**F. Constraints to Higher Yields**

Description - Major historical (biological) constraints to higher yields by crop during the past three years, i.e., factors believed to be yield-reducing at the site.

Evaluation - Describe possible factors to consider in attempting to increase yields.

Sources - Field extension workers, farmer group interviews.

**G. Constraints to Increasing Cropping Intensity**

Description - Major historical and recent constraints to increasing cropping intensity; factors believed to make it difficult to grow more crops/year.

Evaluation - Describe possible factors to be considered in attempting to increase cropping intensity.

Sources - Field extension workers, farmer group interviews.

**H. Desired Crop Characteristics**

Description - Crop characteristics preferred by farmers in the area, including grain/tuber color, duration, height, taste, grain/tuber size, and tolerances/resistances.

Evaluation - 1. Evaluate the compatability of available high yielding cultivars with factors considered important by local farmers.

2. Identify breeding priorities to meet farmers preferences.

Sources - Farmer group interviews.

**I. Research Preferences**

Description - Crops for which farmers desire higher yields, farmers' opinions of how to increase yields, and use of increased output.

Evaluation - Determine farmers' perceived needs.

Sources - Farmer group interviews.

**J. Soil Conservation**

Description - Farmers' soil conservation practices and use of terracing.

Evaluation - Determine farmers' awareness and use of conservation techniques.

Sources - Farmer group interviews.

**K. Family Food Consumption**

Description - Family food consumption patterns and deficit periods.

Evaluation - 1. Describe consumption patterns.

2. Identify the existence of deficit months.

Sources - Farmer group interviews.

VII. MARKETS

**A. System**

Description - Describe where crops are typically sold, the farm gate buyer, and costs to transport to the market.

Evaluation - 1. Describe the marketing system.

2. Evaluate the existence of marketing constraints.

Sources - Agribusiness dealers and farmer group interviews.

**B. Output (crops)**

Description - Monthly prices of major crops sold in the main market place where farmers sell their crops during the past 5 years; wet season paddy rice for past 5 years.

Evaluation - 1. Estimate the mean yearly price and standard deviation around the mean to determine the price level and seasonal variability.

2. Observe potential income gains from earlier planting.

Sources - Bureau of Central Statistics, field officers.

## VIII. COMMUNITY INFRASTRUCTURE

**A. Transportation**

Description - Types of roads connecting the site to the nearest main market, number of vehicles passing through the site per day, and cost/100 kg of product to transport to the nearest major market.

Evaluation - Describe the input supply and output marketing constraints.

Sources - Field extension workers, desa office, farmer group interviews.

## IX. DETAILED ASPECTS OF CROP MANAGEMENT

Description - Farm management consideration for each crop and operation.

Evaluation - Describe practices to identify problems.

Sources - Farmer group interviews.

## X. DATA FORMS FOR AGRO-ECONOMIC PROFILE

Forms are available on request.

## SUMMARY REPORT

Once the research team returns from the field, the information obtained must be written into a report that summarizes the agro-climatic and socioeconomic conditions at the site. In addition, the report should suggest specific field research that may be conducted to find ways to raise crop yields (and profit), increase cropping intensity, and achieve additional goals (such as reducing soil erosion) that may be important in a given target area in order to improve rural welfare. Finally, the research team may uncover certain agro-climatic or socioeconomic constraints to technological change that were inadequately explored during data collection for the agro-economic profile. In such cases, the report should identify those issues which require further consideration and further research by conducting a traditional farmer survey that focuses specifically on these problems. The following outline of the summary report is provided as a guide in preparing this document.

### Topic Outline for "Agro-Economic Profile Report"

**Introduction**

Purpose of report: describe agronomic and socioeconomic conditions in the village to assist in planning cropping systems research.

**Environment**

- Location: latitude and elevation
- Soils: major soil families and identification of soil problems by environment
- Rainfall: monthly mean months with > 200 mm of rainfall, months with rainfall < 100 mm, and year around distribution
- Topography/landscape: area in each topography class, severity of erosion
- Drainage: problems with flooding

**Demographic characteristics**

- Population: total, annual rate of increase, percent adult, persons/km, persons/ha of upland and lowland

- Migration: number of in- and out-migrants in recent years
- Households: number of farm and non-farm households

**Employment**

- Occupational structure: number of persons in each occupational group
- non-farm: industry type and number of persons employed, changes in recent years
- off-farm: months and activity with seasonal labor shortage, changes in recent years
- in-migration: month, activity, source (origin), and recent changes in seasonal labor in-migration
- out-migration: month, activity, destination, and recent changes in seasonal labor out-migration.

**Hired labor and wages paid**

- Hired labor: operations for which hired labor is typically used, by crop
- Wages paid: wage paid or crop share given for operations using hired labor, by crop; changes in real wage rate in recent years

**Land use**

- Environment: hectares in each land use type such as rainfed, irrigated, upland; land in each tax class; extent of terracing; recent changes in land use
- Cropping intensity: hectares double-cropped to rice
- Perennial: importance of and hectares in perennial crops

**Access to land**

- Tenure: number of households by tenure type, number of landless households, and typical size of holding operated
- Land ownership: number of owners by size class, largest five owners, and extent of non-resident land ownership
- Fragmentation: typical number of parcels operated

**Cropping pattern**

- Historical: cropping patterns previously grown and reasons for change

- Current: existing cropping patterns and relative importance of each, by land type
- Crops: hectares planted to each crop, changes in relative importance of crops grown
- Crop calendar: monthly distribution of crops planted or typical planting and harvesting months for each crop

**Crop management (by crop and environment)**

Practices: cultivars grown, fertilizer and insecticide types and amounts used, crop age at weeding, yield, compost use, etc.

Decision rules: considerations in selecting cultivars; source of seed; method of land preparation, planting, weeding, and harvesting and dates; types and input levels; location of crop in field and seed rate; and methods of erosion control

**Power**

- Animals: number of work animals and animals owned by residents/hectare of lowland, number of non-resident work animals providing land preparation services, recent changes in animal population, and reasons and cost/ha for land preparation.
- Tractor: number of tractors (4-wheel full size, 4-wheel mini, and hand tractors) owned by residents/ha of lowland, number of non-resident tractors providing land preparation services, recent changes in tractor population, cost/ha for land preparation

**Irrigation**

- History: year when system was built and dates of major improvement, type of system and source of water, extent of tertiary and quarternary development
- Organization: date of water arrival, method for deciding distribution schedule, local participation in water regulation
- Capacity and reliability: months of available water, reliability of water throughout the season; special problems in functioning of system

**Support service**

- Extension: number of field extension workers (PPL) and subject matter specialists (PPS) serving village, organization of local extension programs, year Bimas started, number of participants and hectares
- Credit: sources of credit, interest rates and availability, location of Bimas office, typical inputs included and value of production package, repayment rate for Bimas credit
- Input dealers (kiosk): location and distance to nearest sources of inputs, cost of transportation from dealer to village, brands available and prices of each, availability and timeliness of input delivery
- Cooperatives (KUD/BBUD): location of cooperatives, number of farmer members, activities of the unit, amount of paddy purchased last year

**Markets and product prices (by crop)**

- Markets: location and distance to nearest market and transport cost to market, usual site where the crop is sold and type of buyer
- Prices: prices paid to the farmer each month of the year, changes in the relative prices of crops that have affected the crops the farmers want to grow

**Community infrastructure**

- Transportation: quality of roads to the village, months road are closed, number of vehicles passing each day
- Social: number of schools, hospitals, and type of medical services
- Electricity: availability of electricity in village
- Processing: number of rice mills

**Previous research**

- Trials: results from previous fertilizer, cultivar, and insect control trials
- Demonstration plots: results from previous demonstration plots conducted by extension service

**Constraints**

- Yields: major insect pests of each crop by season, importance of flooding or drought, non-availability of seed or inputs
- Extensification: major constraints to bring more land into production
- Cropping intensity: reasons why farmers do not plant more crops/year
- Timeliness: operations for which labor is not available when needed for timely completion
- Profitability: estimation of the relative profitability of each crop (gross return minus purchased material inputs)

**Farmers' perception of research needs**

- Cultivars: crops for which new cultivars are needed, desired characteristics of new cultivars (type of disease resistance, color, height, taste, etc)
- Inputs: farmers' opinion about increases in yields that would result from using more fertilizer and insecticide, by crop
- Problems: farmers' description of any problem that constrains yield or cropping intensity

**Recommendations for research**

- Component technology: crops for cultivar screening and characteristics of crops to be evaluated; types of fertilizer and insect control trials, by crop
- Management: types of new practices that might increase yield and/or cropping intensity e.g. dry seeding or no tillage
- Farmers' existing pattern: description of farmers' pattern, input levels and management practices to be included in existing cropping pattern trial
- Introduced cropping pattern: description of introduced pattern, input levels and management practices that should be tested
- Problems-focused survey: description of problems that should be further researched using a problem-focused survey