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TUNTANG AND RELATED RIVERS BASINS
DEVELOPMENT PLAN

APPENDIX F

SOIL AND WATER CONSERVATION

MAY 1980

SUBMITTED BY

PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A. SEMARANG, INDONESIA

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
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PREFACE

The Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works, Government of Indonesia (GOI) contracted PRC Engineering Consultants, Inc. (PRC/ECI) to provide consulting engineering service for preparing an integrated development plan for the Tuntang/Jragung Rivers in the Jratunseluna Basin. In the contract it was stipulated that the plan should include recommendations on water and soil conservation in the Tuntang Subbasin which had not been studied in the past. The study for the preparation of the plan started on May 16, 1979 and was originally scheduled to be completed on November 30, 1979.

As interim report on the study was submitted by PRC/ECI on August 15, 1979 which was reviewed by all the concerned agencies and later discussed on September 24, 1979 in a meeting held by the DGWRD at Jakarta. In that meeting, it was decided that the study on the Tuntang/Jragung Rivers should be modified by including the entire Jratunseluna Basin in certain aspects of the study. In that modified study the interrelationships of the existing, proposed and the potential development works of the Tuntang/Jragung subbasins and those of the adjoining subbasins within the Jratunseluna Basin should be examined. Also, problems and needs of water and soil conservation in the entire Jratunseluna Basin would be identified and a conceptual plan to start conservation measures including design of a pilot demonstration farm would be prepared. The original contract between GOI and PRC/ECI for the engineering services was, therefore, amended to include the revised scope of work for the modified study.

A report on water and soil conservation in the Tuntang Basin, as contemplated originally, was prepared and presented separately in a document titled "Jratunseluna Basin - Updated Development Plan. Appendix F. Part I."

The above mentioned modified study to update the entire Jratunseluna Basin was started in December 1979 and completed in May 1980. The results of that study are presented in this document titled "Jratunseluna Basin - Updated Development Plan. Appendix F. Part II."

Semarang, May 1980

PRC Engineering Consultants, Inc.

PART II

TUNTANG AND RELATED RIVERS BASINS
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SOIL AND WATER CONSERVATION

F.1. INTRODUCTION

The Jratunseluna Basin is located on the north coast of Java in the Province of Central Java and lies east and southeast of the provincial capital city of Semarang. The basin's name is a composite from the five main rivers draining the basin, the JRAgung, TUNtang, SErang, LUsi and JuaNA. Two other small rivers within the basin, the Dolok and Penggaron, drain directly into the Java Sea in the northeast corner of the Basin.

The Jratunseluna Basin covers an area of about 7,700 square kilometers including parts or all of nine kabupatens (regencies) including Semarang, Jepara, Blora, Demak, Purwodadi, Pati, Kudus, Boyolali and Sragen. The municipality of Semarang is also within the basin. The location map is presented in Figure F-1.

The soil erosion problems of the upper watershed are quite evident to the trained observer, as is the high sediment load of all the main river systems. It is also evident that the natural ecosystem of the upper watershed has been disrupted by deforestration, uncontrolled agricultural development, extensive depletion of the soil resource, and many other unwise practices. There has been a growing awareness of the problems created by soil erosion, but to date there has been no integrated approach towards defining the upper watershed problems of the entire Jratunseluna Basin, or in developing a program to solve these problems. This report has the general objective of providing a conceptual plan for clearly defining the upper watershed problems and defining the necessary technical approach to halting the deterioration of the upper watershed condition, and ultimately towards improving the productivity of the lands and in reducing the sediment loads of the streams.

For purposes of studying Soil Erosion, and Soil and Water Conservation the Basin is divided into the following subbasins:

Upper Watershed Areas	km^2	%
Lusi River to Serang Confluence	2,101.0	27.3
Serang River to Lusi Confluence	937.0	12.2
Slopes of the Muria Volcano 1/	700.0	9.1
Tuntang River above Glapan	796.0	10.3
Jragung River above Jragung Weir	133.0	1.7
Dolok River above Barang Weir	41.5	0.5
Penggaron River above Pucanggading Weir	77.7	1.0
Total Upper Watershed	4,786.2	62.1
Lower Watershed and Primary Irrigated Lands	2,913.8	37.9
Total Jratunseluna Basin	7,700.0	100.0

1/ Estimated by using the area above the Jepara - Kudus - Pati - Trungkil Highway.

There are of course many riceland, or flat areas, in the above upper watershed subbasins that produce little or no sediment to the river systems. The upper watershed area of 4,786.2 km^2 (62.1 percent) is simply a means of defining the general area most subject to erosion.

The integrated upper watershed management, erosion control, or resource development program for the Jratunseluna Basin contained in this report was developed with an awareness that watershed problems are really "people problems" that have physical and technical constraints to their solution. Consequently, the well-being of people is the central consideration of the watershed management and resource development program conceived for the Jratunseluna Basin.

The watershed management approach used for evaluating and evolving the resource development program focuses on the total watershed, or hydrologic unit, as the planning and management unit. The program emphasizes the improvement of economic and social conditions, land treatment practices, and the improvement of agricultural and forestry production, rather than emphasizing the capital-intensive structural methods of protecting downstream flood-plains.

The original forested environment of the Basins' upper watershed area has been disrupted by deforestation, uncontrolled upland agricultural development, and sheet, rill and gully erosion. These environmental changes are the result of a large population growth and the resulting increased demand for agricultural production. This has resulted in extending upland cropping to areas where soil conditions or steep slopes make the land very unsuitable for sustained agricultural production. Except for areas of lowland irrigated rice and most of the uncut forest land, the entire basin is being subjected to heavy erosion and high runoff from mismanaged watershed areas, which is producing sediment yields estimated as high as 16,000 t/km^2 for the Jragung River above the Jragung Damsite. This has created a situation where in a few years much of the upper watershed lands could pass the critical point where it is no longer physically and economically practical to effect a rehabilitation to productive uses.

F.1.1. Purpose and Scope

The purpose of the Jratunseluna Basin study is to identify problems of the upper watershed areas and to propose a conceptual plan for the optimum cooperation between governmental agencies for the utilization of the land and human resources of the watershed. The basinwide plan provides for an integrated land and water resource management program designed to provide the maximum long-term production of all watershed lands through soil conservation and community development activities.

The conceptual erosion control plan for the Jratunseluna Basin attempts to provide for the maximum ultimate development of all resources. At the same time, it attempts to keep the program flexible enough to accomodate changing social and economic environments, or shifts in the availability of project funds. It is strongly recommended that all program features be designed from the farmer perspective to allow the farmers and the local villages administrative units to coordinate and develop the project applications in their village. The goal is to focus attention on the farmer's problems and to coordinate the government programs that encourage the farmers and the community to solve their own problems. This can greatly aid in increasing economic stability of the area and in solving the soil and water conservation problems of the upper watershed areas.

F.1.1.a. Objectives of the Study

The objectives of the expanded Tuntang River Basin Development Plan Contract (Contract No. B.58/CES/79) include the following statement:

> "Review of existing water and soil conservation and erosion control plans of the sub-basin within the Jratunseluna Basin; prepare a conceptual plan for the entire Jratunseluna Basin; and prepare detailed designs for an erosion control scheme for a pilot demonstration area within the Jratunseluna Basin."

These objectives are short term in nature and do not includes the specific long term objectives for soil and water conservation or water shed management, but it is implied that they should be developed. These specific objectives are discussed in the Technical Approach Chapter Section F.2.3. General Objectives.

F.1.1.b Scope of Work

The scope of work contained in the expanded Tuntang River Basin Development Plan Contract included this following items:

1. A study to determine the problems and needs for water and soil conservation and erosion control for the basin is to be performed. This study will consider the studies and work on erosion and soil conservation being done by other Consultants and government programs in the Jratunseluna Basin. This study will result in the preparation of a general scheme for the entire basin. The report will include criteria to delineate the types of measures to be used for different types of terrain and typical drawings of the various types of erosion control measures which should be utilized. This is basically the scope of work for this report as Part II Conceptual Plan for the Jratunseluna Basin.

2. The preparation of a detailed design for a 100 ha pilot area. The pilot area design was to include drawings of the area showing the location and types of erosion control measures to be constructed and the drawings are to be of sufficient detail to allow construction of the erosion control measures. This work is completed as the plan for the Pilot Watershed Demonstration Areas in the last section of this report.

Although the terms of reference in Amendment No. 1 to the Tuntang River Basin Development Plan Contract did not include a requirement for an integrated watershed management plan for the basin, it quickly became evident that, in order to improve soil erosion conditions, it would be necessary to use an integrated approach to development problems. This is related to the necessity of the erosion control proj work becoming the local peoples project rather than a government one, and the need to improve the farmers income to the point where he can afford to adopt the needed conservation farming methods which have much higher input costs than for traditional agriculture. Hence, this report has a broader scope than originally proposed.

F.1.2. Statement of the Problem

To an engineer desiring to build a reservoir downstream the problem is the high sediment rates in the stream - 16,000 t/km^2/year on the Jragung River, for example. This means that he would have to provide 70×10^6 m^3 of sediment storage in the Jragung Reservoir, which is one of the reasons that the cost of the project became almost prohibitive [4]. To the social scientist the problem is the lack of resources, both physical and human, that would permit the people in the upland village a desirable standard of living. To the soil conservationist it is the soil erosion problems of the Jratunseluna which are caused by one or more of the following conditions:

- Removal of the original forest cover,
- Planting of crops on steep and long slopes without measures to take care of surface runoff,
- Erosion along roads and trails,
- Lack of proper conservation or bench terraces,
- Lack of waterways to dispose off excess water,
- Lack of vegetative cover to reduce sheet erosion caused by raindrop splash and surface runoff, and
- Naturally erodible or unstable soils in the Watershed.

Each specialist could add to the list until it becomes unmanageably long. What is not generally recognized is that these are "people problems" that have economic, technical and physical limitations on their solutions. More important, planners and government officials seldom realize that the farmer, or other watershed resident, is generally completely rational in his behaviour, given the specific circumstances of his or her situation. Therefore, to initiate a permanent change in upland agricultural methods it is necessary to change the farmer's economic position, his ability to take risk, his perception of the problem, and to show how he might benefit from the solution the technician is suggesting. Because the farmer probably cannot read, his education in conservation farming must be accomplished by oral or demonstrative communication.

The principal cause of low labor productivity by upland farmers is, in fact, the low productivity of their past labor. Production and economic returns are simply not large enough to start the cumulative process of rising production and prosperity. This low productivity, and the high rates of erosion, result from the large population pressures that prevent most upland farmers from obtaining a farming unit that yields more than subsistance levels of production. In most cases the farmer himself does not realize the effects of these limitations, but his insecure and constrained existence largely determine his behaviour. The truth is that upland farmers of the Jratunseluna Basin are not members of modern economic society and have very limited chances of ever accomplishing this feat. But if the erosion of the Jratunseluna Basin is permitted to increase at present rates the upland areas could conceivably support less than one-half the present population by the year 2000.

It is important to understand that conservation practices are bound to agricultural production in two important respects: First, they are physically bound because the ground cover and soil management in agriculture and forestry effect both the degree of erosion and the maintenance of any installed conservation works. Secondly, they are economically bound because the primary justification for conservation of agricultural or forestry lands is that these lands, either now or in the future, will be more productive than they would have without the installation of conservation measures. The real reason for soil conservation activities is to save the land resource for future generations. It is also important to understand that the destruction rate of upland watershed areas in the Jratunseluna Basin is accelerating, and it is only a matter of time before vast areas of the basin will become unproductive.

The major problem of the Jratunseluna Basin is that the present productivity and size of upland farms is such that neither the physical nor economic conditions for a conventional soil conservation program exist. Even if the best possible structural measures (terraces, drop structures, waterways, etc.) were installed, the land, and the structural measures, would continue to erode under the present agricultural practices. Furthermore, the agricultural productivity of most of the upland areas is so low that it is questionable whether the net returns to the farmer are sufficient to pay even the maintenance costs of the conservation works -- much less their initial cost. At this same time, it is very important that the farmer contributes to the construction of the terraces and other structures so he thinks of them as his improvements not that of the government.

Population pressures create related problems on the forested land. The first is where forests are clear cut and the people permitted to raise crops on the land for two years. Most forest land is not suited to crop production and this practice causes large amounts of erosion and losses in fertility that greatly delays the reforestration activities. In most cases it would be more economic to hire people to erosion-proof and reforest the area immediately. The second problem on forested lands is the almost continuous trespass harvesting, clearing and farming of forested areas. After the topsoil is lost by erosion, and it will no longer produce crops, these areas are abandoned. At this stage these abandoned areas will generally only support weed species and a low type of jungle.

Using each hectare of land within its capability unfortunately requires a detailed inventory of the soils and other resources available, and this information has not been developed for the Jratunseluna Basin.

F.1.3. Core Concepts in Soil Conservation

The need for soil conservation has been understood, at least to some extent, by most societies down through history.

But at a no time in history has the earth been asked to feed so many people. The understanding that man is both the only thing in nature that can destroy the environment and the only living thing that can do something to plan and improve his environment is very important to the soil conservation concept. The balance of this section contains some core concepts for understanding the soil and water conservation program for the Jratunseluna Basin.

1. Soil is the base of the food chain and thus life. Soil is the thin outer layer of the earth upon which all life depends; as it furnishes most of the food for plants, and supplies many raw materials for industry.

   - How we treat the land determines how well and how long it can furnish man with the necessary food, fiber and living space.

   - Soil erosion, flooding and sediment deposition are signs (symptoms) of land abuse.

   - Soil conservation practices can keep the land productivity by saving valuable topsoil, but they must be used in a complete conservation farming system.

   - Good land use is "using the land according to its capabilities; steep land for grass and forest, level land for crops".

   - Every hectare of land has a use - its best use must be found.

   - All parts of the watershed lands are interrelated and damage to any part of the system can destroy or damage other areas.

2. Plants, the "producers" in our environment, are also the "caretakers" of our environment. Good plant cover is the primary defense against soil erosion. Almost no erosion occurs in a natural forest area.

   - The fertility of the soil is directly related to plants - both from adding nutrients and reducing soil erosion.

   - Water quality is improved by plants as they protect the watersheds against erosion and reduce sediment in streams.

   - The primary control of erosion is by increasing vegetative cover, which can then be supplemented by other soil conservation measures including structures.

3. The conservation (wise use) of water should be the concern of everyone since each of us is dependent on water for life. Water can be managed - used again and again.

   - Erosion is the source of most sediment in water, but to the extent precipitation infiltrates the soil it is not available to create erosion by surface runoff.

   - Watershed planning and management is necessary to assure the quantity, quality and timing of water supplies.

4. Man has the responsibility to share the earth with other life forms and functions.

   - Life on earth is dependent on available natural resources and functioning of natural systems.

   - Man is the only living thing intelligent enough to plan the use of his environment, but the individual person will not participate in a plan he does not understand.

   - Man's actions can destroy resources, or he can use these resources wisely, thus maintaining the earth's delicate natural system.

F.1.4. Constraints or Limitations of the Plan

The conceptual Plan for the Jratunseluna Basin provides only a technical framework for undertaking the development of a watershed management program for reducing erosion damages in the upper watershed area. Because of time and data constraints it is not even possible to specifically identify the subwatershed where the project should be initiated. From the limited data on sediment production, however, it would appear that the project should be initiated in the Tuntang/Jragung Rivers watershed area.

Time and data constraints also prevented the provision of any specific project budget proposal for the Jratunseluna Basin. Considering the probable limitations on availability of technically trained people for an integrated development program this is probably not important. For at least the first two years of the project, the Pilot Watershed Demonstration Area Project contained in the last section of this report will probably require most of the funding and technical assistance available. As such, it is a recommendation that work in the Jratunseluna Basin be initiated on these or similar demonstration farms.

As noted in the next section of this report it is necessary to develop a considerable amount of data on resource availability and problems before it is possible to develop a truly integrated program for soil and water conservation in the basin. This also requires the development of a highly trained and qualified technical staff that can provide leadership and training for the field staff. Because past agricultural development programs focused on the production of irrigated rice there are essentially no professionals staff who are qualified to solve the problems of upland farmers. Therefore, it would be a waste of funds to attempt to implement a program for the entire basin in the near future. The staff must be trained, and the upland conservation farming method and structural measures must be proved on the demonstration watershed areas before the watershed management program for the basin can be developed.

If funds were available, the process of developing and implementing the watershed management program could be speeded up by hiring qualified consultants to train the local staff and initiate the technical program described in the next section of this report.

F.2. TECHNICAL APPROACH

F.2.1. Watershed Erosion Problems

The destruction of the environment, through the misuse and overuse of the land resources has become the short-run price of survival for upland farmers in virtually all of the less developed countries. The history of man is, of course, replete with those instances in which man's mismanagement of the available soil and water resources has caused the degeneration of once fertile land into wastelands or deserts. The very high population densities of the Jratunseluna Basin has definitely accelerated the destruction of forested areas, plantations, and fertile cropland areas by erosion and/or sediment deposition. Unfortunately, man is often slow to learn from the evidence of the world's many devasted lands, which are testaments to the catastrophies that are certain to follow the mismanagement of upland watershed areas. Fortunately, it is still possible to prevent this from happening in the Jratunseluna Basin.

The consequences of uncontrolled forest exploitation in the Jratunseluna Basin are of critical concern because some of the formerly forested areas are approaching the critical point where they can only be returned to poor quality forest or abandoned to weed species. In addition to the effects previously discussed, this will result in a direct shortage of lumber and fuelwood in the Basin. With the recent energy crisis and the attendant higher prices for petroleum products, the exploitation of fuelwood resources is becoming a serious problem. To some degree, however, this has the advantage that fuelwood produced as a part of an agroforestry program will have a ready market.

Whenever upland agriculture is practiced, or whenever roads and trails are cleared of vegetation, excessive removal of soil is likely to occur. The steeper the land form, the higher the potential rate of erosion. Erosion not only results in the deterioration of the productivity of the land, but it also results in the aggravation of sedimentation and flood damages in downstream areas. No program will control erosion on steeply sloping upland crop areas -- it can only reduce the erosion to some acceptable level or maintain the land resource for use over a longer period of time.

In the Jratunseluna Basin, the problems of erosion from upland crop areas are compounded by the high population density and by the fact that the cultivators are poor farmers operating small parcels without the physical, human (educational), or economic resources to solve the problems. The social dilemma is always there. The resettlement or transmigration of people from the land is a difficult process even when thay are illegally squatting, but the watershed land and water resources will continue to deteriorate unless the process of cultivating even steeper lands can be stopped. Because people must eat, the solution of a watershed's erosion problem may well rest with transmigration and population control. Otherwise, the program suggested in this report can only reduce the rate of deterioration while feeding the existing population better; it will not solve the people problem of the watershed.

All cultivated slopes require protection against erosion by a high degree of vegetative cover or structures, or a combination of these measures. The steeper the slope, the higher the potential for erosion and the more difficult it is to reduce erosion rates to some acceptable level. Mechanical methods of control must be fitted into the upland farming conservation program, and their success lies in the management and maintenance by farmers with some help from governmental technical services. It should be noted that the real reason for most erosion control structural measures is to break the slope into shorter or flatter slopes on which surface runoff can more easily be controlled.

It is especially unfortunate that the erosion problems and loss of soil fertility are seldom recognized until they have reached critical stages or conditions that are very difficult and expensive to reverse. At this stage, the erosion problems of the watershed have already reduced upland crop production, destroyed much of the natural forest cover, caused farmers to abandon eroded croplands, and produced accelerated runoff rates with the attendant flooding and high sediment loads in the streams. This effect, in turn, increases downstream flooding and sediment deposition.

Traditionally, the solution has been to build reservoirs or levees to control river flows and thereby protect the more valuable downstream lands and developments. In some cases a large erosion control project is initiated to solve the erosion problems of the upper watershed area in a brief time--usually five years or less. Such a project usually takes the form of massive terracing, waterway construction, and reforestration projects that, theoretically, will quickly solve the erosion problems of the country or area. However, when the initial technical and financial support of the project is no longer available, the measures are generally not maintained and soon fail, thereby causing damages to be much greater than if no erosion control project had been attempted.

What is not generally recognized is that these watershed problems are really people problems with economic, technical, and physical limitations to their solution. More importantly, planners and government officials seldom realize that the behavior of the individual farmer, or other watershed resident, is generally completely rational within the limits of his knowledge. Therefore, to initiate a permanent change it is necessary first to change the farmer's economic position and his ability to take risk; then to develop his perception of the problem and of how he might benefit from the solution; and finally to instruct him in the methods of conservation farming and to provide him with the incentives necessary to make the desired changes.

Simply stated, the <u>major problem</u> is that the upland farmer's present farm productivity and size are generally so limited that neither the physical nor economic conditions are available for a conventional conservation program. Furthermore, population pressures are causing additional areas of forest and plantation land to be cleared for agricultural production; because most of this land is unsuitable for upland crop production, it will erode and ultimately be abandoned or returned to marginal forest uses.

F.2.2. The Watershed Management Approach to Erosion Control

The watershed management approach to evaluating and developing soil and water conservation programs focuses on the total watershed (or hydrologic unit) as the planning and management unit. This total catchment area concept implies that any conservation treatment should be considered in its relationship to the entire drainage area, both in how the watershed will affect the treatment and how the treatment will affect the watershed. The watershed management approach emphasizes land treatment practices rather than the capital-intensive, structural methods because the primary control of soil and water is exerted by vegetation and all management efforts should aim at increasing vegetative control of erosion and runoff. This is accomplished by the adoption of conservation farming techniques, land use adjustments, and, where necessary, the provision of structural measures.

Increases in runoff and soil erosion generally result from man-caused imbalances between the vegetative cover and the existing soil-landform-climatic conditions. Consequently, the most effective treatment for accelerated erosion and runoff is the restoration of the proper balance between vegetation and site conditions on as large an area of the watershed as possible. Vegetative control of runoff may be achieved either directly, by improving the cover conditions, or indirectly by effectively managing crop residues or by mulching cultivated areas. Therefore, even where structural measures are used, they should be considered adjuncts to vegetative control methods of conservation farming and revegetation of disturbed and eroded areas.

Many types of mechanical protection can be used to reduce erosion of cultivated slopes: level basins (rice paddies), contour planting, strip cropping, conservation terraces, bench terraces, and diversions for example. Many variations of these methods can be used, depending on the slope of the land, the crops to be grown, and all of the climatic and soils factors that affect the erosion potential of the area. The complete treatment of upland slopes will also generally require the development of waterways, drop structures, and channel and gully stabilization.

The general success of the bench terracing program of the Panawangan Pilot Watershed of the Citanduy Basin, has caused many people in Indonesia to believe that bench terracing is the complete answer to watershed erosion control problems. If for no other reason than the vary high cost of bench terracing, this is not a true generalization. Insisting on bench terracing of all cultivated upland will simply mean that no conservation work will be applied to some lands. It cannot be emphasized too strongly that there are no simple answers to solving the problems of watersheds having large population densities in relation to the resources available.

In simple terms, integrated watershed management is the planning and application method that takes into account all the watershed resources and problems and attempts to maximize the economic and financial returns over the long term while maintaining the watershed land and water resources for use by the future generations.

The integrated approach to watershed management is also known as "comprehensive," "conservation management," "multidisciplinary," "interdisciplinary," "basin-wide," or "multiple-use planning;" it does not matter which term is used specifically to describe the process. The term "multiple-use planning" seems to be coming into more common use in relation to watershed management and will generally be used to describe the process in the balance of this report. In simplistic terms, integrated watershed or multiple-use planning is the planning and application method that takes into account all the watershed resources and problems, and attempts to maximize the economic and financial returns over the long term while maintaining the watershed land and water resources.

Notably, in a developing country the integrated watershed management approach is the key to:

1. Efficient use of limited funds and trained manpower;
2. Maximizing use of available resources (physical, human and economic);
3. Coordination of the government programs to reach specific objectives; and
4. Maximizing long-term production from the watershed while protecting the land and water resources.

Historically, only lip service has been paid to the integrated approach in the actual watershed planning process.

Although multiple-use planning is one of the evolving features of watershed management programs, it complicates technical, administrative and political decisions. Technical decisions are intricate because, for the first time, the individual technical staff member is being asked how a practice in his field of expertise will affect the watershed's environment, land and water resources, economic return, and the well being of people. Rather obviously, this requires a higher level of training for the staff and the administrative coordinators of the program. It also requires a team effort from the staff simply because no one person has all of the knowledge required for true multiple-use planning and management.

From the administrative viewpoint, multiple-use planning is very difficult because it requires a blurring of the normal technical and administrative lines of authority. Individual governmental agencies cannot take independent action on the application of practices or the development of budgets if the multiple-use planning and management approach is to produce the desired results. Another administrative problem is that watershed boundaries seldom if ever match the political or administrative boundaries used by government agencies for program administration.

From the political viewpoint, the integrated watershed management approach creates extreme difficulty because it requires a long-term dedication of specific funds and other resources. Politically, it is much easier to remain flexible in regard to agency fund allocations than provide long-term commitments of funds. There is also a problem that many of the results of the watershed management programs are not immediately apparent and may never be visible to the nontechnical individual. The belief that the implementation of a watershed management project will result in muddy streams becoming clear is not even remotely true.

F.2.3. General Objectives

The general objectives of the proposed Integrated Watershed Management Project for the Jratunseluna Basin are to improve the quality of life for the watershed residents through a program that will improve watershed productivity and increase net returns to farmers by implementing conservation farming techniques that will reduce soil losses. However, individual farmers must have the resources necessary to accept and adopt the technical improvements because many erosion control measures and necessary land use changes will actually reduce the net crop area.

A secondary objective of the proposed Integrated Watershed Management Project is to develop the institutional capacity of the project staff to plan, implement, and operate watershed management projects. This will be accomplished by training the watershed staff to work with farmers and farm organizations in promoting acceptance of the needed conservation farming methods and techniques as well as to provide farmers with technical training in upland agronomy, soil conservation, watershed management, and all of the other technical disciplines required. Among institutional changes, the most important is to educate governmental officials to realize the importance of the farmer's understanding the problem and the benefits of the proposed changes. It is very important that the farmers think of the development as their project, not a government project.

The Integrated Watershed Management Project must consider three factors: (1) the existing level of land and water resource development; (2) the existing social structure and infrastructure; and (3) the available resources for accomplishing the improvement program. The integrated approach recognizes that in almost all cases the social factors will be more serious constraints than will the technical problems.

F.2.3.a. Objectives of Watershed Management

Watershed protection, management, and development projects have the following specific conservation objectives:

1. To use each hectare of watershed land within its capability over the long term and to prevent further deterioration.

2. To apply cultural, vegetative, and supporting structural-measure practices on each hectare of land as necessary to prevent soil deterioration and to obtain better soil, water, and vegetation management for maximum production from the land over the long term.

3. To stabilize runoff and control sediment as a means of:

    Maximizing net economic benefits from reducing damages by flooding and sediment deposition,

    Reducing reservoir or levee deposition and other forms of sediment damage to stream channels and rice fields.

Improving the water quality of the streams in order to promote health, recreation, and industrial use and to reduce damage to fisheries, minicipalities, and other related users, and

Achieving a water management balance among the water needs of each watershed hectare such that upper watershed production is maximized and the irrigation systems' dry season water requirements are more fully met.

F.2.3.b. Objectives of an Integrated Watershed Management Program

The development of significant and specific objectives can only be accomplished by studying the individual watershed and it's problems because only then is it possible to isolate and separate the various means of achieving the general objectives. Development of specific objectives for a watershed management program also requires the direct participation of the governmental units in charge of the watershed area being rehabilitated or developed.

Development of a watershed management program involves three components: (1) development of program objectives in accordance with the ultimate ends they are intended to serve; (2) the efficient employment of available resources; and (3) a program to reach the given objectives. The program objectives include:

1. Development by both farmers' and government officials' of an understanding of the true nature and condition of the problems they face; the program should attempt to demonstrate methods of solving these problems.

2. Development of an integrated multidisciplinary plan for solving, with their cooperation, the people problems of the watershed.

3. Optimum use of all previously installed soil conservation works.

4. Adoption of conservation farming methods and other improved agricultural practices through a system of demonstration farms.

5. Development of an efficient system for enabling upland farmers to obtain improved seeds, fertilizers, and other technical inputs as needed and at prices that permit profits from their use.

6. Education of those concerned regarding livestock and fish production as important complementary activities to the conservation program.

7. Increased water use efficiency in the total watershed by:

   Increased use of rainfall in both upland and irrigated areas.

   Increased irrigation system and application efficiency resulting in optimum use of available water supplies.

8. Development of a program for erosion proofing of roads and trails.

9. Improvement and development of the institutions and organizations needed to solve the problems of upland farmers by:

   Development of a multidisciplinary training program for technical staff that is focused on upland agriculture problems and their solutions,

   Development of a research program for upland agriculture and forestry that is focused on solving specific watershed problems,

   Strengthened link between research, extension, and farmers,

   Improved credit facilities,

   Development of cooperative marketing systems and facilities,

   Improved transportation system,

   Development of a conservation education program to reach all watershed residents.

10. Development of an evaluation and basic data collection system for use in improving the integrated watershed management program and provision of a source of planning data for project staff and governmental units.

F.2.4. Program Development

The development of a successful integrated watershed management program generally requires a reorientation of the whole structure of education and assistance to the land user. The land owner must be a part of the decision making process because he will be the person to put the plan into full and successful operation; if he does not believe in it, he will simply ignore it. The farmer must be encouraged to understand his soil and water resources and their proper management.

Five basic, common-sense stages are involved in the development and implementation of a sound soil conservation program for any watershed area. This includes the following activities:

1. Inventory the physical and human resources and problems:

   Farmers' and government officials' interest in and attitude towards soil and water conservation;

   Problems of upland farmers;

   Land use and land use versus land capability;

   Physiography;

   Vegetation type, condition, and use;

   Historical erosion types, rates, and sediment damages;

   Potential erosion rates and damages without conservation program;

   Climate;

   Hydrology and water supply availability; and

   Demographic and socio-cultural conditions.

2. Analyze and evaluate the data and factors found in the watershed inventory and determine possible solutions:

   Estimate total conservation needs for each land type and land capability unit;

   Delineate critical erosion areas and problems

   Evaluate the present resource use and productivity;

   Evaluate the improvement potential;

   Evaluate the most probable improvement rate; and

   Evaluate what will happen if conservation measures are not applied.

3. Develop and initiate a conservation education program to reach all age groups, both sexes, farmer leaders, influential citizens, and government officials:

   Multidiciplinary training in upland conservation farming methods and conservation techniques for all project staff;

   A training program for farmer leaders and local conservation technicians;

   Village meetings to discuss conservation proposals;

   Local watershed development committee training and motivation;

   Educational programs in school system (local dialect and written by an expert in conservation motivation); and

   Demonstration farms and educational tours that will spread knowledge of the best conservation farming techniques and practices.

4. Plan the program to fit the attitudes and desires of the farmers as well as the natural vegetation, land use capability, and land use patterns existing in the hydrologic unit or mini-watershed.

   Attempt to solve some of the problems recognized by the local people as a first step in project implementation;

   Avoid treating symptoms without consideration of the underlying causes of erosion;

   Concentrate on revegetation of disturbed areas, conservation farming, crop yield improvement, livestock and fish management, agroforestry (fruit, fuelwood, or timber production in combination with agricultural crops or pasture), and protection of critical areas;

   Where practical, rehabilitate and modernize existing terrace, waterway, and farming systems; be innovative at improving existing soil conservation systems or traditional practices;

   Use simple structures that can be built with local materials and labor when possible;

   Evaluate the cost effectiveness of the project and revise the program if necessary;

   Keep the operation schedule flexible and revise periodically in light of the experienced treatment effectiveness; and

Expose the smallest practical area for the shortest possible time during construction of terraces and other structures.

5. Implement a thorough maintenance program before, during, and after watershed land treatment and structural measures are installed. This may require a specific fund allocation after the project is officially completed.

F.2.5. Proposed Plan of Work for Program Development

Development of an integrated watershed management program for any major catchment area requires the collection and analysis of a large amount of basic physical, economic, and sociologic information to define the problem and arrive at a feasible project plan for solving the problems. Unfortunately, many of the Jratunseluna Basin watershed areas are eroding, or deteriorating, so rapidly that it is urgent that corrective measures be initiated as rapidly as possible. Therefore, the plan of work should be phased to provide for the initiation of a pilot conservation education and demonstration program in selected areas within six months after project initiation. Feedback from this education and demonstration work will also be very valuable in developing the detailed watershed management program for the entire catchment area.

While it is not possible to determine the number of demonstration watersheds needed without extensive investigation, it is suggested that two education centers and two associated demonstration watersheds, of about fifty hectares each, be developed in the Tuntang Subbasin early in the program and that additional areas be developed as the need becomes apparent.

Program development comprises three primary phases: (1) resource inventory and problem identification; (2) proposal of possible solutions for the problems; and (3) assessment, testing, and evaluation of the proposed solutions. All three phases should be conducted on the two primary demonstration watersheds.

F.2.5.a. Resource Inventory and Problem Identification

(i) Resource Inventory

Resources are those things people can use to satisfy their needs--anything from soil, water, and vegetation to a musical composition; and because of changes in technology, our definition of resources constantly changes. Therefore, no resource inventory is ever complete and final. New and to-be-developed resources exist as people have the skill and creativity to find uses for materials that today have little or no value.

In many watersheds, it is the lack of human resources (education, conservation farming methods, etc.) that has created the most problems; therefore, those resources require the most careful inventory. The demographic and socio-cultural inventory of a watershed's residents (the human resources) is of primary importance because it is their labor, skills, and talents that will ultimately determine the success or failure of any watershed management program. The intelligent use of all the available resources over time is essential to a program's success in increasing the well-being of people.

Natural resources (such as soil, water, air, plant, and animal life) are those materials available in the watershed for improving its resident's quality of life. Therefore, a careful inventory of the natural resources provides the planners with an important measure of the basic resources available for development and use and with an indication of the past and present rate of depletion.

Relations between resources are complex in farming and particularly so in upland farming. The growth of plants and animals is the joint product of seeds, the sun's radiation, rainfall, plant nutrients, and the farmer's labor and cultural practices. This complexity and the consequent complexity of problems emphasizes the need for a multidiciplinary team of specialists to work together in developing an integrated watershed management program.

(ii) Problem Identification

This systematic procedure for identifying problems and constraints begins with a preliminary investigation of the proposed pilot areas and major watershed units, of existing research relating to the watershed system and conservation farming techniques, of existing agricultural practices, and of institutional and infrastructural arrangements and procedures that affect the watershed. This initial step establishes a knowledge of the existing system.

Systematic problem identification is necessary to understand the traditional farming systems (both upland and riceland) of the watershed and to isolate the major constraints on increased agricultural production. The multidisciplinary technical staff must talk with the farmers and attempt to perceive both what the farmers see as their problems, and what "real" problems constrain production and cause farmers to deplete their soil resources.

Any technological improvement must be acceptable to those who provide for, use, manage, and take the risk of the implemented changes. Therefore, this phase must carefully determine the needs of the farmer, including the interrelationships among technology, institutions, and the prevailing economic, social, and cultural structures. Using this approach, the farmer becomes the center of attention; his remarks and suggestions will be recorded for assessment; his needs will be identified and his cooperation solicited. Then, providing the educational program teaches him to understand the erosion problem of his land and providing sufficient incentives are supplied to enable him to take the risk of making the desired changes in his farming operation, the farmer will undertake conservation farming methods.

(iii) Resources and Problems to be Studied

Specific items to be studied would include, but not be limited to:

1. Identification of the "people problems and assets", namely

   Population density,

   Population growth rates,

   Age and sex distribution of the population,

   Employment and underemployment,

   Education levels (particularly farmers and farm families),

   Farmers' incomes and living standards, including nutritions level,

   Farmers' attitudes and desires as related to conservation farming methods, and

   Cultural and institutional constraints to change;

2. Land use in the watershed and historical changes in use;

3. Present farming practices and inputs in the watershed;

4. Climate and water availability and use in the watershed;

5. Soils, land capability, and erosion rates;

6. Credit availability and use;

7. Pest and disease control;

8. Cropping areas and yields under present conditions;

9. Storage and marketing of crops;

10. Economic and social conditions;

11. Infrastructural problems and difficulties in working with farmers;

12. Farmers' respectiveness to social, technological, and institutional changes;

13. Availability of animal and mechanical power;

14. Irrigation development in the watershed and the potential for development in additional areas;

15. Forest resources and problems, namely

    Timber production and marketing,

    Fuelwood and other forest products and marketing,

    Uncontrolled logging,

    Trespass problems and control methods,

    Fire losses and control methods, and

    Plantation development and other reforestration efforts;

16. Eroded areas requiring intensive revegetation or reforestration.

F.2.5.b. <u>Proposal of Possible Solutions for the Problems</u>

After key problems have been identified, a search for solutions is initiated. This search would include, but not be limited to:

1. Studying problems, constraints, procedures, training, and institutional, technical, and economic requirements associated with implementing, managing, and maintaining the proposed watershed management improvements;

2. Defining technologies for conservation farming that could be employed to correct many of the erosion and soil depletion problems;

3. Adapting the available technologies to on-farm conditions and to farmers' attitudes and desires;

4. Assessing governmental agencies' cooperation with, and support for, the proposed improvement program;

5. Assessing the farmers' ability to take risks and developing an incentive program to enable the farmer to make the desired changes to conservation farming methods;

6. Assessing the farmers' willingness to accept land use changes, conservation structures, and conservation farming methods and estimating the potential for farmers to maintain and use these features without direct project incentives.

Criteria for selecting possible solutions must include an evaluation of the farmers' potential long-term acceptance of the Conservation Farming Methods, the probability of demonstrated success's aiding diffusion of the watershed management approach, the probable government cooperation and support in implementing solutions, and the suitability of the approach to the social, economic, technological, and physical environment of the farmer. Of critical importance to the ultimate success of an integrated watershed management project is the recognition by the government of Indonesia that there is no permanent solution to erosion problems and that there must be a continuing program for improvement as long as man has a need for the resources of the watershed.

F.2.5.c. Assessment, Testing, and Evaluation of Proposed Solutions

(i) Assessment Program

In order to ensure that the innovations are appropriate, acceptable, and useful for the farmers, formal assessment of solution is necessary. Primary emphasis must be placed on working with farmers to test the solutions under actual conditions that other farmers will encounter when they apply the same or recommended solutions. Evaluation is essential at all phases of the project; however, it is especially important after implementation of pilot watershed management projects.

Solution assessment is important to provide insights into how the innovations can be improved for wider and more rapid diffusion among farmers. Evaluation of the solutions is also important to determine their feasibility for all classes of farmers, particularly small upland farmers and renters, and to estimate their socio-economic impacts. Both the individual and collective adoption behavior of farmers must be assessed. Improved communication techniques are essential to improved technology.

An integration of physical, agricultural, and institutional components appears to be a necessary requirement to a project's success. The construction of physical improvements will provide the "hardware" for improving soil and water conservation, but it does not necessarily improve food production. In fact, the construction of bench terraces, waterways, and drop structures actually reduces the area available for crop production. Therefore, to be successful, the program must train the farmers in conservation farming techniques, must provide incentives, and must increase the availability of fertilizers, insecticides, new seed varieties, and other inputs. The long-term success of an integrated watershed management project depends on the integration of all activities that can result in the adoption of conservation farming techniques and, hence, in the improvement of the farmers' crop production and standard of living. It is especially important that a thorough maintenance program for all structural and land treatment measures be carried on both during the project period and throughout measures' life, at which time, it is important that they be replaced or rehabilitated. It is well-documented that erosion control structures that fail frequently cause more damage than would have occurred if they did not exist. Therefore, the formal assessment of the possible solutions should include a careful analysis of the probable long-term use and maintenance of proposed structural measures before the funds are committed for construction.

(ii) Testing Program

After assessment of the solutions, the conservation education program and the two demonstration watershed areas (approximately fifty heactares each) should be initiated to test the effectiveness of the solutions selected. Again, it is essential to identify the problems of farmers in each of the watershed demonstration areas, or even subwatersheds of these areas if differences occur. During the testing phase, an atmosphere of functional cooperation should be encouraged between the project staff and the farmers and government agencies involved. The watershed farmers need to be trained and their acceptance of the improved program evaluated. The resulting information should indicate the potential for success in establishing an integrated watershed management program in the subbasin and, later, at the regional or river basin level.

In the development of the demonstration watershed areas, the farmer units or groups should be organized around hydrologic units of land, which may vary in size according to the dictates of the land and water resource management requirements. In general, these hydrologic units should be from five to ten hectares in size. The name, "Conservation Action Units" is suggested as the name of these groups. In each watershed, at least one of the more progressive Conservation Action Units should be selected as a demonstration farm and should be worked with intensely.

At the demonstration farm stage, it is particularly important to recognize that too often planning is done <u>for</u> rather than <u>with</u> people. As a result, the plans which are developed conform to the planners' perception of the needs; if the farmers' perception differs, nothing happens and the plan dies as soon as the project incentives cease. The plan must solve problems that the farmer and his family understand, and it must use methods and goals that are within the resources available to the farm family. Truly, if the farmer does not understand that he has a problem, he does not--it is the Government that has a problem.

The first step in organizing and using demonstration watersheds is to identify, through personal contact with officials and key farmers, the line of authority in each village. Local leaders must understand the need for, and must believe in, the conservation program before it can be established. This is particularly important for the maintenance of project measures.

The initial physical development of demonstration watersheds will, of necessity, be somewhat slowed by the need to initiate the training and extension program to train the staff, local leaders, and farmers. The demonstration farm area farmers must then have sufficient training to develop an interest in the conservation farming program and to organize the necessary Conservation Action Units or some other watershed group to work with the project staff. Of course, the extension personnel should be present and commence activities in the problem identification phase, but the education of farmers to the extent that they are truly ready to try adopting conservation farming methods can take considerable time. Projects around the world have convincingly shown that the basic constraint to innovations in agricultural development is the farmers' attitudes and that many projects have failed because the local people viewed them strictly as a "government project".

To accomplish the goals of the testing program and to ensure that all components are integrated in a timely and proper manner, the project staff should maintain a close coordination with other staff members and their counterparts. To accomplish these goals, the project staff should:

1. Develop and initiate a conservation education program designed to reach all age groups and both sexes of farm families, influential citizens, and government officials by providing:

   Training programs for key farmers and conservation technicians,

   Village meetings to discuss conservation proposals,

   Educational programs in the school system (in local dialect and written by an expert in conservation motivation),

   Direct communication with the farmers as a means of developing strong lines of communication between individual farmers and the staff of the watershed management project,

   Demonstration farms and educational tours to spread knowledge of the best conservation farming techniques and practices;

2. Conduct economic analyses to determine costs and returns for alternative technologies and methods of conservation cropping system improvements, of increased cropping intensities, and of adding structural measures, such as bench terracing;

3. Concentrate the program on revegetation of disturbed areas, conservation farming, crop yield improvement, livestock and fish management, agroforestry (fruit, fuelwood, or timber production in combination with agricultural crops, cut and carry forage systems, or pasture);

4. Complete a soil survey of the demonstration areas to determine soil characteristics, land capability classification, critical erosion areas, and other factors that would limit land use and production;

5. Compile and analyze climatic data for the demonstration watershed regions as a means of defining drought, floods, and clima

6. Establish at least one agrometeorological station to collect climatic data;

7. Develop for all upland areas conservation cropping systems that will provide the maximum net returns to upland farmers for both lands with and without conservation structural measures;

8. Develop crop residue and vegetative cover management systems that provide a maximum feasible protection against erosion;

9. Establish a program of socio-economic research to assess, test, and evaluate alternatives for improving conservation farming techniques, cropping systems, erosion control measures, and the general quality of life for the farmer; to do this, the project staff should:

   Coordinate activities with the agricultural research organizations for development of upland crop varieties and conservation farming systems,

   Assist in developing, testing, and evaluating improvements in farmer marketing associations, farm credit systems, and other institutional developments,

   Place special emphasis on developing effective farmer organizations for achieving the watershed management objectives, and

   Assist with the implementation of any special socio-economic watershed management or regional development research that may be of assistance;

10. Plan for sequencing of technical components to minimize crop disturbances and provide increased efficiency during construction of terraces and other measures;

11. Test and evaluate fertilizer rate experiments and plant, disease, and pest control methods;

12. Test all available upland crop varieties that seem to have a potential for increasing crop production in the demonstration watersheds;

13. Provide supervision and technical guidance to the construction of all erosion control structures and other physical components to ensure correctness;

14. Establish a program to monitor, collect data for, and provide analyses of all major components of the demonstration watersheds. To do this, the project staff should:

Conduct a continuing socio-economic survey to assess the types of changes that occur with the implementation of the integrated watershed management program in a village area,

Develop complete hydrologic and sediment measuring systems for small hydrologic units (demonstration farms and control areas) to measure project effectiveness in controlling erosion,

Document performance of cropping systems, fertilizer trials, and crop variety trials, and

Conduct studies of structural measure costs, experienced or estimated life and maintenance costs, effectiveness (including failures), and estimated physical and economic benefits.

(iii) <u>Evaluation Program</u>

The evaluation program should document the results obtained from the demonstration watersheds as a means of applying the findings to the entire watershed or catchment area. The findings should be used in developing the Integrated Watershed Management Plan for the next phase of the program.

The demonstration area testing and evaluation program will permit the determination of the most appropriate measures and techniques for implementing an integrated watershed management project. The results of this pilot area work and research effort should be presented in a set of manuals, which should be prepared so that they can be used on a regional or nationwide basis to identify upland farmers' crop production and soil and water management problems and constraints on improved production; the manuals should also provide instruction in selecting and implementing solutions that are consistent with the farmer's social, economic, and physical constraints.

F.2.6. Recommended Integrated Watershed Management Program

All living things depend on the natural world for their existence. But only man, among living things, is able to shape the world of nature to his own desire. Unfortunately, the growing population is causing man to use up natural resources faster than man, science, and nature together can now create them. Therefore, man must learn to conserve his available resources. Conservation in this sense is the effort to increase and sustain the supply of resources we now need and will continue to need for generations to come.

The wise or most economical use of resources requires not only the skill of the trained scientist and technician, but also the understanding and interest of the ordinary citizen--because on him rests the ultimate responsibility for action. This is particularly true for the Jratunseluna Basin where the clearing of formerly forested upland areas has created a critical potential for erosion because the farmers seldom have any knowledge of upland conservation farming methods. They only have a desire to feed their families to the best of their ability.

The upland farmer suffers from a chain reaction of constraints. The most important is that he generally lacks the resources (physical, human, and capital) necessary for him to risk modifying his present production methods and adopt the needed conservation farming techniques that would reduce soil erosion losses on his land. An Integrated Watershed Management Program has the goal of reducing some of the farmers' constraints through the provision of education, training, and incentives to the extent that the farmer can adopt the desired conservation farming techniques. The program also should attempt to influence the farmers to think of the project as "their project", not another "Government project".

As previously noted, the development of a watershed management program involves three components: (1) development of program objectives in accordance with the ultimate ends they are trying to serve, (2) accomplishment of an efficient use of available resources, and (3) development of a program to reach the given objectives. The program objectives, or the action levels the programs should be striving toward, can only be stated by the Central Government of Indonesia, but the staff and outside consultants may be able to assist in defining the best project objectives. The efficient use of available resources is largely a function of the efficiency of the governmental organization charged with implementing the watershed management program. In this case, a consultant can review and analyze the effectiveness of the existing governmental organizations responsible for soil conservation efforts and can make recommendations for changes. The development of the Integrated Watershed Management Program to reach the given objectives is the responsibility of the government agency in charge of the project with the technical assistance and leadership of an outside consultant.

The specific development of an integrated watershed management project plan can be accomplished only after a careful inventory of the watershed's resources and problems; after the determination of feasible solutions through a program of assessment, testing, and evaluation of proposed solutions; and after the application of this knowledge by a group of multidisciplinary planners. Therefore, it should be recognized that the balance of this section is an outline of some of the more important features of the needed project plan.

It should also be recognized that the training of the project staff, establishment of demonstration farms, and the testing and evaluation of solutions are actually part of the project implementation phase. Accomplishment of each of these steps is essential for efficient program implementation and to prevent the costly mistakes that have been made in erosion control or watershed management projects elesewhere.

F.2.6.a. Conceptual Framework and Physical Criteria for Watershed Program Development

In order to improve the agricultural production of a country while reducing the soil losses through conservation farming techniques, it is very important to identify the relevant assets among the limited natural resources and to find ways and means of putting these assets to the highest, or best, possible use. This requires an understanding of the simple fact that the basic constraint to innovations in agricultural production methods is the farmer's attitude. Because this farmer must manage the resources and developments in the end, it is vital that he understand the reasons for change and how the changes will benefit him, his children, or even later generations of his family.

Soil and water conservation programs all deal with the management of physical resources and are designed to reach some stated objectives, such as reducing soil losses to some specified level. In designing such watershed management programs, several physical-based concepts, that have been discussed, are particularly relevant. Among the more important of these are: (1) the watershed management approach; (2) vegetative control of erosion; and (3) the use of land within its capability. Conservation is practiced to maintain or improve the quality of the land and water resources for both short-term and long-term uses. Ideally, practices are applied which allow achievement of long-term national goals while maintaining or enhancing the short-term productivity of the land for the present resource user.

In conceptualizing and organizing the needed integrated watershed management project for the Jratunseluna Basin, the following objectives should be studied:

1. Increasing short-term productivity;
2. Increasing long-term productivity;
3. Increasing technical knowledge;
4. Dissemination of knowledge to farmers and communities;
5. Balancing the watershed population with the available resources.
6. Increasing employment opportunities;
7. Basic data development for planning and operations;
8. Reduced sedimentation and flooding;
9. Integration of all natural resource development programs; and
10. Modification of institutional constraints.

While this list is not exhaustive, it does establish a basis for applying the experiences in the pilot demonstration watersheds to the larger problems of reducing the unwise use of natural and human resources in the entire watershed area.

F.2.6.b. Economic Activities

The economic activities during the project implementation phase are primarily related to farm management investigations. The economic evaluation of alternative production methods is very important in assisting the farmers in selecting the most desirable scheme for increasing their output and earnings. These economic analyses would include determination of costs and returns for alternative technologies and methods of conservation farming, increased cropping intensities, and the effects of fertilizer and insecticide use. In the typical food deficit upland watershed area the farmer has very limited interest in adopting improvements that have the risk of causing a reduction in crop production from his limited farmland. The local staff needs well documented farm management studies that show the increased costs and returns associated with the adoption of total conservation farming practices, or even the adoption of a single improved upland crop variety.

F.2.6.c. Technical Activities

Technical guidance on all physical components is required to assure that these components are technically correct. As each bench terracing and water control system is completed, and the conservation cropping system applied, it should be evaluated (utilizing benchmark data) to compare the results with the traditional system. Lessons learned will then be useful in revising guidelines or providing additional staff training for future improvement project areas.

A minimum cost essential improvement program should also be tested and evaluated. This will involve a minimum engineering and capital outlay, and a maximum of farmer planning and installation so the government can decide on the least costly method of accomplishing the major conservation objectives in large areas.

Education and incentive requirements should be investigated to ensure that properly designed bench terraces, waterways, and other structures are constructed and maintained to protect the upland farming areas from long-term erosion.

Analysis of cropping patterns that efficiently use available water while maximizing net food crop production should be made. Water requirements and productivity for new varieties of upland rice should also be evaluated. Climatic records need to be evaluated to provide estimates of the probability for both drought and floods as a means of assisting the farmer in evaluating the risk of changes in cultural practices. At least one agro-meteorological station should be installed to collect the needed climatic data. Planting dates and cultural practices should be shifted to increase cropping intensities and to match the available water supplies to the needs of the crops. Such improved conservation cropping systems need to be tested and revised in the pilot areas, and the performance of the cropping systems documented and compared to traditional or unimproved systems in both physical and economic terms.

In conjunction with the cropping system trials, fertilizer rate experiments and plant disease and pest control methods should be tested and evaluated.

F.2.6.d. Extension and Education Activities

If the educational aspect of the proposed project is to succeed, it must be organized so that the individual farmer is the recipient of the education, and (where possible) all of the education materials are written in his dialect and matched to his level of educational attainment. To do this effectively requires that the project technical staff be trained in the integrated watershed management approach and the conservation farming methods needed for maximizing upland crop production. To be successful the extension program must:

1. Use demonstration farms to more effectively reach farmers;
2. Involve the people in action programs;
3. Be based upon conditions that actually exist in the watershed or village;

4. Work through an understanding of the culture and encompass all local political groups and farmer organizations;

5. Be aimed at the people's needs and desires, not at those of the project staff;

6. Use local leaders as much as possible;

7. Help people to recognize their problems and needs;

8. Use any possible method of teaching; and

9. Value people more than things.

The results from the pilot areas and research efforts should be presented in a set of manuals. These manuals need to be prepared so that they can be used on a regional or nation-wide basis to identify the farmers' conservation management problems and to select and implement solutions in a manner consistent with their social, economic, and physical constraints.

Training and extension activities do not cease at the farm level. In fact, they must premeate all levels of government. All government officials, teachers, and technical staff must be made aware of their role in an integrated watershed management program. The training programs should include the development of materials and methodologies for project implementation and evaluation. Evaluation and refinement of the program should be major activities during both the classroom and on-the-job training periods. The evaluation should also be used to set up methods of trainee selection, methods for improving training and the content of material to be taught, and methods of improving technology adoption rates. Throughout the training exercise, the flexibility of training materials needs to be emphasized with the objective of developing two-way communication with the farmers. When the program begins to solve local people's problems, it can establish the foundation of a training program that will provide the farmer with an understanding of the seriousness of the erosion processes on his farm and the effect they will ultimately have on the entire nation.

The creation of Conservation Action Units presumes the agreement of the farmers' watershed unit to voluntarily proceed with a soil and water conservation program that has the goal of realizing benefits over both short- and long-terms, not only through the program's technical and financial components, but also through organizational components. To ensure that the latter aspect is clearly understood and that farmers are not merely responding to preconditions for assistance, extension personnel must meet with the land owners and operators to discuss the values, customs, and desires that are important to the individual, community, province, and nation. Continuous extension assistance on internal operations (such as voting, accounting, obtaining financial assistance, etc.) must be offered simultaneously with the technical assistance. Workshops should be held to discuss matters of importance to the local groups.

The need for overseas training should be established in the preliminary project phase, and specified recommendations made to the agency in charge of the project. The foreign training program should be based on the need for special knowledge and skills involved in watershed management that are not available in the country's universities. The individual training programs should be carefully tailored to the person being trained and the position to which he will return.

F.2.6.e. Institution and Infrastructure Development Activities

A review of the needs and problems for upper watershed management programs discloses that the governmental organizations currently concerned with programs for solving the upstream land and water resource degeneration problems are not meeting the program needs. Organizations created to deal with downstream irrigation and water management problems neither understand the problems facing the upland farmer nor currently provide him with any real assistance. Upland farmers' problems are not the same as those of rice farmers and the methods for achieving the upstream watershed management objectives must be developed to accomplish different goals. It is also important to point out that for a project to succeed farmers must think that the development is their project and not a government project.

As previously noted, other institutional constraints to increased production are the limited availability of credit for improved crop varieties, fertilizers, and other technical inputs. In many cases there are institutional problems related to the availability of the needed inputs themselves. Each watershed has different institutional constraints and the specific problems must be individually identified and evaluated as a means of reducing the specific constraints.

In problem watersheds the most common specific infrastructure improvement need is the provision of additional nonagricultural employment opportunities. Therefore, specific infrastructural improvement activities should be concentrated on the promotion of labor intensive activities using local resources in their production.

The need for regional development activities through developing farm credit, improved marketing systems, developing new industries, and other similar activities is fully as important as those for soil erosion control. If population limitation activities are included in the institutional changes, it would be more important than the addition of all erosion control practices. The watershed problems really are, after all, "people problems" with physical and technical limitations on their solution.

F.2.6.f. Monitoring Project Performance

Planning a project or a pilot watershed area is quite different from ensuring its performance according to plan. A project cannot be efficiently monitored "on the whole" or by indirect evidence. It can be monitored by adopting and using appropriate data collection and statistical techniques. The large number of farmers who have different production potentials needs monitoring, but if a project has several thousand farms, relatively few of them can be used to monitor project performance. The exact number of farms required to monitor project performance can be determined using statistical procedures, depending upon two important considerations: the degree of accuracy required and the number of farms that could be reasonably monitored within the constraints of budget and time. After the number of farms to be monitored is determined, a random number process can be used to designate the specific farm involved. Once designated, the same farms should remain monitor indicators.

The critical path method (CPM) or similar approach should be used to provide a management control of the varied and interrelated tasks embodied in the Watershed Management Project. During the initial stages of the Project the project administrators should develop a detailed program evaluation and review technique diagram that will include an overall project control system as well as divisional controls for discrete program activities. These systems will assist in identifying project activities that are lagging behind schedule and will enhance timely execution of the integrated program.

An outside consultant is very important in providing a multidisciplinary staff for coordinating the water management project. This consultant staff would need to seek, both individually and collectively, to maintain full communications with the technical and administrative staffs at all levels and in all relevant disciplines.

F.2.7. Project Implementation

In a sense, the Watershed Management Project starts with the initiation of the staff training program and development of the demonstration watersheds. In this case, however, project implementation is viewed as the process of putting all of the solutions obtained from the pilot demonstration areas into action on a larger watershed area. The goal of the project implementation would be to expand the watershed management activities in the watershed as rapidly as funds and trained staff are available to efficiently accomplish the project objectives.

It should be noted that all watersheds with severe erosion problems have been deteriorating for a long time, and that likewise, it will take a long time to reduce the soil losses to an acceptable rate. In this sense the integrated watershed management project proposed herein is only a transition between the present deteriorating conditions and the future, hopefully stable or improving conditions.

It is very important that the implemented project be flexible so that needed changes can be made.

F.3. EXISTING SOIL AND WATER CONSERVATION PLANS OR WORKS

There has been a growing awareness that soil erosion in the Jratunseluna Basin has been progressing at an alarming rate. For example, the soil losses in the Jragung River increased 1.3 times between 1907 and 1938 or from an annual soil loss of 1.60 mm to 2.10 mm [1]. As a result of 1976 sediment measurements of the Jragung River at the Borangan Bridge ECI concluded that the sediment transport was 3 to 4 times as the estimate made from the 1907 measurements [2].

In recognition of the erosion problems the Indonesian Government set up a specific program called "Program Penyelamatan Hutan, Tanah dan Air" (Program on safeguarding Forest, Land and Water). This program deals with reforestration (or greening movement, i.e. penghijauan) and the application of soil conservation practices. Budget for this program comes from REPELITA (Five year development plan) and they are channeled to the local governmental units under INPRES.

F.3.1. Greening Program

For practical purposes the soil conservation for private land in the Jratunseluna Basin has been conducted under the Greening Movement Program (Proyek Perencanaan dan Pembinaan Reboisasi dan Penghijauan). This program is administered by the Directorate of Reforestration and Rehabilitation under the Directorate General of Forestry within the Agriculture Department. It should be noted, however, that the Greening Program staff (P_3RP-DAS) have only a planning, advisory and supervising function. All rehabilitation work is done by local government units using INPRES funds provided at the Kabupaten level. Soil conservation programs are actually conducted with funds from INPRES, PEMDA, PERHUTANI, Provincial Governor Funding and village schemes.

All Greening Movement activities for the Jratunseluna Basin are headquartered at Salatiga.

F.3.1.a. Reported Accomplishments

At a national scale the Reforestration and Greening Program during Pelita II (1974/75 - 1978/75) was reported to have accomplished the reforestration of 692,821 ha and the greening of 1,759,391 ha for a total of 2.45 million ha. This work was accomplished at a total cost of 89,747.5 million Rupiah, or Rp. 36,600 per ha (Table F-1). A regression analysis of this data indicates that the basic administrative cost of the program is about 246.6 million Rupiah per year, and the cost per ha treated is about Rp. 36,100 (R^2 = 0.96). Plans for Pelita III call for treating 3.44 million ha at a cost of 60,400.0 million Rupiah, or a cost of about Rp. 17,600 per ha [1].

Data furnished by the Greening and Reforestration Planning Office in Salatiga indicates that at the start of Pelita II (1974/75) there was a total of 14,211.25 ha of critical land in the forest areas of the Jratunseluna Basin (Table F-2). The data also indicate that all of the critical forest lands were rehabilitated during Pelita II and that there were no critical lands in forests at the start of Pelita III (Table F-2). Field examinations in the Basin indicate that the level of accomplishment is a matter of definition, and a detailed evaluation of erosion problems on national forests should be conducted as a part of any comprehensive watershed management program instituted for the Jratunseluna Basin.

As shown in Table F-3, there was an estimated 180,323 ha of critical land out of the forest at the start of Pelita II (1974/75). Most of this land is private land and amounts to about 23 percent of the 7,700 km^2 area of the Jratunseluna Basin. During Pelita II there was a reported decrease of 74,954 ha in critical area, or an accomplishment of rehabilitating 42 percent of the critical area during Pelita II. Somewhat strangely there was no additional critical area reported during Pelita II, and this probably simply means that it was never estimated.

Certainly there were additional critical areas developed during this five-year period. This leads to the hypothesis that the true area of critical lands at the start of Pelita III is more than the reported 105,369 ha (Table F-3).

The reforestation work in the Jratunseluna Basin shows area planted to the following species (Table 4):

	Area (ha)	
Teak (Tectona grandis)	7,651.3	52.4
Sonokeling (Dalbergia latifolia)	5,064.2	34.7
Mahogani (Swietenia macropylla)	915.0	6.3
Pines (pinus sp)	586.5	4.0
Kayuputih	339.4	2.3
Eucalyptus alba	44.3	0.3
Total	14,600.7	100.0

For some reason, all of this reforestation occurred during the years 1976 and 1977 (Table F-4), and no records seem to exist as to the success of these plantings.

F.3.1.b. Planned Rehabilitation

Because all critical lands in the forest area were reported as being rehabilitated during Pelita II there is no planned program for treatment of critical erosion areas of forest lands during Pelita III. There would of course be the normal program of replanting all harvested forests by the Perhutani Enterprise.

As shown in Table F-5, planned rehabilitation for areas outside the forest during Pelita III is as follows:

Year	Area (ha)	%
1979-80	29,511	28.0
1980-81	20,000	19.0
1981-82	21,768	20.7
1982-83	18,477	17.5
1983-84	15,613	14.8
Total	105,369	100.0

F.3.1.c. Assessment of Greening Program Activities

There is a general agreement that the Greening Program has had limited success in solving the erosion problems of the Jratunseluna Basin. The most frequent complaints are that the tree seedlings and grass sods were frequently dead before reaching the farmers, and that not enough technical assistance and advice were given to the farmers involved.

The Greening Program has several larger problems that affect its impact. First, the program is far too limited in scope, both in the area involved and the range of services offered. Terracing (usually credit terracing) and replanting are not sufficient to solve the problems that create erosion. Second, the approach is too standardized. The combination of practices that may be helpful in one area may have a negative effect in another. Because the terracing subsidy is the same for all types, most terracing is credit terracing (conservation terraces or hillside, ditches, for this report) rather than the needed bench terraces. Third, the implementation of the project is too mechanical: farmers must complete their work by a fixed date, after which seedlings and seeds automatically arrive. Farmers who complete their work early or late are in a vulnerable position, inviting erosion while they wait for deliveries, or losing the planting stock because they were not ready.

A review of the program shows a number of technical deficiencies. Foremost, is the problem that farmers do not understand the purpose of terraces or tree plantings. The result is bench terraces that slope outward and create erosion, and the almost total lack or grassed waterways and drop structures to safely dispose of excess water. Tree plantings are often a failure because the farmer does not understand how trees can give him a better living. Hence, trees are pulled up or harvested for fuelwood before they have a chance to produce much growth. The second problem is that the Greening Extension People (PLP's) are poorly trained to do a complex job and frequently give as much bad advice as good. The field staff at present have only a 50 day training course and little field supervision. This is at least a part of the reason for the problem of the farmers not understanding the conservation program.

From an overall technical viewpoint the major problem of the Greening Movement is the unfortunate attachment of the program to the narrowly specialized Directorate of Forestry. This prevented the deveopment of an interdisciplinary comprehensive watershed management approach [3]. This is particularly noted in the lack of a program to increase upland crop production and improve the well being of the upland farmer. Instead there has been a concentration on reforestration and aforestrations activities that concentrates only on tree planting. As noted in this report the real problems are "people problems" and the need for the upland farmer to adopt conservation farming techniques that would increase upland crop production while protecting the soil resources. Hence, the program of improvement must be focused on human and regional development as well as means of improving long-term agricultural production rather than on forestry programs. Therefore, there are some grave doubts as to the potential success of a program for upland development or watershed managment under the control of the Directorate General of Forestry. Furthermore, it would be a wasted redudancy for the forestry department to acquire the needed expertise in the required interdisciplinary specialties for upland agriculture and infrastructure development.

F.3.2. Other Government Programs For Conservation

F.3.2.a. Perhutani

Perhutani is a semi-governmental forest and plantation resource enterprise that was established in 1961 for the province of Central Java. Perhutani manages and markets the forests and forest products, and is supposed to maintain the forests in a good condition as well as marketing the forest resources. Unfortunately, the approach taken has been to maximize returns and minimize expenditures on the forest areas. This has led to some serious erosion producing methods.

The logging systems of the forest concessionaires create many erosion problems through clear cutting harvesting systems, skid tracks that go straight up and down hills and along stream channels, crossing streams without proper erosion protection, and poorly placed logging roads without erosion protection.

A number of years ago Perhutani started their so-called prosperity approach that was supposed to improve the living standard of forest workers. This has resulted in the "tumpang sari" system of establishing forest plantations. With this method the farmer is allocated about 0.25 ha and he clears the land, plants his crops, plants and maintains the trees, replants where seedlings have died, and supposedly leaves after two years. By this time the trees are supposed to be tall enough to complete with the brush, grass and weeds. The farming practices associated with the "tumpand sari" system have resulted in massive losses of fertility through sheet, rill and gully erosion as well as heavy use of essential elements by crops such as cassava. Many gullies are started in this way that persist for many years even in the established forest areas.

Considering the losses in fertility, and the small net food production, it would appear that the reforestration activities could be more efficiently carried out by hiring forest workers at a living wage. Then as soon as a forest was harvested (preferrably by selective cutting) the area would be treated to prevent erosion and replanted immediately. In addition, selective fertilization and planting of new varieties selected for production should shorten the production cycle by as much as five years, which would more than pay for the additional cost of the intensification of reforestration practices.

Perhutani has also had only limited success in the production of fuelwood from the forest lands, although they do allow fuelwood production from thinning of timber stands. This type of demand is growing very rapidly as a result of rising prices for kerosene. Definite steps should be taken to meet this demand to prevent illegal harvesting of timber for fuelwood.

F.3.2.b. Agricultural Extension and Other Programs

Historically the agricultural extension programs, BIMAS and INMAS have been concentrated on the irrigated riceland areas. In fact, they have largely ignored attempting to increase the production of palawija crops. This has resulted in a situation where the Field Extension Worker (PPL) does not understand the problems of the upland farmer and they render him almost no assistance. BIMAS (Mass guidance for agricultural intensification with government credit at low interest rates) and INMAS (Mass guidance for agricultural intensification without government credit) are designed to increase irrigated crop production and are of only incidental assistance to upland farmers. The extension workers lack the knowledge of conservation farming methods, upland agronomic practices and needed fertilization for maximum upland crop production. In general, government extension workers and programs simply do not help the upland farmer to increase his crop production or in getting him to adopt conservation farming methods.

F.3.3. SMEC Report on Soil Conservation for Upper Serang and Lusi River Catchments

In December 1979 SMEC produced a draft project report for a "Soil Conservation Study for Upper Serang and Lusi River Catchments" [6]. This report recognizes the definite need to achieve erosion damage reduction by implementing a catchment (watershed) rehabilitation and management program. This report also recognizes that excessive population pressures have caused over-cultivation of the soil and that this is the main cause of erosion in the studied catchments.

F.3.3.a. Objectives of the Study

The objectives of this study included the study of soil erosion in the Serang River Basin in two parts: the first, a detailed study of the Serang watershed area above the Kedungombo Damsite, and the second an overall evaluation of the erosion problems in the Lusi River Basin.

F.3.3.b. Soil Erosion in Upper Serang River Watershed

In 1978 the population of the Upper Serang River Basin study area was estimated at 300,000 with an average population density of 490 people per km^2. This population was estimated to be increasing at a 2.4 percent per year rate. The population density in the more productive upland areas is about 700 people per km^2, but population densities of this magnitude can only be supported on irrigated riceland or very productive upland farming areas without creating serious resource depletion problems.

For the 614 km^2 drainage area above the Kedungombo damsite the Serang River is estimated to produce 1.48 million tons of sediment annually, or an average of 2,410 $t/km^2/yr$. Using this estimate they quote an average erosion rate of 1.5 mm per year, but it should be noted that if the 1,100 kg/m^3 unit weight of soil in place used by PRC/ECI were applied this would be an average erosion rate of 2.2 mm per year

A previous SMEC study was conducted in this area in 1979, and this study indicated the most seriously eroded land area amounted to about 98 km^2, much of which is in the immediate vicinity of the Kedungombo damsite. These highly eroded soils have mudstone and sandstone parent materials.

The special soil erosion study for the Kedungombo catchment shows the following evaluated erosion classes:

Erosion Classes	Area (ha)	%
Serious	686	6
Moderate	2,876	27
Moderate/slight	6,112	56
Slight	1,231	11
Total	10,905	100

The 10,905 ha with erosion problems amounts to 18 percent of the watershed area. The report contains a discussion of each of the erosion types and they are identified on a map. The largest serious erosion area of 225 ha is located between the Serang and Kedungrong Rivers, and much of the cropland in the area is being abandoned.

The project also conducted a socio-economic survey of six Kecamatan to collect basic data. In this area the Camats estimated that 20 percen of the eroded lands were government owned and the remainder owned by farmers. Of the 52 farmers who were classed as farming eroded land, 52 percent stated they wished to be transmigrated to areas with better land Considering the difficulties experienced with past transmigration scheme this seems a surprisingly high percentage.

This socio-economic survey also produced some information about the farmers attitudes towards the Greening Movement. Fifty percent of the farmers were dissatisfied with the quality of seedlings provided, and many felt that the timing of deliveries and quality of transport were the problems. Ten percent of the farmers also felt that the Greening Movement's extension input was unsatisfactory.

F.3.3.c. Soil Erosion in the Lusi River Basin

The Lusi River at Purwodadi, with a drainage area of 1,966 km^2, is estimated to have an average annual sediment load of 7.47 million tons. This is equivalent to an average of 3,800 t/km^2 throughout the basin. They estimate the Lusi River Basin to be eroding at 2.5 mm, but using the unit weight of sediment used by ECI this would be 3.5 mm average loss per year.

Total population in the Lusi River Basin is estimated at one million people for an average population density of about 500 persons per km^2; and this population is estimated to be growing at 2.3 percent per year.

Land use in the Lusi Catchment is estimated as follows:

Land Use	Area (ha)	%
Sawah	64,425	31
Upland Crop	51,522	26
Homeyards	23,640	12
Forest	52,933	27
Other	7,460	4
Total	197,981	100

With 27 percent of the land in forest and an additional 31 percent in Sawah the watershed would normally have a low sediment production rate.

The soil erosion study, however, found that the lowland rice areas were actually producing considerable sediment. This is primarily because of irrigation water shortages. During the wet season a crop of rice is raised, then the ground is cultivated for maize production and because the bunds are not maintained considerable very muddy water drains off the fields in heavy rains. There is no statement of measurements of this erosion rate so no judgement can be made of the SMEC conclusions, but this problem should receive further study.

The soil erosion study found the following areas by erosion classes for the Lusi River Basin:

Erosion Class	Area (ha)	%
Serious	-	
Moderate	850	7
Slight	10,962	93
Total	11,812	100

The area of moderate erosion of 850 ha is located on the south side of the Lusi River in the Kendeng Hills.

The quoted erosion study results, and the sediment yield of the basin are not consistant, so much more analysis of the Lusi River Basin erosion problem is needed before reliable conclusions can be reached.

F.3.3.d. Recommendation Watershed Rehabilitation and Management Program and Project Proposal

As a result of the previous investigations the SMEC recommended that a comprehensive watershed rehabilitation and management program was urgently needed on the Upper Serang River Catchment. They particularly noted the seriously eroded area (3 percent of the total) in the vicinity of the Kedungombo damsite.

The recommended program recognized the need to show the farmers how to improve their incomes while putting soil conservation techniques into practices. They also recognize that education and extension are essential parts of the program. A rather complete agriculture and community development programs were recommended.

The project proposal was based on two stages. Stage 1 included an initial pilot project of three years to undertake the needed: (a) Topographic and soil mapping, (b) Land use and socio-economic surveys, (c) The establishment of the pilot demonstration projects with closely coordinated supporting services, and (d) The preparation of a development plan for all land in the Kedungombo Catchment that requires soil conservation treatment. Stage 2 would be the implementation project for rehabilitation of all erosion areas in the catchment. The SMEC project proposal provides an overview description of the specific project features and costs, including the Consultant expertise required.

F.3.4. ECI Jragung and Tuntang Rivers Investigations

F.3.4.a. Upstream Watershed Management-Jragung River

As a part of the Jragung Dam Project ECI developed a specific upstream watershed management report to recommend treatment of the upper watershed area [7]. This report provides an analysis of the erosion problem areas of the Jragung Watershed and provides a framework for the needed watershed management project. This included a recommended organization for implementating the Jragung Multipurpose Project. Copies of this report were provided to the Jratunseluna Project office, or it may be reviewed in the ECI office in Semarang, Central Java.

F.3.4.b. Erosion and Soil Conservation Studies Tuntang/Jragung Rivers Basins Integrated Development Plan

The evaluation of erosion and sedimentation problems of the Tuntang River Basin is contained in Part I of this Appendix. A specific soil and water conservation program is suggested and a recommended system of organization improvements for implementation is provided [8]. The plan for the demonstration farms in Section 8 of this report is a part of this suggested soil and water conservation program.

F.3.5. Other Watershed Projects

F.3.5.a. Solo Watershed Project

The work done on the Upper Solo Watershed Management and Upland Development Project (INS/72/006) of the Food Agricultural Organization of the United Nations provides a major source of information on upland development. These reports were reviewed as a part of preparing the Jratunseluna Basin Plan, and some of the more important conclusions are summarized and discussed in the following sections.

The Solo Project in east Central Java has concentrated on developing erosion control technology and applying it in several subwatershed pilot areas. The technical aspects of the project have yielded invaluable results; indeed, they constitute the technological basis for recommendations in this report. However, the diffusion aspects have been far from successful; even where the recommendations were implemented satisfactorily, maintenance has been a chronic problem. Technical experts in the project selected the sites, designed the pilot demonstration layouts, and supervised construction by the farmers who worked the land. Participating farmers were given incentives in the form of food payments. In most of the seven pilot areas, the Extension Section of the project established contact with farmers in advance of the technical people, in order to explain the program and prepare them to participate in it. In at least one area, the Extension preparation was bypassed, only to be reinstated later when strong farmer resistance was encountered. Some farmers on land nearby or adjacent to the demonstration watersheds followed the example of the project and terraced their own lands, but participating farmers have had a generally poor maintenance record. The situation has worsened over time.

The maintenance problem in the Solo Project is sometimes attributed to the high proportion of land rentals in the demonstration watersheds. The argument emphasizes the disincentive effect of uncertain land tenure. This has merit, of course. But another likely explanation is the general strategy of imposing the project directly on the farmers, virtually ignoring local governments. Even when the Extension Section was involved, its aim was to get people to accept an inflexible, predetermined program, not to adapt it to local needs or local circumstances. Project people assumed they knew what should be done for the farmers, by the farmers. However, the farmers correctly viewed themselves as passive recipients of someone else's program, not participants in it. They worked on the terraces, but to them, the structures belonged to the Project; it was not their program. Thus the farmers have not assumed responsibility for maintenance and the impact of terracing has been less than anticipated. In contrast, people outside the demonstration areas who built terraces and waterways seem to do a better job of caring for them.

Several lessons can be learned from the Solo experience. First, a good technical idea is no more valuable than the program which implements it. Second, programs that violate established patterns of communication and responsibility-sharing have little chance of success. Third, people assume imposed responsibilities, like maintenance, only if the execution of those responsibilities yields direct benefits; that is, the Solo Project technology is good, but it was imposed on people as an end in itself, rather than presented as a means to meeting local needs.

Terraces for upland crops were found to be inappropriate if the soils were shallow, or the slope greater than 40-50 percent. Bench terraces have been implemented on seven selected Solo Watersheds. The soil conservation activities have also included demonstrations of gully control and investigations of erosion and runoff from the bench terraces compared with the traditional terraces in the area. Erosion and runoff investigations in the Dumpul, Tapan, and Wader subwatersheds establish the following relationships [4]:

	Traditional Terrace		Improved Bench Terrace	
Location	Erosion (cm)	Percent Water & sediment runoff	Erosion (cm)	Percent Water & sediment runoff
K. Dumpul	2.9	80	0.2	40
K. Tapan	2.0	75	0.1	30
K. Wader	1.4	75	0.2	30

A study of the production increases from bench terraces in the Solo Watershed, where both bench terraces and traditional terraces received the same fertilizer and cultivation techniques, proved that production increases of 200-300 percent were possible with bench terraces. The internal rate of return for terracing has been estimated to be 18 percent for dryland terracing.

Studies of plant varieties used to strengthen terraces and waterways have been limited to grass varieties, but the best grass variety for soil cover in the Solo Watershed studies has been Brachiria brizantha.

The rehabilitation and reforestration of privately owned land in the Solo Watershed has been implemented with tree species such as like Pinus, Albezia falcata, Eucalyptus alba, and a number of grasses planted in the understory. Elephant grass has been the most successful for soil cover and cattle feed. This program has been used successfully to rehabilitate steep slopes and was calculated to have an internal rate of return of 17 percent. Research on erosion and runoff relationships on treated and untreated forest land in the Tapan and Pidekso Subwatersheds produces the following results:

	Traditional Practice		Treated Private Forest Land	
Location	Erosion (cm)	Percent Water & Sediment Runoff	Erosion (cm)	Percent Water & Sediment Runoff
K. Tapan	2.9	80	0.06	20
K. Pidekso	1.4	75	.0.04	30

These results indicate that it is technically feasible to rehabilitate even rather steep lands by afforestration and elephant grass. While this afforestration program has a good internal rate of return, it is not popular with the farmers because they prefer to grow food for their families directly and because it is difficult to obtain the credit necessary to purchase fertilizer and cattle.

A specific comment from the Kali Samin economic study deserves to be quoted: "The internal rate of return of the complete development plan for the Kali Samin is 22.4 percent, a rate which sustains the comparison with net profit margins of most industries. This is one of the most striking findings of the project; although conceived originally as a costly rescue operation, watershed management and development is in fact leading to possitive, economically sound proposals." [3. Emphasis as in original.]

In summary, the conclusions from the Solo Watershed Demonstration and from field observation indicate that there is very little erosion from areas with good forest cover, home gardens, plantations, and rice-land, except for occasional landslips on steep slopes and some gully erosion from scouring in drainage channels. Virtually all erosion is occuring on the upland areas that are farmed without adequate soil conservation measures. This erosion tends to be more rapid on steep slopes, but high intensity rainfall is the most important single factor in the net erosion rates, and this is one reason for the higher erosion rates experienced on the higher mountains, which have much higher precipitation rates. The observations also concluded that bench terraces that are properly designed, constructed and maintained will reduce erosion to rate acceptably compatible with the rate of soil regeneration [5].

F.3.5.b. Majalenka Watershed Project

The watershed project at Majalenka is more modest than Solo but similar in many regards. The Majalenka Watershed plot is in a subwatershed of the Cimanuk River Basin. It is essentially an erosion control pilot demonstration plot, administered by the Forestry Department, on a tract of land administered by the village. Although officially grazing land, it was actually rented to farmers for cultivation, with dire ecological consequences. From a social point of view, there is little more to the project than the application to the eroded slopes of technology derived from the Solo Project. Farmers already had little say over the land, and they had even less to say about the project. Nor were local officials involved in planning or executing the project. The terracing was executed by farmers, but they are not assuming maintenance responsibilities. Nor are farmers who live in the area copying the techniques used on the demonstration plot. This project remains where it started. This also reinforces the lessons from Solo.

F.3.5.c. Panawangan Pilot Watershed Project

The Panawangan Pilot Watershed Conservation and Development Project is a part of the Citanduy River Basin Development Project. The project plan for this project was submitted in 1976 and project works were started in November 1977 [7]. The program was implemented on the 6.1 ha Pilot

Demonstration Farm and then expanded to the balance of the 365.9 ha Pilot Watershed area. This project is still active and some conservation measures are still being applied.

Records of specific accomplishments in conservation measures were not kept for many practices, and many practices applied have not been specifically measured. Therefore, only a partial record is available for conservation measures applied to the Panawangan Pilot Watershed between November 1977 through May 1979. This conservation work may be

Item	Units	Accomplishment
Bench Terrace	ha	54.8
Waterways	m	19,346.0
Drop Structures	no.	4,345
Sodding of Structures	m^2	275,363.0
Tree Planting	ha	183.8
Grass Planting	ha	55.4
Conservation Terraces	ha	55.0

In addition to the above measures, construction was completed on about 0.6 km of stone surfaced road with proper erosion proofing. An access road was also built from Ciracak Village to sub subwatersheds III and IV. Other roads and trails in the area have been improved, but neither the improvements nor the cost of the work have been recorded.

The Pilot Demonstration Farm totaled 4.0 ha of terracing, which was completed by the local farmers with an incentive payment of Rp. 50,000 to 70,000/ha of land that they owned. The balance of the terracing was completed under the supervision of the P_3RP - DAS Citanduy staff with a payment based on Rp. 300 per manday(md). The labor charges for terracing and waterway construction on 46.4 ha amount to Rp. 8,077,913, or Rp. 174,100/ha terraced. Note that this figure accounts for the government cost of labor for terrace construction; and the farmers' contribution is not included in the labor costs. The farmers' labor contribution probably approaches the government cost, both from the level of pay for terracing relative to other regional wage scales and the labor performed for which no payment was made.

Unfortunately, the available cost records do not include any costs for administrative supervision or transportation furnished by Project Citanduy or the Ciamis District. The costs for two full-time consultant staff for watershed management activities, plus their expenses, are also missing but should have been included in a strict accounting system.

This lack of good cost records is one of the deficiencies of the Panawangan Pilot Watershed Project. These records would be very valuable in setting up other pilot watersheds. Another deficiency of this project is that only bench terracing and conversion of land to agro-forestry were applied to the land and no knowledge was gained as to the applicability of other conservation measures.

The agricultural development program work was all conducted on the 6.1 ha Pilot Demonstration Farm over a 16-month period. This program was an outstanding success and resulted in greatly increased crop yields over the traditional methods used in the area [8]. Several generalized conclusions can be drawn from the field trials in the Panawangan Demonstration Farm. First, a demonstration farm is not the proper place to conduct research on varietal yields, fertilizer response, or cropping systems because inputs cannot be precisely controlled or accurately measured. The certain purpose of demonstration farms is to put the knowledge gained from research to use in demonstrating how to produce maximum economic returns from the land. Secondly, average yields obtained by village farmers are considerably less than research yields because of the many less-than-optimum conditions under which the upland farmer produces. Thirdly, the person in charge of all activities absolutely must maintain close contact with the demonstration farm at all times to enable him to take immediate action on insect or disease control problems and to ensure that production inputs are performed at the proper time, even if the project must hire additional labor. A demonstration farm always has trouble selling success, but a large failure becomes well known over the area very rapidly.

The Panawangan Watershed Pilot Demonstration Project experience stimulates many questions about social aspects of program design and implementation. The Panawangan Pilot Area was planned at the outset to be more comprehensive and more responsive to local characteristics than previous programs. The aim was to obtain the cooperation of farmers in the designated area to build terraces and waterways according to recommended specifications and then participate in agronomic trials to test recommendations about inputs and intensification. Farmers were subsidized for their terracing work, provided with fertilizer and seeds, and guaranteed minimal compensation in case of crop failures. The trials focused on crops familiar to the farmers, as well as on grass varieties intended to support increased livestock production. From initial stages, the project received the enthusiastic support of the Ciamis District Planning Chief, which was then translated into support from village leaders and key farmers. That support has been a fundamental element in the success of the project to date.

The Panawangan Pilot effort benefited from a number of characteristics which should be incorporated into any upper watershed program. First, it has had a local focus, one which was taken very seriously. It started from given conditions and attempted to proceed without being disruptive. Second, local leadership was integrated into the Program, not merely offered lipservice. Third, interaction with leaders and farmers was continual and informal, with emphasis on the quality of rapport as well as on the substance of the work. Fourth, the agricultural input first treated familiar crops and then moved to complementary and supplementary activities -- new crops, livestock, and fishery provement. Even the smallest farm units are complex integrated operations, and the project attempted to respond accordingly. Fifth, the farmers involved in the initial small pilot area became team leaders in the expansion of the project to the rest of the sub-watershed. The technical and organizational success of the expansion is attributable as much to the effectiveness of the local team leaders, benefiting from their own experience, as to the expertise and commitment of the Forestry Department. The Panawangan Pilot effort is a concrete manifestations of the great value of pilot programs. They argue very convincingly for the creation of pilot areas in other watersheds where physical characteristics, cropping patterns, and other conditions are different, before the program is implemented in those areas.

The Panawangan Pilot effort also suffers from typical weaknesses of pilot projects, which limits its usefulness as a program prototype: First, a critical strength -- the response to local conditions -- is a critical weakness as well, because many of the techniques and recommendations will not be applicable to areas with different conditions. Thus, the effort is useful, but it is not an adequate base upon which to design a broad program, nor does it offer a sufficient guide in the formulation of a mechanism to make a broad program as responsive locally. Second, one element of success consisted in consultants, kabupaten personnel, and other interested parties spending a great deal of time in the field, talking to farmers, overseeing, and evaluating. This intense concentration of manpower, expertise and attention will surely not be duplicated elsewhere when the program is implemented on a broader scale. Thus the problem arises as to how to obtain similar results without this important factor. Frequently, the concentration of effort on a pilot project produces the phenomenon called "demonstration effect", in which project subjects think of themselves as special, and consequently respond to project personnel in ways they might not otherwise respond, in order to ensure the success of the project. This is an intrinsic danger in pilot projects and must be reckoned with by careful analysis and appropriate planning. Third, the Panawangan Pilot effort required inputs from a number of different agencies, and therefore created a number of budgetary and coordination problems. Fourth, in any program, it takes time for participants to become fully convinced of the value of the program and to accept routinely the burdens it imposes upon them. Under any conditions, the conviction and acceptance of burdens do not really occur until after the participants have obtained dependable, concrete benefits from the program. In agricultural programs, the results are often not apparent for a season or two. In Panawangan, it may still be premature to determine whether the participating farmers will translate their satisfaction with the program into spontaneous, systematic maintenance and improvement of the terraces and waterways. Many factors suggest, but cannot yet certify, that they will. Nonetheless, the need for erosion control is too important and immediate to delay planning the program until the question is answered. Instead, periodical evaluations should be built into the program to assess its results and allow for changes in strategy if things do not work.

In sum, the Panawangan Pilot Project avoided some of the weaknesses of the Greening Program and the Solo and Majalenka Projects, and thus offers some lessons regarding general strategy and basic components of an upper watershed program. First, local officials must be integrated into the program from the outset, and contacts must be maintained continually through field staff stationed in the project area. Second, the program must be tailored to the specific needs of farmers in the target area. It will become a community program only if it is indeed a local program in each community. Furthermore, the terracing and waterway elements will be adopted only if they complement other aspects of a broader program. Terrace construction takes time and energy and reduces the cultivable land area; farmers cannot be expected to spend the time and energy or to accept the land loss without assurance of a commensurate increase in productivity and income. Third, defining an appropriate package of program elements for a specific area will require the coordination of different agricultural and other agencies. This will not be easy and may be impossible without judicious planning.

TABLE F-1

REFORESTATION AND GREENING DURING PELITA II

(1974/75 - 1978/79)

Year		Hectares			Budget (million Rupiah)		
		Reforestration	Greening	Total	Inpres/ Assistance	Sector *	Total
I.	(1974/1975)	37,103	52,529	89,632	-	2,377.2	2,377.2
II.	(1975/1976)	42,376	82,285	124,661	-	4,905.0	4,905.0
III.	(1976/1977)	122,189	302,597	424,786	16,000.0	2,163.5	18,163.5
IV.	(1977/1978)	203,095	632,689	835,784	24,476.6	1,824.7	26,301.3
V.	(1978/1979)	288,058	689,291	977,349	36,000.0	2,000.5	38,000.5
	Total	692,821	1,759,391	2,452,212	76,476.5	13,270.9	89,747.5
Pelita II Target		1,690,000	1,750,000	3,440,000	-	-	60,400.0

* The Assistance/Inpres System by Sector Budget is for Planning and Managing (technical) Implementation/Support projects except Training and Education project and Forest Inventory and Consolidation.

Source: Laporan Kualitas Lingkungan Hidup Indonesia 1979 by Menteri Negara Pengawasan dan Lingkungan Hidup. p. 40. Table 2.

TABLE F-2

JRATUNSELUNA BASIN CRITICAL UNCULTIVATED LAND IN THE FOREST FOR THE PELITA III MASTER PLAN.

(Hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Telawah							
1. Karangrayung	117.6	117.6	-	-	-	-	-
2. Ketawar	383.5	383.5	-	-	-	-	-
3. Krobokan	360.3	360.3	-	-	-	-	-
4. Guwo	449.5	449.5	-	-	-	-	-
5. Karangwincug	975.6	975.6	-	-	-	-	-
6. Kedungcur	721.9	721.9	-	-	-	-	-
7. Gemolong	763.5	763.5	-	-	-	-	-
8. P.M.	30.6	30.6	-	-	-	-	-
Subtotal	3,802.6	3,802.6	-	-	-	-	-
Randublatung							
1. Trembes	22.4	22.4	-	-	-	-	-
2. Tanggel	4.4	4.4	-	-	-	-	-
3. Kedungjambu	9.2	9.2	-	-	-	-	-
4. Kemadoh	1.3	1.3	-	-	-	-	-
5. Banyuurip	25.6	25.6	-	-	-	-	-
6. Selogender	20.3	20.3	-	-	-	-	-
7. Bata	9.0	9.0	-	-	-	-	-
8. Beran	38.3	38.3	-	-	-	-	-
Subtotal	130.5	130.5	-	-	-	-	-

TABLE F-2 (Cont.)

JRATUNSELUNA BASIN CRITICAL UNCULTIVATED LAND

IN THE FOREST FOR THE PELITA III MASTER PLAN

(hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Cepu							
1. Wonogadung	17.6	17.6	-	-	-	-	-
2. Nglobo	24.7	24.7	-	-	-	-	-
3. Ledok	38.5	38.5	-	-	-	-	-
4. Kendilan	153.7	153.7	-	-	-	-	-
5. Pucung	22.9	22.9	-	-	-	-	-
Subtotal	257.4	257.4	-	-	-	-	-
Kebonharjo							
1. Gununglasem	89.6	89.6	-	-	-	-	-
2. Karas	2.6	2.6	-	-	-	-	-
3. Sale	39.2	39.2	-	-	-	-	-
4. Gayam	44.7	44.7	-	-	-	-	-
5. P.M.	200.5	200.5	-	-	-	-	-
Subtotal	376.6	376.6	-	-	-	-	-
Gundih							
1. Gundih	320.6	320.6	-	-	-	-	-
2. Juworo	330.4	330.4	-	-	-	-	-
3. Monggot	335.6	335.6	-	-	-	-	-
4. Madoh	100.3	100.3	-	-	-	-	-
5. Kuncen	295.2	295.2	-	-	-	-	-
6. Panunggalan	333.3	333.3	-	-	-	-	-
7. Jambon	65.7	65.7	-	-	-	-	-

TABLE F-2 (Cont.)

JRATUNSELUNA BASIN CRITICAL UNCULTIVATED LAND IN THE FOREST FOR THE PELITA III MASTER PLAN

(hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Gundih (Cont.)							
8. Kragilan	356.7	356.7	-	-	-	-	-
9. Dalen	288.55	288.55	-	-	-	-	-
10. Segorogunung	53.6	53.6	-	-	-	-	-
11. Ngaren	156.9	156.9	-	-	-	-	-
12. Trembes	5.0	5.0	-	-	-	-	-
Subtotal	2,641.85	2,641.85	-	-	-	-	-
Semarang							
1. Penggaron	389.6	389.6	-	-	-	-	-
2. Barong	184.1	184.1	-	-	-	-	-
3. Jembalo Selatan	358.4	358.4	-	-	-	-	-
4. Jembelo Utara	182.1	182.1	-	-	-	-	-
5. Tanggung	211.1	211.1	-	-	-	-	-
6. Kedungjati	82.0	82.0	-	-	-	-	-
7. Tempuran	235.1	235.1	-	-	-	-	-
8. Manngar	442.5	442.5	-	-	-	-	-
9. Padas	462.0	462.0	-	-	-	-	-
Subtotal	2,546.9	2,546.9	-	-	-	-	-

TABLE F-2 (Cont.)

JRATUNSELUNA BASIN CRITICAL UNCULTIVATED LAND
IN THE FOREST FOR THE PELITA III MASTER PLAN
(hectare)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Magelang							
1. Candiroto	746.5	746.5	-	-	-	-	-
2. Temanggung	216.5	216.5	-	-	-	-	-
3. Ambarawa	279.0	279.0	-	-	-	-	-
Subtotal	1,242.0	1,242.0	-	-	-	-	-
Purwodadi							
1. Penganten	190.8	190.8	-	-	-	-	-
2. Jatipohon	134.5	134.5	-	-	-	-	-
3. Linduk	81.7	81.7	-	-	-	-	-
4. Sambirejo	66.6	66.6	-	-	-	-	-
5. Tumpuk	24.6	24.6	-	-	-	-	-
6. P.M.	513.8	513.8	-	-	-	-	-
Subtotal	1,012.0	1,012.0	-			-	-
Pati							
1. Bangsri	52.8	52.8	-	-	-	-	-
2. Gajahbiru	76.5	76.5	-	-	-	-	-
3. Ngarengan	157.1	157.1	-	-	-	-	-
4. Muriapatiayam	382.8	382.8	-	-	-	-	-

TABLE F-2 (Cont.)

JRATUNSELUNA BASIN CRITICAL UNCULTIVATED LAND IN THE FOREST FOR THE PELITA III MASTER PLAN

(hectare)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Pati (Cont.)							
5. Sukolilo	34.2	34.2	-	-	-	-	-
6. Tambakromo	148.5	148.5	-	-	-	-	-
7. Kuwawur	118.8	118.8	-	-	-	-	-
8. Lunggoh	148.9	148.9	-	-	-	-	-
9. Barusan	74.8	74.8	-	-	-	-	-
10. P.M.	463.0	463.0	-	-	-	-	-
Subtotal	1,657.4	1,657.4	-	-	-	-	-
Blora							
1. P.M.	450.7	450.7	-	-	-	-	-
Mantingan							
1. P.M.	69.6	69.6	-	-	-	-	-
TOTAL	14,186.95	14,186.95	-	-	-	-	-

TABLE F-3

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN [1/]

(Hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II: Real APBN	Real APBD	Real Other	Additional Critical Land During Master Plan: Delayed Planting	Other Additional	Critical Land Early in Master Plan III
Kendal							
1. Singorpjo	1,950	475	-	-	-	-	670
2. Limbangan	690	615	-	-	-	-	75
3. Boja	550	475	-	-	-	-	75
Subtotal	3,190	2,370	-	-	-	-	820
Semarang							
1. Klepu	2,934	2,218	-	-	-	-	716
2. Suruh	2,703	2,049	-	-	-	-	654
3. Jambu	1,990	1,250	-	-	-	-	740
4. Ambarawa	1,233	715	-	-	-	-	518
5. Bawen	1,585	715	-	-	-	-	870
6. Gunungpati	2,402	1,330	-	-	-	-	1,072
7. Banyubiru	1,830	1,139	-	-	-	-	691
8. Bringin	3,151	2,785	-	-	-	-	366
9. Ungaran	1,711	1,158	-	-	-	-	553
10. Getasan	3,224	2,319	-	-	-	-	905
11. Tengaran	2,146	2,046	-	-	-	-	100
12. Salatiga LK.	415	250	-	-	-	-	165
13. Tuntang	1,560	1,120	-	-	-	-	440
14. Sumowono	3,160	3,050	-	-	-	-	110
15. Susukan	1,496	1,496	-	-	-	-	-
16. Mijen	1,090	1,090	-	-	-	-	-
17. Semarang Selatan	1,042	1,042	-	-	-	-	-
Subtotal	33,672	25,772	-	-	-	-	7,900

TABLE F-3 (Cont.)

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN 1/

(Hectare)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Kudus							
1. Dawe	4,408	2,060	-	-	-	-	2,348
2. Gebog	4,279	2,150	-	-	-	-	2,129
3. Jekulo	600	350	-	-	-	-	250
Subtotal	9,287	4,560	-	-	-	-	4,727
Jepara							
1. Mayong	1,800	600	-	-	-	-	1,200
2. Mlonggo	1,355	-	-	-	-	-	1,355
3. Bangsri	720	190	-	-	-	-	530
4. Keling	1,925	675	-	-	-	-	1,250
5. Batealit	1,345	350	-	-	-	-	995
Subtotal	7,145	1,815	-	-	-	-	5,330
Pati							
1. Pucakwangi	1,078	500	-	-	-	-	578
2. Sukolilo	4,907	2,505	-	-	-	-	2,402
3. Cluwak	3,984	550	-	-	-	-	3,434
4. Kayen	1,678	650	-	-	-	-	1,028
5 Tambakromo	1,730	500	-	-	-	-	1,230
6. Margorejo	1,087	450	-	-	-	-	637
7. Jaken	1,937	450	-	-	-	-	1,487

TABLE F-3 (Cont.)

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN [1/]

(Hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Pati (Cont.)							
8. Gembong	3,416	1,050	-	-	-	-	2,366
9. Tlogowungu	3,302	600	-	-	-	-	2,702
10. Gunungwungkal	2,676	1,475	-	-	-	-	1,201
Subtotal	25,795	8,730	-	-	-	-	17,065
Rembang							
1. Lasem	2,275	-	-	-	-	-	2,275
2. Sulang	3,105	500	-	-	-	-	2,605
3. Sedan	2,505	400	-	-	-	-	2,105
4. Pamotan	3,175	470	-	-	-	-	2,705
5. Lasem	1,125	-	-	-	-	-	1,125
6. Gunem	1,505	400	-	-	-	-	1,105
7. Pancur	1,283	-	-	-	-	-	1,283
8. Kragan	2,070	-	-	-	-	-	2,070
9. Sluke	1,828	-	-	-	-	-	1,828
10. Bulu	2,405	825	-	-	-	-	1,580
11. Sarang	1,866	-	-	-	-	-	1,866
Subtotal	23,142	2,595	-	-	-	-	20,547

TABLE F-3 (Cont.)

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN [1/]

(Hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Blora							
1. Sambong	1,636	475	-	-	-	-	1,161
2. Menden	1,365	-	-	-	-	-	1,365
3. Jati/Doplang	2,143	975	-	-	-	-	1,168
4. Randublatung	845	340	-	-	-	-	505
5. Kedungtuban	1,359	1,060	-	-	-	-	299
6. Jiken	2,480	1,200	-	-	-	-	1,280
7. Jepon	6,062	1,375	-	-	-	-	4,687
8. Tunjungan	2,460	1,450	-	-	-	-	1,010
9. Ngawen	5,822	2,865	-	-	-	-	2,957
10. Todanan	5,320	1,400	-	-	-	-	3,920
11. Cepu	550	210	-	-	-	-	340
12. Banjarejo	825	825	-	-	-	-	-
13. Kunduran	1,455	1,455	-	-	-	-	-
Subtotal	32,322	13,630	-	-	-	-	18,692
Grobogan							
1. Toroh	1,290	845	-	-	-	-	445
2. Geyer	5,719	1,475	-	-	-	-	4,244
3. Kedungjati	1,240	425	-	-	-	-	815
4. Karangrayung	3,435	410	-	-	-	-	3,025
5. Tawangharjo	1,002	575	-	-	-	-	427
6. Grobogan	1,964	575	-	-	-	-	1,389

TABLE F-3 (COnt.)

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN 1/

(Hectare)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Grobogan (Cont.)							
7. Wirosari	3,203	675	-	-	-	-	2,528
8. Pulokulon	1,190	-	-	-	-	-	1,190
9. Gabus	2,605	-	-	-	-	-	2,605
10. Kradenan	1,305	-	-	-	-	-	1,305
11. Ngaringan	1,615	-	-	-	-	-	1,615
Subtotal	24,568	4,980	-	-	-	-	19,588
Sragen							
1. Sumberlawang	5,935	2,850	-	-	-	-	3,085
2. Miri	3,006	2,000	-	-	-	-	1,006
Subtotal	8,941	4,850	-	-	-	-	4,091
Boyolali							
1. Wonosegoro	7,331	4,752	-	-	-	-	2,579
2. Ampel	4,267	2,050	-	-	-	-	2,217
3. Karanggede	1,493	758	-	-	-	-	735
4. Klego	1,990	1,700	-	-	-	-	290
5. Andong	1,675	1,450	-	-	-	-	225
6. Kemusu	2,500	2,150	-	-	-	-	350
7. Juwangi	905	692	-	-	-	-	213
Subtotal	11,361	4,752	-	-	-	-	6,609

TABLE F-3 (Cont.)

JRATUNSELUNA BASIN CRITICAL LAND

OUT OF THE FOREST FOR THE PELITA III MASTER PLAN 1/

(Hectares)

Unit Forest Administration	Critical Uncultivated Land According to F.S. (ha)	Decrease During Master Plan II			Additional Critical Land During Master Plan		Critical Land Early in Master Plan III
		Real APBN	Real APBD	Real Other	Delayed Planting	Other Additional	
Demak							
1. Mranggen	600	600	-	-	-	-	-
2. Karangawen	300	300	-	-	-	-	-
Subtotal	900	900	-	-	-	-	-
Total	180,323	74,954	-	-	-	-	105,369

1/ Land out of the forest is mostly privately owned land.

TABLE F-4

REFORESTATION SPECIES PLANTED IN THE JRATUNSELUNA BASIN (Hectares)

District	Year 1974	1975	1976	1977	1978	Total
Purwodadi/Gundih						
Teak (Tectona grandis)	-	-	1,103.3	1,395.8	-	2,499.1
Sonokeling	-	-	230.4	524.5	-	754.9
Mahoni (Swietenia macropylla)	-	-	50.2	101.9	-	152.1
Kayuputih	-	-	121.8	217.6	-	339.4
Eucalyptus alba	-	-	24.3	20.0	-	44.3
Subtotal	-	-	1,530.0	2,259.8	-	3,789.8
Mantingan/Kebonharjo						
Teak (Tectona grandis)	-	-	173.8	-	-	173.8
Sonokeling	-	-	273.2	-	-	273.2
Subtotal	-	-	447.0	-	-	447.0
Semarang						
Teak (Tectona grandis)	-	-	662.2	524.5	-	1,186.7
Sonokeling	-	-	166.3	854.4	-	1,020.7
Mahoni	-	-	339.5	-	-	339.5
Subtotal	-	-	1,168.0	1,378.9	-	2,546.9
Blora/Cepu						
Teak (Tectona grandis)	-	-	840.4	-	-	840.4
Mahoni	-	-	21.6	-	-	21.6
Subtotal	-	-	862.0	-	-	862.0
Telawah						
Teak (Tectona grandis)	-	-	591.9	777.8	-	1,369.7
Sonokeling	-	-	623.1	1,635.3	-	2,258.4
Mahoni	-	-	-	34.5	-	34.5
Subtotal	-	-	1,215.0	2,447.6	-	3,662.6
Pati						
Teak (Tectona grandis)	-	-	816.3	765.3	-	1,581.6
Sonokeling	-	-	-	101.5	-	101.5
Mahoni	-	-	40.0	327.3	-	367.3
Subtotal	-	-	856.3	1,194.1	-	2,050.4
Magelang						
Pinus	-	-	-	586.5	-	586.5
Sonokeling	-	-	-	655.5	-	655.5
Subtotal	-	-	-	1,242.0	-	1,242.0
Total Reported	-	-	6,078.3	8,522.4	-	14,600.7

TABLE F-5

PLANNED REHABILITATION IN THE JRATUNSELUNA BASIN - CRITICAL LANDS OUTSIDE THE FOREST UNDER PELITA III FOR THE GREENING PROGRAM

(Hectares)

District/ Subdistrict	Critical Area Start of Pelita III	Year				
		1979-80	1980-81	1981-82	1982-83	1983-84
Kendal						
1. Singorojo	670	270	400	-	-	-
2. Limbangan	75	75	-	-	-	-
3. Bojo	75	75	-	-	-	-
Subtotal	820	420	400	-	-	-
Semarang						
1. Klepu	716	135	275	156	150	-
2. Suruh	654		100	225	329	-
3. Jambu	740	380	340	20	-	-
4. Ambarawa	518	225	275	18	-	-
5. Bawen	870	610	200	60	-	-
6. Gunungpati	1,072	552	110	200	210	-
7. Banyubiru	691	240	100	200	151	-
8. Bringin	366	145	200	21	-	-
9. Ungaran	553	280	200	73	-	-
10. Getasan	905	655	200	50	-	-
11. Tengaran	100	-	100	-	-	-
12. Salatiga LK.	165	165	-	-	-	-
13. Tuntang	440	440	-	-	-	-
14. Sumowono	110	110	-	-	-	-
Subtotal	7,900	3,937	2,100	1,023	840	-
Kudus						
1. Dawe	2,348	345	500	500	500	503
2. Gebog	2,129	176	500	500	500	453
3. Jekulo	250	250	-	-	-	-
Subtotal	4,727	771	1,000	1,000	1,000	956
Jepara						
1. Mayong	1,200	450	600	150	-	-
2. Mlonggo	1,355	-	620	735	-	-
3. Bangsri	530	330	200	-	-	-
4. Keling	1,250	400	850	-	-	-
5. Batealit	995	765	230	-	-	-
Subtotal	5,330	1,945	2,500	885	-	-

TABLE F-5 (Cont.)

PLANNED REHABILITATION IN THE JRATUNSELUNA BASIN - CRITICAL LANDS OUTSIDE THE FOREST UNDER PETITA III FOR THE GREENING PROGRAM

(Hectares)

District/ Subdistrict	Critical Area Start of Pelita III	Year				
		1979-80	1980-81	1981-82	1982-83	1983-84
Pati						
1. Pucakwangi	578	260	250	68	-	-
2. Sukolilo	2,402	450	400	500	550	502
3. Cluwak	3,434	950	365	750	700	669
4. Kayen	1,028	670	350	8	-	-
5. Tambakromo	1,230	510	320	200	200	-
6. Margorejo	637	425	150	62	-	-
7. Jaken	1,487	225	250	300	325	387
8. Gembong	2,366	400	250	500	600	616
9. Tlogowungu	2,702	500	400	500	600	702
10. Gunungwungkal	1,201	-	265	350	300	286
Subtotal	17,065	4,390	3,000	3,238	3,275	3,162
Rembang						
1. Lasem	2,275	1,435	290	300	250	-
2. Sulang	2,605	-	360	800	750	695
3. Sedan	2,105	-	325	600	700	480
4. Pamotan	2,705	-	350	900	725	730
5. Lasem	1,125	715	275	135	-	-
6. Gunem	1,105	-	300	400	405	-
7. Pancur	1,283	690	300	293	-	-
8. Kragan	2,070	920	325	425	400	-
9. Sluke	1,828	920	325	300	283	-
10. Bulu	1,580	-	300	350	450	480
11. Sarang	1,866	-	350	400	500	616
Subtotal	20,547	4,680	3,500	4,903	4,463	3,001
Blora						
1. Sambong	1,161	-	200	400	526	35
2. Menden	1,365	735	300	330	-	-
3. Jati/Doplang	1,168	-	250	400	518	-
4. Randublatung	505	-	250	255	-	-
5. Kedungtuban	299	-	290	9	-	-
6. Jiken	1,280	605	285	390	-	-
7. Jepon	4,687	500	300	500	1,250	2,137
8. Tunjungan	1,010	500	225	285	-	-
9. Ngawen	2,957	535	200	650	800	772
10. Todanan	3,920	1,320	200	600	800	1,000
11. Cepu	340	340	-	-	-	-
Subtotal	18,692	4,535	2,500	3,819	3,894	3,944

TABLE F-5.(Cont.)

PLANNED REHABILITATION IN THE JRATUNSELUNA BASIN - CRITICAL LANDS OUTSIDE THE FOREST UNDER PELITA III FOR THE GREENING PROGRAM

(Hectares)

District/ Subdistrict	Critical Area Start of Pelita III	Year				
		1979-80	1980-81	1981-82	1982-83	1983-84
Grobogan						
1. Toroh	445	-	200	245	-	-
2. Geyer	4,244	979	300	950	1,000	1,015
3. Kedungjati	815	335	225	255	-	-
4. Karangrayung	3,025	190	275	850	900	810
5. Tawangharjo	427	365	60	2	-	-
6. Grobogan	1,389	849	200	340	-	-
7. Wirosari	2,528	1,075	250	350	450	403
8. Pulokulon	1,190	690	220	280	-	-
9. Gabus	2,605	915	300	400	500	490
10. Kradenan	1,305	825	220	260	-	-
11. Ngaringan	1,615	625	250	300	440	-
Subtotal	19,588	6,848	2,500	4,232	3,290	2,718
Sragen						
1. Sumberlawang	3,085	420	500	700	715	750
2. Miri	1,006	-	500	506	-	-
Subtotal	4,091	420	1,000	1,206	715	750
Boyolali						
1. Wonosegoro	2,579	504	200	600	600	675
2. Ampel	2,217	455	405	550	400	407
3. Karanggede	735	393	200	142	-	-
4. Klego	290	-	245	45	-	-
5. Andong	225	-	225	-	-	-
6. Kemusu	350	-	225	125	-	-
7. Juwangi	213	213	-	-	-	-
Subtotal	6,609	1,565	1,500	1,462	1,000	1,082
Total	105,369	29,511	20,000	21,768	18,477	15,613

F.4. RESOURCE BASE FOR JRATUNSELUNA BASIN

F.4.1. General Description

The Jratunseluna Basin (7,700 km^2) is formed by the action of the Jragung, Tuntang, Serang, Lusi and Juana Rivers, and includes the area drained by the Dolok and Penggaron Rivers. The main rivers originally from volcanoes Ungaran, Kepiting, Telomoyo, Merbabu and Muria, and from the central mountain ranges. The main feature of the Jratunseluna Basin is the wide flat coastal plain, which is also the principal area for irrigated crop production. Approximately, 1,000 km^2 of this lowland area has an elevation of less than 20 meters, and the Lusi valley has an additional 950 km^2 between 30 and 50 meters elevation.

Admin stratively, the basin is entirely under the jurisdiction of the Province of Central Java along the north coast of Java. The basin is made up of following Kabupatens [20]:

	km^2	%
Semarang	1,009	13.1
Demak	1,093	14.2
Kudus	454	5.9
Pati	1,040	13.5
Blora	1,032	13.4
Purwodadi	2,017	26.2
Jepara	431	5.6
Boyolali	439	5.7
Sragen	185	2.4
	7,700	100

F.4.1.a. Land Resources

Basically, only the irrigated, or potentially irrigated lands, of the Jratunseluna Basin have received much development. Data that is available for upland areas is frequently conflicting and the terminology varies from one area to another. Therefore, there is a definite need for a specific land use and problem area survey of the entire upper watershed area as one of the first steps in development of an integrated watershed management program for the Basin.

The NEDECO studies of the Basin in 1973 developed an estimate of land use for the Basin from the data on six kabupaten. This estimate is summarized in Table F-6. The major land uses were: irrigated cropland 18.7 percent, rainfed riceland 16.7 percent, upland crops 25.8, homeyard crops 14.2 percent, forested areas 23.4 percent, and other uses 1.2 percent.

An attempt was made to analyze the 1980 upper watershed subbasin's land use, by using the latest hydrologic or other evaluation studies and empirical estimates (Table F-7). This evaluation points out the wide variability in land use of the various upper watershed subbasins. It also indicates some conflicting answers for forested and plantation areas. In fact, there is a strong reason to believe that a considerable area that was forested in 1973 has been converted to other uses by 1980. The estimated present condition land use in the upper watershed subbasins is as follows:

	km^2	%
Rice fields	1,146.0	24
Upland crops	1,479.0	31
Homeyards and villages	695.0	14
Forests	935.0	20
Plantations	48.0	1
Other uses	465.2	10
Total	4,786.2	100

F.4.1.b. Water Resources

Most of the available hydrologic and sediment data pertaining to the upper watershed subbasins is summarized in Table F-8. More detailed information on climate, precipitation, water yields, and sediment production for the areas above all proposed damsites is contained in Appendix A - Hydrology (Part I and II.)

F.4.1.c. Human Resources

In 1971, there were approximately 4.5 million people living in the Jratunseluna Basin. Of these, an estimated 650,000 were concentrated in the municipality of Semarang. At that time the basins' population was growing at about 2.38 percent per year [21]. If this growth rate has continued there would be an estimated 5.56 million people in 1980. There seems to be no detailed population estimate available for the Jratunseluna Basin area, but if this projected figure is correct the average population density would be 720 people/km^2 versus about 585 people/km^2 in 1971, and it illustrates the reason for the "people problems" of the basin.

Two special research reports on socio-agro-economic factors in the basin were prepared by the Research Institute in Social Sciences of Satya Wacana Christian University in 1973 and 1974 [22, 23]. These reports provide much valuable information, but they are out of dat and they concentrated on the irrigated and rainfed riceland areas rather than the upland crop and forestry areas of the basin.

In order to develop an integrated upper watershed management program for the Jratunseluna Basin it will be necessary to compile the available basic data from the upland watershed areas. It will probably also require a specific baseline data collection through a research study similar to the ones previously completed by Satya Wacana Christian

University. This information is essential in identifying problem areas of population concentrations, rural poverty, education levels, and non-agricultural industries. It is also needed in developing any regional economic development program.

The areas selected for demonstration watershed will require a much more detailed survey of both physical and human resources, and farming methods to serve as a baseline for evaluating progress in improving the welfare of the farm families, and in adoption of conservation farming methods.

F.4.2. Resource Inventory and Problem Identification Needs

As previously noted the information available for defining the upper watershed areas resources and problems is almost entirely the result of irrigation project development studies. As such, it does not supply the information needed. As discussed in Section F.2.5.a. Resource Inventory and Problem Identification the information needs for developing an integrated watershed management are extensive and complex. As a generalization, it can be said they are not presently available for the Jratunseluna Basin upper watershed areas.

It should be noted that there is a large potential for making costly mistakes by trying to develop an upper watershed soil and water conservation program without adequate data, and without conducting a specific research and demonstration program in the field to find the best methods for implementing a soil and water conservation program.

The next section of this report briefly describes the water resources problems of the Basin. It also indicates the relative magnitude of the erosion problems caused by the high population densities in portions of the upland watersheds. But one of the more important effects is to point out the facts that we do not know precisely what has caused the physical factors that create erosion, and we do not know what resources are available to solve the watershed problems. It is very important to do a careful resource inventory and problem identification study before initiating a full scale erosion control program. Experience in Indonesia and elsewhere shows that rapid project implementation is good way to waste scarce government funds, and, it often creates more problems than have been solved.

TABLE F-6

ESTIMATED 1973 LAND USE IN THE
JRATUNSELUNA BASIN

Land Use	hectares	
Agricultural Cropland		
Irrigated (Technical Systems)	100,000	
Irrigated (Rural Systems)	44,000	
Subtotal Irrigated	144,000	18.7
Rainfed Riceland	129,000	16.7
Upland Crops		
Upland Rice	8,000	
Maize	76,200	
Cassava	53,500	
Sweet Potatoes	9,200	
Groundnuts	11,300	
Soybeans	15,300	
Vegetables and other Crops	25,500	
Subtotal Upland Crops	199,000	25.8
Homeyard Crops	109,000	14.2
Total Agricutlural	581,000	75.4
Forested Areas	180,000	23.4
Other Uses	9,000	1.2
Total Jratunseluna Basin	770,000	100.0

Source: NEDECO, "Supporting Report 1 - General Information," page 26 [20].

TABLE F-7

ESTIMATED LAND USE IN THE UPPER WATERSHED AREAS (1980)

	Lusi River Above Serang		Serang River at Lusi Confluence		Muria Volcano Slopes		Tuntang River Above Glapan		Jragung River Above Jragung Weir		Dolok River Above Barang Weir		Penggaron River Above Barang		Total Upper Watershed	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Rice Fields	624	30	195	21	116	16	154	19	42	32	3	7	12	15	1,146	24
Upland Crops	515	25	386	41	285	41	224	28	22	16	10	25	37	48	1,479	31
Homeyards and Villages	236	11	158	17	118	17	160	20	11	8	3	7	9	12	695	14
Forests	529	25	110	12	82	12	157	20	38	29	22	53	15	19	953	20
Plantations							33	4	8	6	3	7	4	5	48	1
Other	197	9	88	9	99	14	68	9	12	9	0.5	1	0.7	1	465.2	10
Total	2,101	100	937	100	700	100	796	100	133	100	41.5	100	77.7	100	4,786.2	100

F.5. PROBLEM IDENTIFICATION

F.5.1. Introduction

As shown in Appendix A - Hydrology and Appendix H - Sedimentation Studies Jragung Watershed, the sediment loads carried by most of the Jratunseluna Basin streams are an indication that critical erosion rates are occurring over almost all of the watersheds. Unfortunately, we do not even know what an acceptable level of erosion is for the various soil types occurring in the Basin. A soil formation rate of 25 mm in 30 years is frequently qouted for land that is being cultivated [12, 19]. For lack of a better target figure the generalization of an acceptable erosion rate is the loss of one millimeter of soil per year, or approximately 1,100 $t/km^2/yr$ (11 tons/ha/yr)1/. Naturally, the acceptable soil loss will depend on the soil conditions at the site; if the soil profile is deep and relatively fertile the loss of soil is less serious than if the soil consists of a few centimeters of soil over rock.

F.5.2. Soil and Water Losses in the Upper Watershed Areas

There is very little question that presently the lowland rice producing areas and some of the better natural forest are the only areas with acceptable levels of soil loss. To provide an estimate of the magnitude of the soil and water losses in the Basin, all available reports were reviewed and summarized to obtain an estimate of present condition. Table F-8 summarizes the available hydrologic and sediment data for upper watershed areas and the results are discussed by area in this section.

F.5.2.a. Lusi River

The Lusi River down to the confluence with the Serang River has

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1/ Assuming a unit weight of 1,100 kgs/m^3 for soil in place.

a 2,101 km^2 drainage area. The Lusi River catchment has a high percentage of forest or plantation land (27 percent) and sawah (31 percent) and would be expected to have a relatively low surface runoff and erosion rate, but a number of factors increase this above what might be expected.

The Lusi River watershed has a calculated average annual precipitation of only 1,873 mm and a water yield of 860 mm (46 percent) leaving an estimated actual evapotranspiration of 1,013 mm (Appendix A). Since the potential evapotranspiration for the natural vegetation of the watershed is about 1,500 mm there is a considerable water shortage during the dry season. The high runoff rate is an indication of poor cover conditions, and shallow soils with very low water holding capacities, which will present a problem in any soil conservation and rehabilitation activities.

SMEC [6] has estimated the sediment load in the Lusi River at Purwodadi as 7.47 million tons, or 3,800 t/km^2. If this rate is arbitrarily estimated for the entire watershed the Lusi River is producing 7.89 million tons of sediment per year in the average annual water yield of 1,807.8 million cubic meters. This estimated 3,800 t/km^2/yr sediment yield would indicate an erosion rate of from 2.5 to 3.5 mm/yr depending on the unit weight of the soils eroded. Since approximately half of the watershed has either forest cover or is relatively flat the upland areas are experiencing heavy soil and water losses.

Since the SMEC study of erosion classes identified only 11,812 ha (5.5 percent) as having an erosion problem, and there is no mention of excessive streambank erosion, there must be a great deal of serious erosion that is not identified. A very crude erosion balance can be hypothesized from the available data as follows:

Land Use	Area (km^2)	Estimated Net Erosion Loss ($t/km^2/yr$)	Sediment Production (10^6 tons)
Forest	529.3	1,000	0.53
Sawah	624.2	1,000	0.62
Home yards	236.4	6,000	1.42
Upland Crop	515.2	8,600	4.43
Other 1/	195.9	5,000	0.98
Total	2,101.0	3,800	7.98

1/ Including streams and water areas.

While the specific erosion rates are only empirical estimates the erosion balance indicates that some areas have to be losing a critical amount of topsoil each year. It should also be noted that in watersheds of this type and size only 70 to 90 percent of the erosion products are normally transported from the watershed so all of the above estimates are low in relation to erosion rates on the upland areas.

F.5.2.b. Serang River

The Serang River has a drainage area of 937.0 km^2 at the confluence with the Lusi River, but information is only available to estimate runoff and erosion at the Sedadi Weir. The Serang River at the Sedadi Weir has an average annual runoff of 1,150 mm for a water yield of 998.2 million cubic meters from the 868 km^2 catchment [9]. Precipitation averages 2,520 mm for this catchment so 46 percent of the precipitation becomes runoff.

An analysis of the sediment loads in the Serang River by SMEC gives the following relationships [10]:

Location	Drainage Area (km^2)	Total Sediment	
		10^6 tons	tons/km^2
Serang River at Kedung-ombo	614	1.48	2,410
Serang River at Sedadi Weir	868	3.36	3,870
Lusi River at Purwodadi	1,966	7.47	3,800
Serang River at Godong	3,047	11.15	3,659

Analysis of the above figures for the 254 km^2 area between the Kedungombo Damsite and the Sedadi Weir gives the conclusion that this area produces 1.88 million tons of sediment annually, or at a rate of 7,400 tons/km^2. If this is true, the area is in much greater need of soil conservation activities than the area above the Kedungombo Damsite. The 3,659 tons/km^2 sediment yield for the Serang at Godong is, as expected, lower than the upstream stations as a result of floodplain deposition of sediment during flood periods.

The erosion analysis of the area above Kedungombo Damsite conducted as a part of the soil conservation study indicates that the areas of erosion amount to only 109 km^2 of the 686 km^2 watershed area, or 16 percent [6]. While data is not available to check these erosion classes, it would seem that most of the Kedungombo watershed probably has the lowest erosion rates of any of the upper watershed subbasins. This may well be the reason for initiating a soil and water conservation program in this watershed as rapidly as possible to prevent further deterioration in the watershed condition and to restore the presently eroded areas.

F.5.2.c. Muria Volcano Drainage

Very little information is available from the areas draining the south slope of Muria Volcano. This area has been approximated at 700 km^2 by measuring the area above the Jepara-Kudus-Pati-Trungkil highway. This area drains into the Lower Serang River and the Juana Valley but no attempt was made to divide the total. The SMEC Juana Valley Irrigation Project estimated the average precipitation as 2,450 mm [11], and the water yield has been estimated at 1,050 mm, or 735.0 x 10^6 m^3 annually. Available indications are that the erosion rate from these watersheds is about 3,600 tons/km^2/yr. Specific evaluations of the erosion rates, and soil and water conservation problems of this area should be undertaken as soon as possible.

F.5.2.d. Tuntang River at Glapan

Detailed hydrologic information on the Tuntang River at Glapan is available in Appendix A - Hydrology and other Part I Appendices of this report. The annual precipitation amounts to about 2,630 mm and the water yield is 1,120 mm, or 43 percent. Total annual water yield averages 892 x 10^6 m^3 for an average streamflow of 28.3 m^3/s. Sediment yield, as estimated in Appendix A, amounts to 6.95 x 10^6 tons, or 8,730 t/km^2. This does not include an estimated sediment yield of 5,000 t/km^2 that is basically retained in Rawa Pening from its 282 km^2 drainage area.

The major sediment source area for the Tuntang River is downstream from the Jelok Weir and upstream from the Gunung Wulan Damsite. This area is estimated to have an average sediment yield of 15,000 t/km^2, which is over 13 times the acceptable erosion rate. As noted in Appendix A, the soil in the Kendeng Hills is very erosive and the area is heavily populated. The Bancak River watershed is also a large producer of sediment.

There can be little question that the erosion rates in the Tuntang River Watershed above the Gunung Wulan damsite are critical and that some of the lands are already so eroded that the cost of making then productive again is prohibitive. These lands can only be planted to a permanent cover of trees and/or grass and not utilized until they have healed. This process may take 25 to 50 years depending on the treatment methods used and the degree of nonuse during the period of recovery.

F.5.2.e. Jragung River above Jragung Damsite

More recent water and sediment yield information is available on the Jragung than for other subbasin areas. This information is summarized in Appendis A - Hydrology and Appendix H - Sedimentation Studies Jragung Watershed. These studies point up the high precipitation (2,640 mm) and high water yield (1,280 mm) of this watershed. With a runoff factor of 48 percent the watershed certainly has problems of poor vegetative cover, shallow soils and poor infiltration rates. The physical problems are so severe in this case that they are nearly catastrophic in some areas.

The average sediment delivery from the Jragung River above the Jragung damsite is currently estimated at 16,000 $t/km^2/yr$ for the 94 km^2 watershed area. This amounts to a loss of between 10.7 and 16.0 mm of soil per year from the entire drainage area. When it is considered that the rice terraces, and teak forests or rubber plantations do not suffer much erosion the answer is obvious that many areas have passed the critical point of economically feasible reclamation.

More dramatic is the fact that the flood of 22 January 1980 produced the peak flood and volume of runoff in the history of the Jragung River. This single storm produced sediment equivalent to 8,000 t/km^2 over the entire catchments. Unfortunately, there is little likelihood that any major rehabilitation work will be undertaken in this watershed in the near future, and it has definitely been damaged to the extent that only a major program of transmigration to reduce the population pressure coupled with a program of returning much of the eroded land to permanent cover could have any major beneficial effect.

F.5.2.f. Dolok River

The Dolok River above the Barang Weir has a 41.5 km^2 drainage area and an average annual precipitation of 2,415 mm. The average annual water yield is 46.3 x 10^6 m^3, or about 1,116 mm of runoff from the watershed. This small watershed is just east of the Jragung Watershed but it is not as denuded. There are no known sediment measurements, so the empirical rate of 12,000 t/km^2/yr is used for evaluation purposes. With the current interest in developing the Dolok damsite a special sediment measuring, and soil and water conservation survey, should be undertaken in the mean future; followed immediately by the development of a soil and water conservation plan.

F.5.2.g. Penggaron River

The Penggaron River above the Pucanggading Weir has a 77.7 km^2 drainage area that is estimated to yield 103.0 x 10^6 m^3, or 1,325 mm of runoff from a 2,721 mm average annual precipitation. This is a runoff factor of 51 percent and is an indication that the watershed is in poor condition. Visual inspections verify this assumption and the sediment delivery at the damsite is estimated at 16,000 t/km/yr. This watershed is probably similar to the Jragung Watershed in that it is probably too late to save much of the more severely eroded lands, which must now be returned to permanent cover to solve the erosion problems.

F.5.2.h. Upper Watershed Summary

The upper watershed summary shown on Table F- 8 analyses only 4,678.2 km^2 of the 4,786.2 km^2 of the Upper Watershed Subbasins because of data availability, but it does give a reasonable picture of erosion in the total area.

The weighted mean annual precipitation for the upper watershed is 2,242 mm, the estimated evapotranspiration is 1,237 mm, and the mean water yield is 1,005 mm. Rainfall is considerably lower in the western part of the basin, or Upper Lusi River, and increases over 80 cm to the eastern edge of the basin where precipitation is about 2,720 mm.

The estimated annual sediment yield from the watershed amounts to 24.05×10^6 tons, for an average sediment delivery of 5,140 t/km/yr from the upper watersheds. This would be an average soil loss of 3.4 to 5.1 mm depending on the unit weight of the soil being eroded, which is 3 to 5 times the acceptable rate of erosion if we assume 100 percent delivery of eroded materials. Since the true sediment delivery on these watersheds is about 75 percent the true erosion rate in the upper watershed areas is probably 4.5 to 6.8 mm, or 4 to 7 times the acceptable erosion rate.

This analysis of the Upper Watershed Subbasins is definitely empirical, but it is in the correct order of magnitude for defining the erosion rates. It also points out the urgency of developing an integrated watershed management program of the type described in Section F.2. - TECHNICAL APPROACH.

The balance of this section describes the "people problems" of the upper watersheds, and some of the major sources of sediment as a result of the misuse and overuse of the watershed lands.

F.5.2. Interrelationships of the Soil Conservation System

The factors which cause soil losses are complex and highly variable for the various climatic zones, local topography, and vegetative cover types. Figure F-3 provides a schematic presentation of the more important interrelationships affecting the soil conservation system. In reality the factors affecting the soil conservation system are much more complex than can be shown on a schematic diagram. It is also beyond the scope of this report to describe most of these physical and economic relationships.

Conservation practices are bound to agricultural productivity in two important respects: First, they are bound physically because ground cover and soil management affect both the degree of soil erosion and the maintenance cost of all installed conservation works. Secondly, they are bound economically because the primary justification for the conservation of agricultural land is the higher productivity of these areas, either now or in the future, than would have been possible without the conservation efforts. To expect the farmer to make expenditures for practices that do not directly benefit him is unreasonable, just as it is poor fiscal policy to spend government funds for conservation measures that provide the farmer with benefits greater than his cost. The farmer should pay these costs since it is to his benefit.

The farmers economic condition must be improved a significant amount before the farmer will be able to adopt the needed conservation farming practices and measures for erosion control. This generally will mean that the government must provide fertilizer, seeds and other incentives to the farmer. Proposed developments must also consider the etchnic background and socioeconomic position of the individual farmers involved. Decisions on alternative structural and land treatment measures or production schemes must be made in accordance with all the human, physical, and economic resources available and with the abilities and special wishes of the people in the small watershed unit or village concerned. These projects can only be developed in direct cooperation with the local people. It must be recognized that it is relatively impossible for anyone in the provincial or district planning offices to really understand local problems, but these offices can coordinate and implement the various projects as they are developed locally. Planning leaders can also ensure that the projects developed are varied enough to broaden the conservation experience of both the local staff and the upland farmers.

F.5.3. People Problems

F.5.3.a. Introduction

The soil erosion problems of the Jratunseluna Basin are caused by one or more of the following physical conditions:

1. Removal of the original forest cover,
2. Lack of vegetative cover to stop sheet erosion caused by raindrop splash and surface runoff,
3. Lack of proper bench terraces,
4. Lack of waterways to dispose of excess water,
5. Erosion along roads and trails,
6. Planting of crops on steep and long slopes without measures to take care of surface runoff, and
7. Sluicing to create paddy land.

These problems are well known and have been reported many times. They are also found in many other watersheds of Indonesia and of other developing countries. However, these are not generally recognized as people problems with economic, technical and physical limitations to their solutions. More importantly, planners and government officials seldom realize that the individual farmer, or other watershed resident, is generally completely rational in his behaviour, given the limited resources and knowledge available to solve the problems facing him. Therefore, to initiate a permanent change it is necessary to change the farmer's economic position along with his ability to take risk. He must understand the soil erosion problem and how he might benefit from the solution proposed by the government. Because he often cannot read, this education must be accomplished by meeting with the farmers and by the use of demonstration farms to show the needed agronomic and conservation farming techniques.

F.5.3.b. Population Pressure

Most people familiar with the agricultural and population conditions of the Jratunseluna Basin agree that there is a population problem but few people agree on the solution. Some people see transmigration as the solution; some, birth control; some, industrialization; some irrigation development; and currently some people want to terrace all upland crop areas to provide both jobs and increased food supplies while "solving" the watershed problem. This controversy results from myopia, single-minded dogmatism, and self-interest that causes many people to see only "their" solution, rather than a complex of solutions. There is also considerable intra-governmental rivalry between agencies and individuals. The different approaches, governmental agencies and the individuals responsible should instead complement each other to achieve vitally important end--the current and future well being of the people living in the watershed

F.5.3.c. Quality of Life

Concurrent with the realization that the watershed problems are really people problems, comes the realization that nothing can be done about the upper watershed condition unless some of the people problems can be solved. Foremost among these problems are the significant rural poverty and the isolation of most of the upland farmers from any of the government programs. Thus family planning is reasonably effective for the educated and reasonably affluent government worker or merchant in the town but has no effect on the rural poor.

Further, the rural poor can not take advantage of most programs because they are too poor to buy the necessary technical equipment, or to travel to the place of distribution.

In considering the problem of the upland farmer's quality of life, it hardly matters whether a farmer is upland with a small patch of cassava or on the lowland floodplain where he gets floods and sediment deposition on his land almost every year. He is so poor that he does not have the resources to attempt the improvement in the quality of his life. Therefore, what is required is a combination of irrigation development, upland watershed management, and general economic development programs so that these people will gain the knowledge and resources necessary to start the human rehabilitation and improve their quality of life. Without this improvement, the ultimate solution of the human problem is to limit the population of the watershed and the country; but the control will be exerted by human misery.

F.5.4. Development Trends and Problems

F.5.4.a. Introduction

Severe change in local ecosystems, and consequently in the total environment, began taking place in the Jratunseluna Basin about the turn of the century, and accelerated following World War II. The first change was the removal of much of the tropical forest, nature's climax vegetative cover. Concurrently, rapid population growth, partly through an influx of people from other areas and islands resulted in increased demands for food production. This required the cultivation of lands less suited for cropping. Traditional agricultural practices used in upland cultivation and farming of steeper and less suitable land resulted in serious soil erosion. Severe alterations in the soil and micro-climate often brought on serious problems of vegetation and soil management. Unwise use of the agriculture resources has taken its toll by severely altering the landscape and has resulted in depletion of the soil fertility and a gradual degredation of agricultural production in the basin.

Natural fertility and deep soils have somewhat hidden the gravity of the conditions for many years and has delayed the impact of the dwindling agricultural productivity.

In watersheds like the Jragung, the sediment load resulting from upstream erosion is a clearly visible, and constantly shocking reminder to all observers of the insidious effects of current damages in what was once one of the most fertile agricultural areas in the basin. This is the reason that the area has such a high population density, the highly fertile land supported many people before it became eroded.

One problem associated with watershed development is caused by the prevalent impression that farming and forests are not compatible and that there is some simple way of defining where forests should be (for example, all lands with slopes greater than 50 percent). In fact, the land best suited for forestry, or upland agriculture, can only be determined by a complete resource inventory and multiple-use evaluation. An eroded area such as the Jragung River Watershed should attempt the maximum development of agroforestry systems of trees and grass, trees, fruit and grass, or trees and upland crops. Admittedly, native trees and wild plants must usually be eliminated to create the open spaces for the sun-rich environment favored by most agricultural crops to reduce competition for nutrients and water, to reduce the insect damage, and to generally facilitate cultivation. However, some specialized crops can be successfully grown under trees, and a maximum effort should be initiated to develop systems that produces the maximum food and fiber from each land resource type.

F.5.4.b. Traditional Agriculture

Cultivated fields on sloping terrain and the concentration of a single crop, such as cassava, that provides little ground cover results in soil erosion, nutrient depletion, disease and pest infestations, and even physical damage to the plants. Most agricultural crops, like their wild relatives, respond with higher total yields in mixed composition and structurally complex communities. The interior of a forest is a benign ecosystem partially shielded from solar radiation, strong winds, and the impact of falling rain. By planting a variety of crops with different growth habits in upland agricultural areas, farmers may profitably imitate some of the structure and species diversity of a tropical forest. To some degree the Indonesian farmer already does this in his garden plot which copies the layered configuration of mixed forests. These small home garden areas contain taller plants such as coconut and papaya; a lower layer of banana, coffee, or cacao; and tall or low annuals such as corn, beans, taro, and the spreading vines of peanuts or sweet potatoes. Using this system, food production takes place at many levels and erosion rates are a fraction of the clear cultivated cassava fields on the slopes above

Denuded forest land that either is left in an unprotected condition, or is farmed with upland crops is a major source of sediment and consequent loss of fertility in the watershed. Land with 50 to 75 percent slopes is being encroached upon by farmers as pressures for food production increase.

As a result of repeated plowing, erosion, and leaching, some of the steeper natural forest area in the basin has deteriorated to the point where even growing grasses and trees may be difficult. In some places even large amounts of fertilizer may not permit food crop production. Such area must be used for agroforestry type livestock forage production, forestry and very limited farming operations.

In the Phillipines, research on a 40 percent slope at Diadi, Nueva Vizcaya, stressed the importance of vegetative cover for upland agricultural land. The control (protected plot) had a sediment yield of less than 0.1 t/ha/y, whereas rice and corn had sediment yields of about 73.5 and 69.8 t/ha/y [22]. The paucity of erosion data makes it difficult to objectively state the importance of soil cover and conservation measures for continued or sustained upland crop production. Visual observations can easily be made by an outsider, but it is the farmer who daily confronts the problem, and he usually fails to see it because it develops so slowly. He usually does not realize the problem exists, or he only vagualy remembers that his father used to get much higher yields of cassava than he does. The higher prices for his smaller crop may yield the same income as his father's so the problem is further masked.

In general, accelerated erosion, low soil fertility and productivity, poor or nonexistent terraces, the near absence of developed waterways, a lack of credit facilities, limited infrastructural facilities, inacessibility to markets, low-level application of known technology, and some land tenure conflicts constitute the main problems associated with upland farming.

F.5.4.c. Road Construction and Maintenance

Road construction, and the poor maintenance of roads, in the watershed are among the major sources of sediment to downstream areas. Road construction disturbs the natural channels for water and at the same time loosens and exposes the soil. Erosion problems are especially acute during the early life of a road when the slopes are still devoid of vegetation and a large amount of finer soil size materials are still susceptible to erosion because ground cover has not developed.

Field observations show obvious signs of soil erosion and depletion, and an advanced degradation of agricultural resources. Growing crops, or even vegetative cover, to protect the soil is very difficult. Soil erosion and depletion of land resources are thus aggravated, resulting in more rapid land deterioration and more rapid fertility depletion. In many areas the farmers are now farming soils with a depth of 30 centimeters or less which are largely subsoil. This is a poor and unproductive soil for food crops. The local farmers state that in the past 10 years cassava yields dropped from 8 t/ha to 1.5 or less.t/ha

Erosion on cropland degrade the productivity of the soil resource base which is necessary for crop and food production. When new cropland is brought into production to meet demands for an increased food supply, its erosion problems are often more serious than those of lands already being farmed. Soil erosion reduces the potential soil productivity because plant nutrients and fine particles are selectively removed, causing poor soil tilth and increasing runoff of poor infiltration. Usually crop yields can be increased by the addition o: fertilizer, pesticides, hybrid seed varieties, and management, but eventually the progressive degradation of the soil resources througl erosion becomes evident.

During runoff and transport of eroded sediment, plant nutrients are lost from the soils either as soluble constituents (primarily NO_3 or N) or attached to the sediment particles (particularly phosphorus, the exchangeable cations, trace metals, and organic nitrogen). The loss of organic matter by erosion from the surface is detrimental to crop production not only because of the plant nutrients it supplies, but also because of the beneficial role of organic matter in maintaining soil structure, water holding capacity, and increasing infiltration r-

Roads are continuously being developed to provide access to additional areas of the watershed, to exploit the timber resources and to provide access for construction. The road network still leaves many villages without proper access and almost all of the roads need erosion proofing. The current practices of clean cultivating of the road shoulders and waterways must cease. These areas, and the large amount of steep cutbank cause considerable soil loss even on the paved provincial road systems. The district road system has considerably more erosion, and the village road system is often impassible to vehicles because of road surface erosion and mud holes from poor drainage. Almost all of forest roads are of low quality and suffer severe erosion problems. The erosion proofing of forest roads should have a high priority in the management budget, but it has received little attention in the past.

F.5.5. Floods

Historical records do not indicate that floods have caused much damage in the upper watershed areas. The runoff from the steeper upland areas concentrates rapidly in the steep mountain streams, but the well developed and incised stream channels prevent much overbank discharge. There is, however, considerable local flooding of flatter rice land areas where adequate drains are not available or where the rivers overflow their banks and flood dikes.

The accurate determination of Jratunseluna Basin historical flood damages and trends towards increasing damages is an essential feature of a complete upper watershed project evaluation and project justification. If there is a positive correlation between deforestation and annual flood damages, it will provide both an estimate of damages and a means of estimating benefits if the watershed condition trend can be reversed. This determination should definitely be a component of the future evaluations. However, it should be recognized that no watershed management program can ever be effective in reducing floods from the infrequent large precipitation events.

F.5.6. Erosion and Sedimentation

Erosion occurs in any watershed with or without the aid of man. However, the natural or geologic rate of erosion for the Jratunseluna Basin with a high percentage of forest cover would have been less than the 1,100 t/km^2/yr acceptable rate of erosion. The information of large deltas and filling in of the Juana Valley since the turn of the century are an indication that erosion rates started to increase about the turn of the century. As discussed in Appendix H, Rutten found in 1907 that the Jragung River was already eroding at a rate equivalent to 4,000 t/km/yr. This provides a strong indication that erosion is not a new factor in the basin's watersheds. It should also be noted that even with a very expensive watershed management program there would still be unacceptable level of erosion in many parts of the Basin because population densities are too high, and people have to eat. Therefore, there will always be serious erosion problems in this upper watershed areas.

Most upland areas exhibit a combination of sheet, rill, gully, subsurface flows and channel flows. A decrease in the amount of runoff or of runoff rates from upland farms affects the detachment and transport capacity in the stream channels. While sediment yield rates of the streams relate directly to sediment production on upland crop areas, it should be understood that controlling upland erosion will not immediately reduce sediment yields. Instead, eliminating incoming upland sediment makes channel flow more erosive. If sediment is available from previous deposition or from erodible channel boundaries, sediment yields will continue for several years at the same high rate before the system readjusts and responds, if it ever does, to control of upland erosion from agricultural and nonagricultural lands. For this reason, the control of upland erosion will have greatly delayed benefits to the downstream watershed areas even if the treatment program on upland areas is very effective. Quite simply, a great deal of sediment remain in the stream system, and it will eventually be delivered to the floodplain areas or the Java Sea.

The products of erosion are not destroyed, they are merely moved to a new area for deposit. In fact, at least initially, most of the soil particles travel only a short distance before being deposited, in a small depression or in a stand of grass, for example. The sediment taken downstream may itself provide benefits from deposition in deltas that eventually become cropland, but it generally produces damages rather than benefits.

Some of the definitions needed for understanding erosion and sediment discussions in this report are defined in Appendix A - Hydrology, pages A-40 and 41, and other definitions may be found in the glossary at the end of thi

F.5.6.a. Geologic or Natural Erosion

Natural erosion is the watershed's rate of erosion that is not affected by man's influences. It is also known as "geologic erosion" and is one of the major factors in landform evolution. In truth, it is more a concept than a precise phenomenon. Perhaps it would be better to define it as erosion unaffected by modern man's activities since it is relatively recent that man acquired the ability to really transform the landscape to his purposes.

Natural erosion rates vary greatly because of the great difference in weathering rates of parent rocks; the differences in rainfall amounts, intensity, frequency, and type; and the effects of various vegetation types on total ground cover.

F.5.6.b. <u>Accelerated Erosion</u>

Accelerated erosion is the degree of man-caused erosion beyond the normal or geologic erosion. The major activities by man that have caused accelerated erosion are: removal of the original vegetative cover, upland farming, road construction, timber harvesting methods, and other unwise uses of the watershed resources.

Accelerated erosion occurs when the stabilizing vegetation is destroyed by man and is no longer able to hold the soil against the eroding forces of nature. Such erosion is generally the aftermatch of vegetation removal or diminution of the vegetative cover. Since this is caused by man, man's wise use of the resources may reduce or correct accelerated erosion, although this may require that, that particular resource not be used for anything but watershed lands. Corrective measures can consist of altering the land-management systems so that nature can rebuild the damaged ecosystem. However, if erosion is far advanced, waiting the necessary decade for nature to rebuild the eco-system may be impractical. In these cases, speeding up natural healing processes by mechanical structures and by re-establishment of vegetation may be necessary.

Since reduction in vegetative cover is the primary cause of accelerated erosion, vegetation is also the chief weapon in controlling erosion. The manager or planner must determine the highest and best use of the land from a scientific, social, and economic viewpoint.

Two major factors control the erosion of soil. The first is the particular soil's resistance to erosive forces, and the second is the protection provided by the natural vegetation or by the crop being grown on the l

In the entire upper watershed area, gully erosion in the upland areas is the dominant form of channel erosion and is almost entirely of the accelerated type. The main river system of the watershed is well developed, and only limited streambank erosion occurs under the present regimen, but this would be subject to change if these same streams were carrying clear water.

Gully erosion is characterized by the severe downcutting of the channel bed, followed by the widening of the channel as the banks cave in and the material is eroded. Gully erosion advances in the upstream direction, and generally all tributaries to the gully become eroded in the same manner.

The process whereby gully erosion is initiated is complex and not well understood. In an effort to help predict the initiation of gully advance, Schumm (1977) put forth the concept of treshold geomorphology [14]. In its simplest context, gully erosion begins as a result of exceeding an "erosional treshold", which is the set of conditions or stage at which the effect is produced. This can be the result of increased flows upstream or disturbance of the natural cover in the stream channel or any number of other factors. The resulting change from stream channel to gully is quick and dramatic. In most areas the development of gullies is almost entirely related to man's activities.

When left to nature, gullies sometimes do fill themselves in, then recycle into the erosional state many times. However, the time span for recycling is too slow to be of any value for watershed management; that is, we cannot expect gullies to heal themselves in the time span of an erosion control project.

Studies at different locations in Java indicate that soils derived from sedimentary rocks are approximately 5 times as erodible as residual soils derived from volcanic rocks [13]. Even though the volcanic rocks are watershed in place to depths of 50 m and the dry unit weight of the soils is less than 1,000 kg/m^3, the ionic forces developed between the soil particles, when the soil is wet, resist erosion very well.

No real definition of the erodibility of the basins soils has been attempted to date. This information, very important to the development of a watershed management program, must be the object of investigation in the development of a program in any planning area. Unfortunately, there is a lack of good base maps, aerial photography and trained soil scientists to do the field mapping. Mapping of upland soils is much more difficult than mapping of riceland soils in irrigated or potentially irrigated areas because of the more limited accessibility of upland areas and the much larger variability in factors to be mapped.

All the information available indicates erosion in the uplands of the Jratunseluna Basin is severe and increasing. The continued loss of the soil resources of Java in untenable. This trend must be stopped and reversed.

From a technical point of view, the answer is simple: "good farming and forestry practices". By using the universal soil loss equation we can predict how much soil can be saved through various management practices.

F.5.7. Prediction of Soil Losses with the Universal Soil Loss Equation

The universal soil loss equation was developed by the U.S. Department of Agriculture with experimental data collected from cultivated plots [15,16]. The purpose of the research was to develop a method of predicting soil loss from agricultural land under various cropping patterns and conservation management programs. In general, the equation can be used to predict erosion from small fields or evaluation sites, but not from larger watersheds.

The universal soil loss equation is presented in the form

$$A = RKLSCP$$

in which
- A = average soil loss, t/ha
- R = rainfall erosivity factor, tm/ha
- K = soil erodibility factor, t/ha/unit of R
- L = slope length factor
- S = slope gradient factor
- C = crop management factor
- P = erosion control practice factor

Figure F-2 - Interrelationships of the Soil Conservation System provides a schematic diagram of how these factors fit into the conservation system and how the soil losses ultimately affect the net income of the farmer.

The rainfall erosivity factor, R, is a number indicating the impact power of the rain and the erosive power of moving water. The expression for this factor is

$$R = \frac{EI_{30}}{100}$$

in which
- E = kinetic energy of the storm rainfall, tm/ha
- I_{30} = maximum 30-minute intensity during the storm, cm/h.

The component of E occurring during a fraction of the storm (Δt) is

$$e = p\,(210 + 89 \log i)$$

in which p = amount of storm rainfall in time, Δt, cm
i = intensity of rainfall in time, Δt, cm/h

Then for the storm

$$E = \sum e$$

and

$$P = \sum p$$

the summation being for all increments of time Δt comprising one storm. Here P is the total storm rainfall in cm.

Researchers in Indonesia [13] have shown that, when averaged for many storms

$$E = 247\ P$$

and

$$I_{30} = \frac{P}{0.073P + 0.73}$$

These two equations were developed from rainfall records for the tropical storms experienced in Indonesia. Then

$$EI_{30} = \frac{247\ P^2}{0.073P + 0.73} \quad \text{or} \quad R = \frac{2.5\ P^2}{0.073P + 0.73}$$

Annual values of the erosivity factor, R, in Indonesia rnage from approximately 1,900 tm/ha to 8,000 tm/ha.

When only monthly rainfall records are available, the rainfall erosivity factor R can be estimated using the expression

$$R = 6.12\ (P_m)^{1.21}\ (N)^{-0.47}\ (P_{max})^{0.53}$$

in which R = average monthly erosivity factor, tm/ha
P_m = average monthly rainfall, cm

N = average number of days with rain per month

P_{max} = average maximum precipitation in 24 hours for every month.

In developing the Iso-erodent map for Java and Madura three climatic stations in the Jratunseluna Basin were evaluated, Semarang, Salatiga and Kudus. The month and total annual R values and percent of total for these stations were as follows:

Month	Semarang		Salatiga		Kudus	
	R Value	%	R Value	%	R Value	%
Jan	370	19.4	296	13.5	639	28.7
Feb	345	18.1	285	13.0	425	19.1
Mar	193	10.1	333	15.2	251	11.3
Apr	150	7.9	239	10.9	109	4.9
May	109	5.7	127	5.8	76	3.4
Jun	69	3.6	103	4.7	38	1.7
Jul	69	3.6	83	3.8	38	1.7
Aug	46	2.4	41	1.9	22	1.0
Sep	95	5.0	61	2.8	45	2.0
Oct	109	5.7	109	5.0	91	4.1
Nov	135	7.1	226	10.3	147	6.6
Dec	217	11.4	287	13.1	345	15.5
Total	1,907	100.0	2,190	100.0	2,226	100.0

As can be noted on the above tables the risk of erosion is much higher in the wet season months of December through March. Therefore this is the season when the farmer needs to maintain maximum ground cover on his cropland.

Under field conditions, the distribution of erosive rainstorms within the year in relation to seasonal vegetative cover and crop residue effects is very important. High intensity rain when there is little foliage produces much more erosion than when the crops have maximum foliage.

The soil erodibility factor, K, is a measure of the rate at which a soil erodes under standard conditions of slope and cultivation. The factor is the rate of soil loss from a hectare of land 22.1 m long with a 9 percent slope under conditions of continuous fallow when the rainfall erosivity factor is unity.

Values of K are determined from plot studies on various soils. In the Pacific, K values have been obtained in Hawaii [18] and Indonesia [13]. In Java, soils derived from volcanic rock have K values approximately one tenth of those derived from marine sediments. Typical values are 0.03 and 0.3 t/ha/unit of R. Values of K obtained in Hawaii range from 0.2 to 1.1 t/ha/unit of R. In the mainland United States, K varies from 0.04 to 1.6 t/ha/unit of R.

An analysis of the erosion plots conducted by the Belgian Technical Assistance Program [13] provides the following estimates of "K" values for Indonesian Soils:

Location	Soil Type	Erodibility Factor (K)
Darmarga	Latosol	0.034
Sentolo	Litosol	0.134
Putat	Mediteranian	0.260
Punung	Mediteranian	0.140
Jegu	Grumosol	0.204
Citaman	Latosol	0.104

The slope length factor, L, is the ratio of soil loss from a specific length of slope to that with a length of 22.1 m. The slope length is the distance from the point where overland flow begins to the point where the slope decreases enough that deposition begins (to the point where runoff enters a well-defined channel that is part of the drainage network. The reason for applying conservation terraces or hillside ditches is to shorten the slope length, and of course dispose of runoff in a noneroding manner.

The L factor is given by the expression

$$L = \left(\frac{a}{22.1}\right)^m$$

in which a = length of slope
m = 0.6 if the slope is greater than 10 percent
m = 0.5 if the slope is 5 to 10 percent
m = 0.4 if the slope is 4 percent
m = 0.3 if the slope is 3 percent or less

The slope gradient factor, S, is the ratio of soil loss from a specific percent slope to that on a 9 percent gradient. The expression for this factor is

$$S = \frac{0.43 + 0.30s + 0.043s^2}{6.613}$$

in which S = slope angle in %

The crop management factor, C, is the ratio of soil loss from land cropped under specific conditions to the corresponding loss from tilled continuous fallow. In physical terms, the crop management factor describes the effect of vegetation in protecting the soil from erosion. Continuous fallow is land that has been tilled and kept free of vegetation for a period of at least three years or until prior crop residues have decomposed.

Because there are many combinations of crops and soil management, the crop management factor is widely variable. Crop residue can be removed. left on the surface, or plowed under. Seedbeds can be left rough with much available surface capacity to absorb rainfall, or they can be left smooth. Different combinations of these variable have different effects on soil loss

The effectiveness of crop residue depends on the amount of residue kept on the surface. The canopy protection of crops depends on the type of vegetation and varies greatly in different months or seasons. Therefore, the overall erosion reduction effectiveness of a crop depends largely on how much of the erosive rainfall occurs during the periods when the crop and crop residues provide the most protection.

Some typical crop management factors are:

Crop	C Value
Bare, continuously fallow, up and downhill cultivation	1.00
Upland rice at 0.2 x 0.3 m followed by groundnuts	0.45
Upland rice followed by sorghum	0.43
Upland rice followed by fallow	0.71
Sorghum at 0.2 x 0.5 m	0.30 - 0.61
Bracheria decumbens (first season)	0.30
Bracheria decumbens (second season)	0.003
Cassava	0.50 - 0.78
Cassava on parallel ridges up and down slope	0.78
Peanuts	0.4 to 0.8
Palm trees, coffee, cocoa with cover crop	0.1 to 0.3
Savannah, prairie in good condition	0.01
Forests, dense shrubs, very high mulch crops	0.001
Bench terraces unplanted	0.03 - 0.14
Bench terraces planted to groundnut	0.02
Bench terraces planted to sorghum	0.01

The erosion control practices factor, P is the ratio of soil loss from a plot with specified conservation practice to the soil loss occurring from up and downhill tillage operations when other conditions remain constant.

Terraces are effective mechanical practices used to reduce soil loss. Typical P values for terraces in Indonesia range from 0.03 to 0.05 for the benched type and from 0.10 to 0.50 for the broad base conservation terraces. Traditional upland terraces in shallow soils sometimes have P values greater than 1.0 because they act to concentrate the wate

The universal soil loss equation's primary value is its use in comparing different crop and conservation practices. We can use the equation to predict how much soil can be saved. The two multiple factors are the crop management factor and the erosion control practice factor.

The factor C is by far the most important manipulative factor. In fact, as long as the vegetal cover is uninterrupted, whether it is forest, bush, savannah, pasture land, or a simple mulch, erosion and runoff are small despite the erosivity of the rainfall, slope steepness, and soil instability. Studies show that when the soil is totally denuded in the tropics, erosion becomes catastrophic; soil losses are multiplied by 100 to 1,000 and the flow by 20 to 50. Under cultivation, the erosion is intermediate and varies to a large degree according to the type of crop, the rapidity with which it covers the soil, and the cultural techniques put into use to encourage its growth. Density and earliness of planting, cultivation of the soil, appropriate fertilizers, and return of plant residues play predominant roles.

Control of erosion by crop management is just good farming. The costs are low and the benefits are high. Soil loss from agricultural land should be reduced to no more than 5,000 $t/km^2/y$ in the hilly upper watershed areas.

Many erosion control practices cost very little. Intercropping cultivation and contour cultivation are two inexpensive methods. Mechanical measures, such as bench terraces, are very effective but more expensive.

The amount of soil saved in upland areas by good management practices is illustrated in the following comparisons for a site near Salatiga using the following factors to evaluate the universal soil loss equation A

$$A = RKLSCP$$

in which R = 2,190 full year for Salatiga Climatic Station
K = 0.25 t/ha/unit of R
L = for 100 meter slope length = 2.47
S = for 20 percent slope gradient = 3.57

Using these factors the erosion on bare soil with no conservation practice would be (2,190 x 0.25 x 2.47 x 3.57) = 4,835 t/ha/yr. This is 440 times the acceptable rate of soil loss of 11 t/ha/yr.

The following table gives a comparison of some crops and conservation practices on the evaluation site near Salatiga:

Crop	Practice	C	P	A t/ha/yr
Bare Soil	None	1.00	1.00	4,835
Cassava	None	0.78	1.00	3,770
Cassava	Contour farmed	0.78	0.75	2,830
Cassava	Bench terraced	0.78	0.03	115
Upland Rice followed by Sorghum	None	0.43	1.00	2,080
Bracheria decumbens (Second Season)	None	0.003	1.00	15
Natural forests	None	0.001	1.00	5
No Crop	Bench Teerace	1.00	0.05	240
Groundnuts	Bench Terrace	0.40	0.05	95
High Mulch Crop	Bench Terrace	0.001	0.03	1

As can be seen by this analysis, it requires a natural forest cover, or intensive conservation practices to reduce the erosion rate to an acceptable level. Admitedly, the K value of 0.25 is high for most Indonesian soils, but it does indicate the intensity of conservation measures required to reach acceptable erosion rates that would permit permanent crop production on the site.

The above analysis also indicates that cassava in a monoculture system is not a suitable crop even if the land is bench terraced. Intercropping, relay planting, minimum tillage, stubble, mulching and other conservation farming practices are all needed to reduce erosion rates to the acceptable levels or some minimum that will permit cropping for as many years as possible. The specific conservation measures needed are discussed in the next section of this report.

TABLE F-8

SUMMARY OF AVAILABLE HYDROLOGIC AND SEDIMENT DATA FOR UPPER WATERSHED AREAS

Item	Unit	Lusi River at Serang Confluence	Serang River at Sedadi Weir	Muria Volcano above Highway	Tuntang River above Glapan	Jragung River Above Jragung Damsite	Dolok River	Penggaron River	Total
Catchment Area	km^2	2,101.0	868.0	700.0	796.0	94.0	41.5	77.7	4,678.2
Mean Annual Rainfall	mm	1,873	2,520	2,450	2,630	2,640	2,415	2,721	2,242
Mean Annual Runoff	mm	860	1,150	1,050 1/	1,120	1,280	1,116	1,325	1,005
Estimated Evapotranspiration	mm	1,013	1,370	1,400 1/	1,510	1,360	1,299	1,396	1,237
Estimated Percent Water Yield	%	46	46	43	43	48	46	51	45
Average Annual Water Yield	10^6 m^3	1,807.8	998.2	735.0	892.0	120.0	46.3	103.0	4,702.3
Estimated Annual Sediment Yield	10^6 tons	7.98	3.36	2.52	6.95 2/	1.50	0.50	1.24	24.05
Average annual stream Flow	m^3/s	58.8	32.5	(many streams)	28.3	3.8	3.3	1.5	
Estimated Net Sediment Delivery from Watershed	$T/km^2/yr$	3,800	3,870	3,600	8,730	16,000	12,000	16,000	5,140
Watershed Erosion Rate :									
Assuming a unit weight of 1,000 kg/m^3	mm	3.8	3.9	3.6	8.7	16.0	12.0	16.0	5.1
Assuming a unit weight of 1,500 kg/m^3	mm	2.5	2.6	2.4	5.8	10.7	8.0	10.7	3.4

1/ Estimated Values not available from other sources.
2/ Does not include an estimated 1.41×10^6 tons deposited in or adjacent to Rawa Pening

F.6. CONSERVATION PRACTICES AND TECHNIQUES

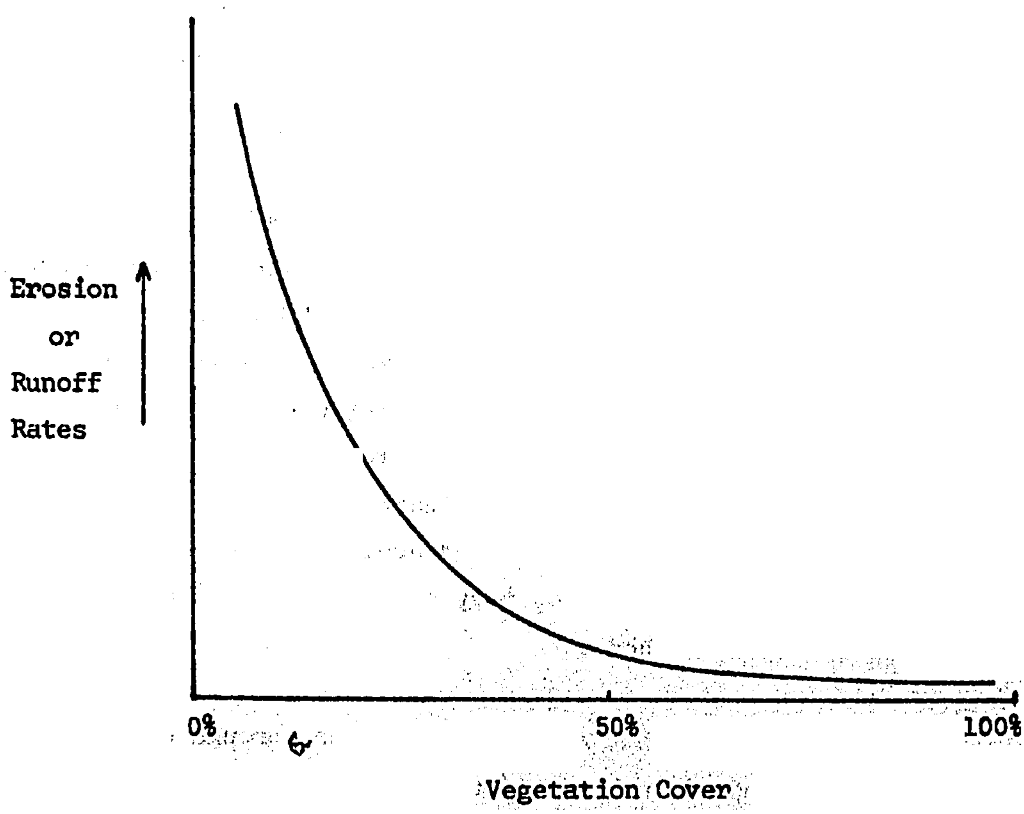
The primary purpose of this section is to provide a description of the alternative conservation techniques that are believed to be applicable to the Jratunseluna Basin. The objective is to provide a verbal description, generalized designs or sketches of the measures, and a generalized cost estimates for 1980 conditions in sufficient detail to permit the development of effective land management or soil and water conservation programs for subbasin areas. All recommendations are made with an awareness that success of the erosion control program is dependent on the degree of farmer and village involvement and acceptance. This assumes that the integrated watershed management approach described in Section F.2, Technical Approach will be used in planning and implementing the conservation program.

F.6.1. Vegetative Control Concept

The vegetative control results from the recognition that man-caused increases in soil erosion and runoff result from an imbalance between vegetative cover and soil-landform-climatic conditions. Consequently, the most effective treatment for accelerated erosion and runoff is the restoration of the proper balance between vegetation and site conditions Vegetative control of runoff and erosion may be achieved either directly, by improving the cover conditions, or indirectly, by effectively managing crop residues or mulching on cultivated areas. Therefore, even where structural measures are utilized, they should be considered as adjuncts to vegetative control metl

It should be noted that resource depletion through deforestration, upland cropping, and disturbances (such as road and trail construction) may cause little change in erosion or runoff until a critical cover density is reached, after which erosion and runoff increase at accelerating rates. Good watershed management attempts to manage cover so that the critical point is not exceeded. For areas already damaged by erosion, increases in vegetative cover and underground root mass (particularly fibrous roots) tends to increase infiltration rates rather rapidly, and, hence, reduce surface runoff and erosion.

The following figure illustrates the general relationship that exists between vegetative cover and erosion:



As noted in the above figure the rate of surface runoff and erosion increases gradually as the percent vegetative ground cover decreases from 100 percent to about 55 percent. As the vegetative cover goes below this point raindrop splash erosion increases dramatically. The fine material thus dislodged is both easily eroded and it clogs the soil pores which reduces infiltration. This is one of the reasons that as the vegetative cover approaches zero very high rates of surface runoff and erosion occur. Of course, the specific rates vary widely depending upon the soil texture, parent materials, soil depth, percent organic matter and ground slope. But the generalization still applies that as ground cover exceeds about 50 percent dramatic reductions in erosion occur, particularly if this is during critical periods of high intensity rainfall.

This vegetative relationship also explains why there is essentially no surface runoff in the natural forest or jungle areas. The multi-layered vegetation of the natural tropical rain forest provides a very high level of ground cover and most of the water movement is by inter-flow or groundwater flows. Hence, there is essentially no erosion from natural forest or even mature teak plantations areas. Conversely, on these same site, the newly plowed surface of a recently planted cassava is very subject to both surface runoff and erosion because there is essentially no ground cover.

F.6.2. Multiple Use Planning

Multiple-use or conservation planning is a process of planning the soil, plant cover and water management, and conservation practices that can control erosion on farms, plantations, or other operating units, in a given watershed (catchment) or problem area. Multiple use is really the harmonious use of land for more than one purpose: i.e., upland crops, grazing of livestock, watershed and timber production.

The planning process must offer the farmer treatment alternatives for the problems of erosion, excess water, etc. This gives the land user opportunity to select a treatment plan in accordance with his or her physical and economic capabilities. These alternatives are actually combinations of practices for various land uses. Ideally, they will attain all of the management and conservation objectives and therefore are complete treatments in themselves.

Planning is decision making. The plan is a record of decisions. Only the land user can decide how he will use and treat his land. Hence, he is the planner. Government technicians can only teach, demonstrate, and provide cash or input incentives to accomplish the desired governmental conservation objectives, although this point is seldom recognized by government officials and staffs.

One of the major objectives of conservation farm planning is to help the farmers to understand the erosion and water problems on their farms and how they can correct these problems by using the land in accordance with its capabilities. The land use and capability maps are used by the technician in assisting the farmers to decide which are the best uses of his land and what conservation practices will be required.

In the Jratunseluna Basin the most frequent land misuse is the cultivation of cassava on steep slopes. The steeper the slope, the greater the land damage from cultivation. Many steep slopes currently being cultivated are badly damaged and gullied. Gullies started in banks of natural waterways are often eroded to a great depth, and they grow deeper as they advance up the slope. This branching continues until a network of gullies covers the upland fields and the area is ultimately abandoned.

The first step in controlling erosion in the hydrologic unit is to develop a multiple-use plan for the farm so as to make the best possible use of the land. This includes making an inventory of the steep and eroded lands that can be properly terraced and converting slopes greater than 40 to 50 percent to permanent cover or agroforestry. Only moderately sloping land should be used for cultivated crops without terracing and other structural measures. The conservation plan has the goal of producing the maximum net return from the farm over the longest period. Where it is to the government's advantage to have certain practices applied that do not directly benefit the farmer, the government should pay for the practice or provide other incentives.

The most economical and best methods of controlling or preventing erosion are vegetative controls, such as mixtures of grass and legumes, conservation cropping systems, and the combination of vegetation and engineering controls. The use of engineering controls, such as terracing, water disposal structures and check dams should always be used in combination with good and proper vegetative practices.

The cost of controlling erosion on steep gullied land and the protection required should be considered in relation to the use that can be made of the land, the farmer's needs, and his willingness to apply conservation practices. In many cases his needs are not compatible with the land capability, especially in steep upland areas. Or his needs and land capability may be compatible, but the resources required are frequently beyond his economic ability. For both of these conditions, it requires a decision by Government as to whether subsidization is feasible or desirable in order to stabilize the agricultural activity and attempt to control erosion. In many cases the only technically feasible solution is to move certain upland farmers to other areas through transmigration or employment opportunities.

It is emphasized that the farmers must be trained and educated to assume the responsibility of installing and following a conservation farm plan. It is essential that he understands his individual responsibility to use conservation farming practices, to maintain terraces, check dams, etc., and to repair any damage that occurs. Where farmers do not understand their responsibilities or are not willing to cooperate, conservation practices quickly become damaged to the point that they are no longer effective. The government may be willing to initiate conservation structures and farming practices, but if it does not become the farmer's project, all efforts become futile.

Some necessary steps in developing a conservation farm plan with the local farmers include:

1. The technician should point out the ability of the soil to produce crops, current erosion problems, and measures for proper management of the soil and water resources available to the farm.

2. The technician should explain what is meant by land capability and why it is necessary to make changes in the management of the land.

3. A hydrologic unit map should be prepared showing land ownership of each farm lot and a plan on how to control erosion, changes necessary to manage water, changes in cropping systems, structures required, and finally what will be expected of each land owner or land operator.

4. A map and plan for accomplishing the conservation works should be prepared and kept on file in the Desa office. This plan should show what will be done on each field and when it will be done: crops to be grown, trees and shrubs to be planted, terraces, and other engineering measures needed to meet the conservation objectives.

The specific process consists of nine essential steps:

1. Pre-planning preparation by technician and land user;

2. Soil, plant, and water resources appraisal;

3. Conservation and management needs identification;

4. Treatment alternatives development;

5. Analysis of the effect of treatment alternatives on farming operation and income;

6. Decisions on measures to take, by the landowner and/or operator;

7. Record of the decisions of the land user and/or owner;

8. Development and record of the soil and water conservation, and management plan.

9. Keeping the plan up-to-date

During the planning process it must be recognized by the technical and administrative staff that there is a considerable area of farmer owned land that must be placed under the permanent vegetative cover in the interest of proper land use. The change from annual food cropping to agro-forestry methods, including grass and trees, creates problems. It is not known whether the introduction of a tree-grass-food crop or a tree-grass-livestock program will be technically sound and economically workable. However, even if it be so proven, it is believed that this innovation will be resisted for a partly physiological reason that the farmer ceases to be a free agent with his land, which has been growing annual food crops. Instead he is being requested to dedicate his land in perpetuity to the growing of trees and other crops. It may be shown that the practice can provide an annual income equal to or more than that obtained from annual cropping, but it does not directly produce food for his family. The conservation technicians must be able to show the farmer that it is to his advantage to make the desired changes. This may include incentive payments until trees become productive or provision of a larger land area.

F.6.2.a. Land Use Capability

Soil and land capability classes are defined by the physical features (including climate) of the land that determine its suitability for sustained crop production and determine the management level necessary to protect it from erosion hazards. These features include soil depth, texture of the topsoil, percent slope, climatic limitations, drainage, fertility, stoniness, erosion, flooding and other crop production related factors. The determination of these factors requires a detailed soil survey of the area under consideration at a mapping scale that permits a definition of all major soil and topographic features. Detailed soil surveys are estimated to cost about Rp. 4,600 per ha (Table F-4), and should be done by either experienced soil surveyors hired by the project or by the Soil Research Institute at Bogor (LP_3).

Detailed soil surveys and land capability classification are particularly important for implementation of pilot watershed demonstration areas and demonstration farms because it can prevent some costly mistakes. Land capability classes are used to group soils within a complex watershed which permits partitioning the watershed into a minimum of homogeneous units for planning and hydrologic evaluation.

It the land is used beyond its capability, natural relationships are imbalanced and it results in increased runoff, accelerated erosion and the consequent loss of soil productivity and soil moisture storage capability. Low productivity is mainly a function of shallow soil profiles, soil texture, slope, experienced erosion, and the parent (geologic) materials from which the soil is derived. Only a detailed soil survey and land capability classification will permit all of the factors to be defined for use by the farmer and the conservation planner.

It should be noted that this concept of land capability includes the possibility of adding conservation practices, such as bench terracing, that will allow land with known physical limitations to be used for upland crop production without suffering excessive damages. Soil conservation structures do not change the land capability, but they do permit a higher level of land use when properly installed and maintained. Conservation structures such as, detention basins, check dams, gully control streambank protection, etc. also play an important role where the terrain is highly eroded and cannot be rehabilitated by vegetative cover alone.

F.6.2.b. Soil and Land Capability Classification in Conservation Planning

The detailed soil and topographic survey and subsequent analysis of the area into land capability classes is the basis for developing a conservation plan because it permits a definition of all topographic and major soil factors. This map permits the conservation planner to divide the area into minihydrologic units for implementing waterways, terraces, grade control structures, trees, agroforestry and other conservation development measures.

The land capability map also defines the areas that require a change in land use to control erosion, either because of excessive slope, shallow soils or severe past erosion. The map also provides the basis for developing the water control system through grassed waterways and other structures. The individual farmers must develop a cooperative system because one farmer almost never has enough land for a complete system. Therefore, the farmers in the entire minihydrologic unit must work together to safely disposes of the surface runoff. The past dumping of runoff from terraces down property lines and trails is one of the major causes of erosion.

Increasing agricultural production and incomes of upland farmers is one of the prime goals of the conservation plan. By using each hectare of land according to its capability it will produce the maximum return over the longest period of time. Unfortunately, it frequently happens that the farmer does not have the resources necessary to feed his family if he makes the needed land use and farming method changes. The land capability map can identify this problem and the conservation planner can attempt to get the farmer to use contour strip cropping and inter-planting to reduce erosion even though he is planting cassava on very steep lands. All of this requires that the farmer become directly involved in the planning process and that he understands the limitations of his plot of land.

To promote the self operation concept of planning and operation of the project it is suggested that the Kelompok Conservation Action Unit serve as the primary medium for education and technical assistance to the farmers. Thus, the specialists would work with the individual groups to provide conservation planning, conservation cropping systems, marketing, facilities and other information the farmers may need to improve their economic conditions.

F.6.2.c. Adjustments in Land Use

The clearing of steep forested areas followed by planting of cassava wihout conservation measures is one of the principal causes of erosion in the basin. Statistics are not available for the amount of forest and plantation land that has been converted to upland agri-culture in the last 10-year period, but it could amount to 100,000 ha. Of course there has also been considerable abandonment and some of this has been replanted to forest. The critical feature for the Jratunseluna Basin is to halt the invasion of forested areas by upland farmers because the forested lands are essential to the future management of the Basin's resources. There is a possibility, however, that the soil survey and land capability classification may show that certain areas of the teak plantations may be suitable for upland crop production. In which case it would be desirable that these lands be exchanged with farmers who are using steep eroded lands that should be converted to forestry.

The most difficult land use adjustment to accomplish is the conversion of the greater than 40 percent slope lands to some type of permanent cover to protect against erosion. As previously noted, there is no assurance that the upland farmers will be willing to adopt agroforestry cropping systems on the upland areas. It is certain, however, that the tree-grass-food or tree-grass-livestock programs will require a larger area for the individual farmer to feed his family. Thus, it is going to be necessary to develop programs or some upland farmers to find employment elsewhere before the steep upland areas can be converted to a permanent cover.

It is particularly important to understand, however, that while it may not be possible to make the desired land use change it is still possible to apply conservation farming practices to the growing of upland crops on very steep lands. In some cases it may even be necessary to bench terrace lands with as much as a 50 percent slopes. Conservation terraces, contour strip cropping, interplanting, mulching, minimum tillage, fertilizer and improved crop varieties can all act to reduce erosion. Any increase in vegetative cover, or reduction in the period when the soil is bare, will dramatically reduce erosion rates.

F.6.3. Conservation Farming Methods

F.6.3.a. General

The upland watershed areas do not produce sufficient food to feed the residents. Upland arable and tillable lands compose only a small percentage of the Basins food producing capability, and the projected population increase further accentuates this food deficit. To meet this shortage of food, the usual practices are to increase the hectarage of food crops, increase the yield per hectare, and to tap other food sources.

The potential for additional agricultural expansion (increased hectarage) is quite limited. Essentially no suitable land is available for new agricultural development except by destroying additional plantation areas.

Increasing yields per hectare offers the greatest opportunity, however, this will not, by itself produce an adequate food supply for the inhabitants. In order to achieve increased yields, the primary requirement is not research into new methods, but the increased application of techniques and practices which are already known or have become available. Other requirements are, more research into local conditions, more fertilizers, more capital, and reduction of crop loses from pests, disease and poor storage systems. The immediate problem is to increase yields of the subsistance agriculture by the application of elementary agronomy and soil conservation practices. Theoretically, this should be simple, but available evidence indicates it is much more difficult to achieve this increase in subsistance productivity than to increase production in the more developed countries. The reason is that the upland farmer of this watershed simply does not have the resources, either his own human resources or the economic resources, to take advantage of the "green" revolution technical inputs and knowledge.

Without a major resource development program, it appears that there are limited opportunities for expanding conventional food supplies in the basin. The disparity between future supply and demand also focuses attention on the vital need for conservation farming to prevent the depletion of soil resources and the decreased productivity that is rapidly creating a critical situation.

Types of erosion and slope protection problems have been described elsewhere in this report. However, the question of which form of erosion is the most serious remains unanswered. This is important because the conservation program has limited resources which are insufficient to tackle the whole erosion problem and must therefore, be used against a selected part of the watershed. There is no simple answer to the question because the basic data is not available to determine either sediment sources or the economic losses associated with upland soil losses. The approximately 273,000 ha of irrigated and rainfed riceland (Table F-6) produces relatively small amounts of sediment so it can be basically eliminated. There is also an estimated 180,000 ha of forested land that is mostly under direct government supervision. The primary difficulty there is that the forest service or Perhutani does not have sufficient funds to efficiently manage this resource. This basically leaves the upland farming areas as the principal problem needing solution. Therefore, it is recommended that the project concentrate on reducing erosion on upland crop areas and on improving economic conditions for the upland farmer.

F.6.3.b. Cropping Systems and Rotations

Contour cropping should be practiced on almost all upland farming areas of the watershed. In fact, one of the reasons for terracing is to force contour cropping. Contour planting is not done strictly on the contour, but rather on a slope of 0.5 to 1.0 percent to allow for adequate drainage and to reduce runoff velocities in furrows. A ridgefurrow system of planting should be used for increased soil moisture intake intake during light rains. Gradient of the contours can be varied across the slope to improve field and row alignment. Contour planting can be accomplished on slopes up to 15 percent, providing the downslope distance does not exceed 30 m. On unterraced cassava fields, contour cropping should be instituted on very steep slopes to reduce erosion damages. Intercropping can also be used to increase the amount of ground cover from contour cropping.

There are no construction costs for contour cropping, since all that is involved is changing the direction of farm operations, but the extension service will require much time and effort to get the farmers to adopt this practice. They will also have to assist the farmer in laying out contour furrows in his fields.

Contour strip cropping is the alternate planting of row crops and strips of crops with close-growing habits (Figure F-3). Thus, if water breaks through a series of row crops, it is spread out in the close-growing crop, has a reduction in velocity, and sediments are deposited. It is recommended for slopes in the range from 8 to 15 percent. The width of the strips are a function of slope. Contour strip cropping will not be as readily adopted in Indonesia because of the lack of economical close-growing crops as alternatives to cassava. Upland rainfed rice could be used, but it is of doubtful value since it is generally planted as clumps and not drilled to provide a dense plant population.

On steeper land a special type of agroforestry with alternate strips of trees, grass and field crops has a large potential for reducing erosion rates, but it will require an intense extension program and incentives to cause the farmer to adopt the practice.

Terracing or any other type of mechanical practice by itself, generally will not increase crop yields. Because of depleted condition of the soils the timely use of commercial fertilizer will have to be increased to improve crop yields. In addition to the traditional crops (cassava, rice, corn, sweet potato, and peanuts), it would be advisable to try some other dry-season crops that are more drought resistant (such as sorghum). Unfortunately, to date the Panawangan Pilot Demonstration Farm of the Citanduy Basin and the Solo Watershed work are the primary sources for specific upland farming recommendations.

Considerable research and development is needed on upland crop varieties and cropping systems with the view towards both increasing gross yields and providing higher nutrition levels. Introduction of the wing bean is an example, in which the pod, beans and plant are all highly nutritious.

Root crops should not be planted on the lip of the terraces because this will damage the terrace lip when the crop is harvested. The terrace lip and riser should be planted, where possible, to grass or a grass and legume mixture for use in a cut and carry livestock program.

Crop rotations will have to be planned with the farmer after taking into consideration soil conditions, the steepness of the land, and the needs of the family. The farmer should understand why it is necessary to retire some land to grass and trees, and why it is necessary to use conservation measures to converse soil.

Intercropping should be given preference over sequential planting because it usually ensures greater economic returns and a better income stability for the farmer by protecting him against the risk of a total crop failure and against the wide price fluctuations of a one crop system. It should confer almost the same benefits as a crop rotation with regards to its effects on the soil. This is especially true if the legumes are included in the combination even though the legume may be removed for fodder. The fine root system with nodules remain in the soil to decay and supply nutrients for following crops.

F.6.3.c. Crop Residue Management and Mulching

As previously noted, vegetation is the first line of defense against erosion, but it should be emphasized that this material need not be living. Mulches, stubble and any other forms of ground cover are effective in decreasing raindrop splash and in increasing infiltration. For this reason it is very important that the upland farmers adopt a minimum tillage system that maintains crop residues, and that they cease burning the rice straw and other crop residues both because it is needed as a mulch and because burning destroys some nutrients.

A mulch prevents surface sealing of the soil by preventing direct raindrop impact, and by enhancing biologic activity which leads to the development of macropores in the soil. Manure, or composted crop residues, also provides nutrients which thereby reduce the commercial fertilizer requirement. Flat cultivation with trash or mulch has produced significant increases in crop yields in most cases, but there is a definite problem with weed control. The farmers must be introduced to this practice because it is not a part of the traditional agricultural system at all, although some upland farmers use composted materials in their vegetable patches.

F.6.3.d. Fertilizer, Lime and Soil Fertility Maintenance

Mixing the soil during terrace and contour constructions as well as the inherent low soil fertility level make it essential to apply fertilizer if crop yields are to be increased significantly. Fertilizer trials will have to be established to determine the recommended rates of application for different crops and soils throughout the Basin. It is known that fertility levels are very low in the eroded upland areas, and the large amounts of fertilizer would be necessary to build up the nutrient cycle to the point of maximum crop production.

Fertilizer inputs should be provided by the Government for a predetermined number of years as an incentive for the farmers to participate in the program. It is suggested that perhaps 400 kg of fertilizer be provided in the year of constrcution for practices such as terracing because the more fertile soils are often buried during construction. Rates of application will change after experimental data are available, however, it is known that farmers recognize the benefit of fertilizer. They have simply not been able to afford it for upland crops.

The end result of total soil removal is easily recognized, but the reduction in soil productivity or soil fertility as the soil is being removed by sheet erosion is less commonly understood. This has been named "fertility erosion", and it is caused by the action of water which sorts out and removes the light-weight fertility bearing portion of the soil, leaving behind parent materials, sand, and other heavy material. The amount of topsoil that may be materially reduced by the removal of coarse materials over the years is considerable, but the most fertile portion of the soil is usually the first to be removed by water. It is also evident from the limited laboratory analyses made for the area that fertility erosion has occurred and will continue to play a major role in impairing the productivity of all upland croplands.

F.6.3.e. Water Management

Water management is an indispensable part of modern upland agriculture. In water management, the ultimate target of any knowledge transfer is the individual farmer, for it is on farmland where production resources, including water, climate, soil, crop, fertilizer, and management, are all integrated into an upland agricultural system. The transition from traditional upland farming to conservation farming methods will be difficult and costly; however, this is necessary if runoff and siltation is to be controlled. Part of this process will be preparation of farm land to receive and store or dispose of the water without creating erosion. This process may include: bench terraces, conservation terraces, rural irrigation system development; diversion channels and waterways to dispose of surplus runoff. Improvement of the entire physical system is a requisite to a conservation water and soil management program.

The ultimate objective of an upland agricultural water management program is the upland farmer's awareness of his problems. To obtain this objective it will be necessary to train farm management advisors, upland agronomists, agricultural engineers, soil conservationists, and administrators. The farmer must be provided with necessary technical advice, seed, fertilizer, and management procedures; but unless he understands and can see a profit in his conservation efforts, it will be difficult to get him to change from the traditional methods. Capital is scarce and labor relatively abundant; therefore, the conservation farming and watershed program must focus on adapting the technology to conditions that the farmer understands and can achieve with his resources. More importantly, he has to be reasonably certain that it will pay him to adopt the conservation farming approach.

A particular advantage of modern upland conservation plan is that it has a considerable amount of management built into it and the farmer is automatically led to correct decision in the application of soil and water conservation measures. A farmer will make fewer mistakes with a well planned system than a farmer lacking the technical input regarding water management. Continued focus on improved water management must become a new way of life for the upland farmer if he is to continue using the upper watershed soils.

F.6.4. Protection of Cultivated Slopes

Cultivation of any land in the humid areas of the world will cause erosion and degradation of the soil. The steeper the land form, the higher the potential rate of erosion. Erosion not only results in the deterioration of the productivity of the land, but it also results in the aggravation of sedimentation and flood damages in downstream area. No program will control erosion on steeply sloping upland crop areas--it can only reduce the erosion to some acceptable level.

The protection of cultivated slopes is very complex and some of the hydrologic or engineering aspects are beyond the scope of this report. Therefore, a special report developed by PRC Engineering Consultants, Inc. for the Citanduy Upper Watershed Management Project is being furnished in limited numbers for use by technical staff members in designing and building structural works such as waterways, diversions, and bench or conservation terraces [24]. This report, Appendix D - Protection of Cultivated Slopes, was specially reproduced and furnished by the Citanduy Project Office of PRC/ECI in Banjar, West Java.

All cultivated slopes require protection against erosion. The steeper the slope, the higher the potential for erosion and the more difficult it is to reduce erosion rates to some acceptable level. Mecahnical methods of control must be fitted into the upland farming conservation program, and their success lies in the management and maintenance by farmers with some hlep from governmental technical services.

Structureal protection proves expensive because of capital cost, which can exceed one million Rupiah per ha for bench terraces. Therefore, emphasis should be placed on the least costly means of protection, and steeper slopes should be eliminated from cultivation (particularly cassava production) if at all possible. Vegetative controls are still the best means of controlling erosion since disturbed soils can never be completely protected.

The following upland conservation practices can be utilized in carrying out soil and water conservation programs for the Jratun-seluna Basin. The practices included are used to achieve soil and water conservation, reduce downstream flooding, pollution abatement, and improve the quality of the environment. Each practice sets forth the objective or purpose of the practice, the conditions under which it should be used, and a guide to its specifications. The actual specifications for most of the practices that are found to be effective in reducing erosion will have to be developed as parts of detailed technical guides that should be prepared as more experience is obtained. Where possible a figure is provided to illustrate the use of the practice and a generalized cost estimate is provided.

The practices are in three parts: soil management practices; plant management practices; and water management and conservation practices. It is considered that management has more to do with soil and plants and that management and conservation deal more specifically with water. This section does not include specific conservation measures for forestry, treatment of road and trail damages, or stream channel improvement and stabilizstion which are discussed later in the report.

F.6.4.a. Soil Management Practies

1. Access Road (meters or kilometers): A road constructed as a part of a conservation plan to provide needed access; roads constructed to provide access to farms, villages, forest plantations, conservation planting systems, structures and recreational areas.

   Purpose -- To provide a route for travel, for moving equipment and supplies, for moving livestock and for providing access for proper operation and management of forestry or conservation enterprises.

   Where Applicable -- Where roads are needed to provide access from a municipality, village or highway to the conservation planting enterprise, or to provide travelways within the planned area.

   Specification Guide -- Specifications shall describe requirements for proper installation, maintenance and protection of the practice to achieve its purpose.

2. Contour or Cross-Slope Farming (hectares): Conducting farming operations on sloping cultivated land in such a way that plowing, land preparation, planting, and cultivation are done on the contour or across the prevailing slope. (This includes following established grades of terraces, diversions or contour strips.) This does not add to the cost of farming and the only cost associated with it is providing the farmer with the original contour staking. It is, however, very important to reducing erosion on upland farming areas.

   Purpose -- To reduce erosion and provide water control.

   Where Applicable -- On sloping cropland and certain forestry land where other cultural and management practices in the cropping system do not adequately control soil and water losses.

   Specification Guide -- Alignment requirements with terraces, diversions, or contour strips, and where contouring is used without the use of the above practices; allowable deviation from the contour or specified grade and row length.

3. Contour Stripcropping (hectares): Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a strip of clean-tilled crop (Figure F-3).

   Purpose -- To reduce erosion and provide water control.

Where Applicable -- On sloping cropland and certain agroforestry lands where the topography is sufficiently uniform to permit practical tillage and harvesting operations, and where it is an essential part of the cropping system to effectively reduce soil and water losses.

Specification Guide -- Width of strip, based on percent of slope; and allowable deviation from the contour, or specified grade and row length.

4. Contouring Orchard, Agroforestry, or Small Fruits (hectares): Planting orchard, trees and crops, or small fruits so that all cultural operations are performed on the contour. (Does not include Contour Farming).

Purpose -- To reduce soil and water losses; provide for better control and utilization of water; and to facilitate the operation of farm equipment.

Where Applicable -- On sloping lands where soil and water losses need to be controlled, especially where permanent cover is not established.

Specification Guide -- Allowable deviation from the true contour, and the specific recommended varieties of trees and small fruits.

5. Conservation Cropping System (Hectares): Growing crops in combination with needed cultural and management measures. Cropping systems include the use of interplanting, relay planting and rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops.

Purpose -- To increase the production of food crops while meeting the needs of the soil for improvement or maintenance of good physical condition; to protect the soil during critical periods when erosion usually occurs; to aid in the control of weeds, insects and diseases; and to fulfill the needs and desires of the farmer for an economical return.

Where Applicable -- On all cropland, and certain agroforestry lands used for food crop production.

Specification Guide -- Crop sequences, or percentage of row crops, grain and /or grass and legumes, in combination with essential cultural and management measures.

6. Cover and Green Manure Crop (hectares): A crop of close-growing grasses, legumes or small grain used primarily for seasonal protection

and for soil improvement. It usually occupies the land for a period of one year or less, except where there is permanent cover as in orchards. At least initially, the government will have to pay to have this crop grown. Including seed, fertilizer and labor costs it will amount to approximately Rp. 40,000 per ha.

Purpose -- To provide a vegetative cover for erosion control during periods when the major crops do not furnish adequate cover; add organic materials to the soil; improve infiltration, aeration and tilth. It will also often be necessary immediately after terracing of infertile areas.

Where Applicable -- On cropland, orchard, and small fruit areas.

Specification Guide -- Seedbed preparation, date of seeding, seed mixtures, fertilizer, management, and time and manner of incorporating into the soil.

7. Crop Residue Use (hectares): Utilizing plant residues to protect cultivated fields against erosion in that part of the year when critical erosion usually occurs.

   Purpose -- To conserve moisture, increase infiltration, reduce soil losses, and improve soil tilth.

   Where Applicable -- On land where adequate crop residues are produced.

   Specification Guide -- Amounts of surface residues necessary to reduce erosion; suitable alternative methods for managing the crop residues; and time and manner of incorporating them into the soil.

8. Farm Path (meters or kilometers): An erosion proof path constructed as a part of the conservation plan to provide needed access to fields and terraced areas. Figure F-4 is an example for bench terraced areas.

   Purpose -- To provide a means of access for livestock and humans to individual fields, home gardens, or even villages that is so constructed as to minimize potential erosion.

   Where Applicable -- All upland areas where livestock and people consistently travel.

   Specification Guide -- Specifications shall describe the proper alignment, erosion proofing and means of handling surface runoff from existing and planned trails.

9. Minimum Tillage (hectares): Limiting the number of cultural operations

to those that are properly timed and essential to produce a crop and prevent soil damage.

Purpose -- To retard deterioration of soil structure; reduce soil compaction and to improve soil aeration, permeability and tilth.

Where applicable -- On all cropland, and certain agroforestry land used to produce food crops.

Specification Guide -- Include suggested tillage operations that are applicable to field crops, orchards, and home gardens.

10. Mulching (hectares): Applying plant residues or other suitable materials, not produced on the site, to the surface of the soil. This may be by direct cut and carry systems or by composting any organic matter.

Purpose -- To conserve moisture; prevent surface; compaction or crusting; reduce runoff and erosion; increase fertility; control weeds; and aid in establishing plant cover.

Where Applicable -- On soils subject to erosion when low residue producing crops are grown, and also on soils that have a low infiltration rate.

Specification Guide -- Amounts and management under different conditions.

F.6.4.b. Plant Management Practices

1. Critical Area Planting (hectares): Stabilizing sediment producing and severely eroded areas by establishing vegetative cover. This includes using woody plants, such as trees, shrubs, or vines, and adapted grasses or legumes established by seeding, sodding, or branch cuttings to provide long-term ground cover. (Does not include tree planting mainly for the production of wood products). This practice is estimated to cost Rp. 622,200 per ha treated (Table F-10).

Purpose -- To stabilize the area and to reduce damages from sediment and runoff to downstream areas and to improve production from the area.

Where Applicable -- On highly erodible areas or severely eroded areas such as cutbanks or fill areas and, denuded or gullied areas where vegetation is difficult to establish with normal seeding methods. These areas are normally small in size.

Specification Guide -- Species of grasses, legumes, shrubs and trees; rates of seeding or planting; fertilizer and lime requirements; land or plant site preparation; time of establishment or planting; mulching and irrigation.

2. Desilting Area Establishment (hectares): An area above an impoundment planted to grass, shrubs, bamboo or other vegetation, or fenced to protect the native vegetation.

Purpose -- To reduce the velocity of flow of the runoff which will cause water-borne sediments to be deposited in an area above the impoundment.

Where applicable -- In natural watercourses above impoundments where a vigorous vegetative growth can be established and where the valley gradient is conducive to the intended purpose.

Specification Guide -- Include seedbed preparation, kinds of plants, time and rates of planting or seeding, and fertilizer and lime requirements.

3. Field Border Planting (meters or kilometers): Establishing a border or strip of perennial vegetation at the edge of a field.

Purpose -- To control erosion; protect edges of the fields that are used for "turn rows" or travel lanes; or reduce competition from adjacent woodland;

Where applicable -- At field edges, especially crop fields and along steep areas or waterways adjacent to cropland.

Specification Guide -- Specify: seedbed preparation; width of border; adapted species and mixtures; rate, time and method of seeding; fertilizing; and management for establishment and maintenance.

4. Grasses and Legumes in Rotation (hectares): Establishing grasses and legumes, or mixtures of them, and maintaining the stand for a definite number of years as a part of conservation cropping system.

Purpose -- To produce cut and carry forage, seed, or grazing; reduce soil and water losses; maintain a favorable level of organic matter; and improve soil productivity.

Where applicable -- On cropland and certain agroforestry land where they are an essential part of the conservation cropping system, or otherwise needed to fulfill the needs of the land owner and operator.

Specification Guide -- Species and mixtures, rates, time of seeding, seedbed preparation, and maintenance treatment and management practices for planned uses.

5. Livestock Exclusion (hectares): Excluding livestock from any area where grazing is harmful or otherwise undersirable.

Purpose -- To protect, maintain, or improve the quantity of the plant resources, to maintain adequate cover for soil protection, to maintain moisture resources, and to enhance natural beauty. This practice is largely used immediately after construction where an area is disturbed, or in some cases after critical area planting.

Where Applicable -- Where soil, hydrologic and other values are damaged by livestock and the desired crop is impaired.

Specification Guide -- Specifications should include the period for which exclusion is required and the methods to be used for excluding livestock from the area.

6. Pasture Planting (hectares): Establishing long-term stands of adapted species of perennial, biennial, or reseeding forage plants on land converted to pasture from other uses. (Does not include Grassed Waterway on cropland).

Purpose -- To make land use adjustments, produce high quality forage, and reduce erosion.

Where applicable -- On land that is converted from other uses, and where the species will remain idefinitely after re-establishment through a system of agroforestry land use.

Specification Guide -- Methods of seedbed preparation; adapted species and mixtures; methods of planting fertilization and liming.

7. Proper Grazing Use (hectares): Grazing pastures, "native pasture", and agroforestry land at an intensity which will maintain adequate cover for soil protection and maintain and improve the quantity and quality of desirable vegetation. This would include cut and carry harvesting systems.

Purpose -- To permit accumulation of litter and mulch necessary for conservation of soil and water, improve condition of the pasture, and increase forage production.

Where Applicable -- On all agroforestry, native or planted pastures and watershed lands used for grazing by domestic livestock.

Specification Guide -- Specify: (a) planned use (class of livestock and season of use) by grazing units: (b) the key forage species to be used in judging the degree of use; and (c) for the key grazing area and key forage species, the allowable percent, by weight, of the current year's growth to be grazed, by range sites, and condition classes.

8. Streambank Planting (meters or kilometers): Establishing perennial vegetation on streambanks.

Purpose -- To reduce scour and erosion, produce livestock forage and/or wood products, and improve the landscape.

Where applicable -- Along eroding streambanks that require protection by vegetation.

Specification Guide -- Specify: planting species, methods of planting and maintaining desired vegetation.

9. Tree Planting (hectares): Planting tree seedlings or cuttings to establish a stand of forest trees.

Purpose -- To establish a stand of trees for the conservation of soil and moisture, watershed protection, and the production of wood products or fuelwood.

Where applicable -- In open fields, cut over forests, beneath less desirable tree species, or other areas suitable for the production of wood products, or where erosion control and watershed protection are needed. This can be an important means of land use conversion.

Specification Guide -- Specifications should include adapted tree species for the purposes outlined above, site preparation, spacing, planting method, and as applicable cultural practices and maintenance requirements.

10. Vegetative Barrier (meters or kilometers): A narrow barrier of perennial vegetation established across the slope of a cultivated field with a definite interval and gradient, with or without ditches, to retard runoff, check erosion, and provide a permanent guideline for contour cultivation.

Purpose -- To reduce soil and water losses, and provide a guide for contour cultivation.

Where Applicable -- On sloping cropland where it will provide protection against serious soil and water losses. It works well in combination with hillside ditches and contour strip cropping.

Specification Guide -- Width; adapted plants; time and rate of planting; fertilizer, if applicable; and seedbed preparation.

F.6.4.c. Water Management and Conservation Practices

1. Dam, Diversion (number): A structure built to divert part or all of the water into a different watercourse, an irrigation canal or ditch, or a waterspreading system. This type of structure is not cost estimated for this report because each site requires specific engineering investigations and design.

   Purpose -- To control streamflow and supply water to irrigation systems and also to upland cropping areas as supplemental overland irrigation.

   Where Applicable -- On cultivated rice lands under irrigation and flat or slightly sloping upland crop areas and in bottomland areas where diversionary control is necessary.

   Specification Guide -- Should include capacity, cross section and shrinkage, outlet and spillway criteria, construction materials and requirements, and also provisions for outlet protection and maintenance, etc.

2. Debris Basin (number): A barrier or dam constructed across a waterway or at suitable locations to form a siltation or sediment basin. This practice is not applicable in the high sediment production areas of the Jratunseluna Basin because the basins would often fill in the first big storm.

   Purpose -- The purpose of this practice is to provide a desilting action in silt or sediment laden waters and thereby remove a threat of sedimental deposition to more valuable lands.

   Where Applicable -- In areas of little or no value - old stream channels, depressions, etc. into which water can be diverted and allowed to spread over.

   Specification Guide -- Should include capacity, inlet and outlet criteria and provisions for protection and maintenance of inlet and outlet, etc.

3. Dikes and Levees (meters or kilometers): An embankment constructed of earth or other suitable materials to protect land against overflow from streams, lakes and tidal influences; also to protect flat areas from diffused surface waters.

Purpose -- To contain surplus flow within natural or artificial channels and so prevent overflow damage to valuable farm land and urbanized areas.

Where applicable -- In agricultural and urban areas or other valuable sites requiring this type of protection. It is not normally used in the upper watershed areas.

Specification Guide -- Should include cross-section and shrinkage, construction materials and requirements; also provisions for protection and maintenance.

4. Diversion (meters or kilometers): Grading or digging a channel, with a supporting ridge on the lower side, across the slope (Figure F-5). The cost for developing one kilometer of diversion is estimated at Rp. 301,250 based on an average capacity requirement of 385 l/s (Table F-11).

   Purpose -- The purpose of this practice is to divert surface runoff from areas where it is in excess to a natural water course in a non-damaging fashion.

   Where Applicable -- In sites where: (a) runoff from higher-lying areas is damaging cropland, pasture land, farmstead or structures such as terraces or irrigation systems, (b) diversion of runoff into or away from fish ponds is needed, and (c) diversion away from a gully head cut is required.

   Specification Guide -- Should include grade, capacity, cross-section and shrinkage, also provisions for channel and outlet protection.

5. Fish Ponds or Farm Ponds (number): A water impoundment made by constructing a dam or embankment or by excavating a pit or "dug-out". (Such ponds do not include Spring Development or Irrigation Reservoirs). Ponds constructed by the first of these methods are referred to as "Embankment Ponds" and those constructed by the latter method as "Excavated Ponds". Ponds resulting from both embankment and excavation are classified as Embankment Ponds where the depth of water impounded against the embankment at spillway elevation is 60 cm or more. Excavated ponds that intercept only subsurface water are classified as "Seep-Type Ponds".

   Purpose -- Fish Ponds or farm ponds are constructed to provide water for fish livestock, fire control, and related uses.

   Where Applicable -- This practice applies only where it is determined that available water supply justifies building fish ponds, but it is one of the most productive uses of the land when properly managed.

Specification Guide -- Site Guide -- Site conditions for Embankment Ponds shall be such that a peak rate of runoff that can be expected to occur once in 50 years can be safety passed through:

1. A natural or constructed emergency spillway, or

2. A combination of a principal structural spillway and an emergency spillway.

Large drainage areas can be used as a source of water for Excavated Ponds provided the ponds can be located on sites where the flow is diverted away from the structure after the pit fills with water. Seep-type Ponds may be used in areas where a subsurface water table will provide adequate year-round water.

The dam design must consider the soil and its bearing strength to sustain the construction and the stored water and the topographical characteristics of the site.

6. Fishpond Stocking (number): Stocking impounded waters with sport fish, bait fish, food fish, shrimp and other fishery animals.

   Purpose -- To produce desired kinds of fishery animals.

   Where applicable -- In ponds and reservoirs suitable for fish production.

   Specification Guide -- Specify: species and numbers to be stocked and desirable water area, depth, temperature and quality.

7. Fishpond Management (number): Developing or improving a fishpond by fertilizing, liming, using fish toxicants, feeding, controlling diseases and parasites, or by other means.

   Purpose -- To improve or maintain fish production and fishery use by: creating a favorable water habitat; supplementing natural food supplies; and reducing or eliminating undesirable plants and animals.

   Where applicable -- In ponds, lakes and reservoirs used for fish production.

   Specification Guide -- Specify kind, amount, method and time of treatment needed for the particular purpose.

8. Floodwater Diversion (meters or kilometers): A graded channel with a supporting embankment or dike on the lower site constructed on a lowland subject to flood damage.

Purpose -- To divert floodwater away from valuable land susceptible to overflow and damage.

Where applicable -- In agricultural, recreational and urban areas and other valuable sites requiring this type of protection.

Specification Guide -- Should include channel grade and capacity, cross section and shrinkage of embankment, and provisions for channel and embankment maintenance and protection.

9. Grade Stabilization Structures (number): A structure to stabilize the grade or to control head cutting in natural or artificial channels. (Does not include Stream Channel Improvement, Streambank Protection, Diversion or Structure for Water Control). The use of grade stabilization structures is discussed more fully in section F.6.4.c. Gully stabilization. The recommended types of grade stabilization structures are shown in Figures F-9 through F-12.

   Purpose -- To stabilize active gullies, overfalls or critical erosion points.

   Where Applicable -- Grade stabilization structures apply to any land use provided they can be economically justified and the required protection or control cannot be provided by more economical means. Each type of grade stabilization structure has its own adaption and limitation, depending upon the site, foundation material, quantity of water which it is required to safely convey, and economics. Types of structures applicable under this practice are: earth dams with or without detention storage; formless concrete chutes; masonry or reinforced concrete chute spillways; rubble masonry or reinforced concrete drop spillways; gabions, loose rock drop/checks etc.

   Specification Guide -- Should include design and installation criteria and maintenance requirements.

10. Grassed Waterway (hectares or kilometers): A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff from a field, diversion, terrace, or other structure. The cost of the grassed waterway is normally included in the cost of the bench terracing (Tables F-14 and F-15) or other treatment measure.

   Purpose -- To prevent the excessive soil losses and formation of gullies.

   Where applicable -- Where concentrated runoff must be disposed of at safe velocities.

Specification Guide -- Seedbed preparation; type of sprigging or time of seeding, seeding mixture and rates; stabilizing crops, mulching or other mechanical means; and fertilizer and lime requirements.

11. Hillside Ditch (meters or kilometers): A channel with supporting ridge on the lower side constructed across the slope at definite vertical intervals and gradient, with or without vegetative barriers, to detain or control the flow of water to a protected outlet to check erosion on sloping land. They also can be developed so as to serve as access trails. Hillside ditches with contour farming is the minimum needed treatment for cassava hillside farming with slope greater than 15 percent. Hillside Ditches are estimated to cost an average of Rp Rp. 32,500/ha (Table F-12).

Purpose-- To intercept runoff and conduct it to a protected outlet so as to reduce erosion damage.

Where applicable -- On sloping cropland having a water erosion problem. This structure is generally non-farmable with the channel and supporting ridge usually being vegetated.

Specification Guide -- Should include channel capacity and gradient spacing, cross section and shrinkage of embankment, construction requirements, adequate outlet criteria and also provisions for channel and embankment protection and maintenance.

12. Irrigation Water Management (hectares): The use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where water is applied at a rate and in such a manner that the crops can use it efficiently and significant erosion does not occur. Includes the timing of irrigations to meet crop needs, the control and adjustment of stream sizes to prevent erosion, and the control of the length of "set" to minimize water losses. This practice is particularly important for farm systems where the water supplies are generally limited.

Purpose -- The purpose of water management is to accomplish efficient beneficial use of irrigation water according to the moisture needs of the crop to achieve maximum production while minimizing losses of soil and plant nutrients.

Where Applicable -- This practice is adapted to all lands that are suitable for irrigation and have a water supply of suitable quality and quantity. An adapted conservation irrigation system must be available (portable) or must have been established on the land to be irrigated.

Means must be available for determining application rates, irrigation stream sizes, elevation of controlled water tables, and rates of flow of surface runoff, where these measurements are applicable to the method being used.

Specification Guide -- Should include such things as: consumptive use rates for the crops grown; how to measure or estimate the amount of water required for each irrigation; how to determine when irrigation needs to be applied; how to recognize erosion caused by irrigation; how to compute the amount of water delivered to the area; how to evaluate the uniformity of water application; the normal time needed for the soil to absorb the required amount of water; to detect changes in intake; and how to adjust stream size and irrigation time to compensate for changes in intake.

13. <u>Outlet Construction</u> (meters or kilometers): Constructing designed structures for the disposal of runoff water from diversions or terraces including alteration of watercourses (Figure F-9). As with grassed waterways, the cost of these structures is usually estimated as a part of the terracing or diversion channel cost estimates.

Purpose -- To provide safe disposal of runoff water by means of pipe drop inlets, hood inlets, and sod chutes so as to stabilize a watercourse of gully or protect downstream or lower lands from sediment and debris.

Where applicable -- At the ends of terraces, diversions, drainage ditches where safe disposal of water is needed.

Specification Guide -- Should include construction materials and requirements, structure, capacities, types of safeguards, etc.

14. <u>Rock Barriers of Stone Walls</u> (meters or kilometers): A rock retaining wall constructed on contours across the slope to form barriers to soil eroded downslope and to from and support a bench terrace which will control the flow of water and check erosion on sloping land.

Purpose -- To form the riser portion of a bench terrace where such type of support is needed. It also enables the utilization of the rocks and stones on the slope.

Where Applicable -- On sloping cultivated lands where terrace structures are needed to control the runoff and reduce erosion damage.

Specification Guide -- Should include the permissible angles of repose, construction and maintenance requirements, etc.

15. <u>Streambank Protection</u> (meters or kilometers): Stabilizing and streambanks or excavated channels against scour and erosion by vegetative or structural means. (Does not include Stream Channel Improvement).

Purpose -- The purpose of streambank protection is to control bank cutting in order to protect valuable land and reduce the silt load of the stream.

Where Applicable -- This practice is applicable on farm lands or other lands whose value is high enough to justify the expenditure of protecting them.

Specification Guide -- Should include types of control devices, construction materials for each, spacing etc.

16. <u>Stream Channel Stabilization</u> (meters or kilometers): Stabilizing the channel of a stream with suitable structures. The type of control is discussed more fully in section F.6.6.

Purpose -- To stabilize the stream channel against deepening by means of structures.

Where Applicable -- This practice is used in streams which are actively bed-cutting and increasing the silt load of the stream.

Specification Guide -- Should include such design criteria as types of structures, construction materials for each, spacing, etc.

17. <u>Terrace, Conservation</u> (meters): An earth embankment or a ridge and channel constructed across the slope at a suitable spacing and with an acceptable grade (Figure F-6). This is also known as a "gradient diversion" or "drainage" terrace. This type of erosion control is discussed more completely in Section F.6.4.c.

Purpose -- Conservation terraces are constructed to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity.

Where Applicable -- Conservation terraces may be used on cropland, agroforestry or forestry areas having a water erosion problem. They should not be constructed on deep sands, or on soils that are too stony, steep or shallow to permit practical and economical installation and maintenance. The topography must be such that useable terraces can be constructed. Conservation terraces should be used only where suitable outlets are or will be made available.

Specification Guide -- Should include improved alignment considerations, appropriate lengths, dimensions, spacing and grade, adequate outlet protection, construction and maintenance requirements and provisions for field checking.

18. Terrace, Bench (meters): Are essentially a series of level or nearly level strips running across the slope at suitable spacings, and supported by steep risers. The risers are either earth protected by grass, or by rock walls if the rocks are available. There are essentially four types of bench terraces, i.e., level, outward sloped, conservation bench, and reverse slope (Figure F-7). The only type recommended for Indonesian conditions is the reversed slope type, which is built sloped inversely towards the hill and is particularly suited to the steep humid conditions because it safely drains off the excess water. This type of structure is more fully discussed in Section F.6.4.d.

Purpose -- Bench terraces are constructed to reduce erosion damage by intercepting runoff and allowing it to percolate into the soil in the channel behind the terrace embankment. They are constructed to make cropping possible and safe on slopes of from 5 to 50 percent.

Where Applicable -- Bench terraces should be used on soils where a good management system is followed so that the surface soils will not seal. They should not be constructed on soils that are too stony, steep or shallow to permit practical and economical installation and maintenance.

Specification Guide -- Should include improved alignment considerations, appropriate lengths, dimensions, spacing, construction and maintenance requirements, and provisions for field checking.

F.6.4.d. Conservation Terracing

A terrace systems' main purpose is to shorten the slope length and remove the water at a velocity that will not cause erosion. Because a terrace as with almost all structures, concentrates the surface runoff it is very important that the system be carefully maintained. If not maintained, the terrace system may fail and cause erosion damages far exceeding those that would have occurred without the terraces.

Additional specific design and construction information is available in the Citanduy Upper Watershed Project Appendix D - Protection of Cultivated Slopes Report [24].

A conservation terrace is a ridge and channel constructed across the slope on a gradient that will conduct surface runoff to a waterway at a non-erosive velocity. Conservation terraces are recommended on slopes of 4 to a maximum of 25 percent where bench terracing is not contemplated. For steeper land and "greening program" areas hillside ditches are recommended. The vertical and horizontal intervals depend primarily upon land slope. However, they also depend upon soil and climate, crops grown, and machinery (if any) used. The drain channels must discharge into a protected waterway. Conservation terraces do not disturb the cropping area, except for the drainage channels. Therefore, only a minimum amount of soil must be moved. The crops are grown on the contour between terraces. It should be recognized that conservation terraces can be converted to bench terraces during farming operations over a period of years by the farmer moving additional soil with each tillage practice. The farmer should be encouraged to do this where the need exists.

The conservation terrace areas developed will be small because at present this is not a common practice in the Basin. The only known use of conservation terraces has been as a part of the greening program, and many of these were poorly constructed hillside ditches. The estimated cost for constructing a conservation terrace on a 15 percent slope is Rp. 45,825 per ha (Table F-13). Cost estimates include the cost of constructing grassed waterways and drop structures to remove surface runoff to natural waterways.

F.6.4.e. Bench Terracing

The most significant thing about bench terraces is that they cover the entire ground area rather than being spaced irrigularly over the land. Bench terraces are constructed by cut and fill, leaving a nearly horizontal bench and a steep riser (one horizontal for each two vertical), so that the system looks like stair steps. The benches have a back slope of 5 percent, with the drain channel constructed at the rear of terrace in the cut area. The gradient of the terrace is 0.5 to 1.0 percent. The vertical interval between terraces should be limited to less than 2.0 m. Applicable land slope for bench terraces ranges from 5 to 50 percent. The 50 percent limit is due to a vertical interval limit of about 2.0 m and a need for a net farmable width of 1.50 m. Widening the net farmable area reduces the maximum slope on which terraces can be constructed. For practical purposes, bench terraces on greater than 40 percent slopes are not particularly economical.

The specific design and onstruction methods for terraces is extremely complex depending upon the desires of the farmers, soil depth and fertility, general topography, and the slope of the land to be terraced. Alignment can be made parallel or non parallel, and the benches can be uniform or variable width when farmed by hand labor. Only after many terraces have been built and farmed for a period of years will it become clear which specific design criteria is the most desirable and efficient for the specific farming system and physical conditions. Additional bench terrace design information is contained in the previously mentioned Citanduy Upper Watershed Project Appendix - D [24].

In designing a bench terrace system the most important feature is an answer to the question, "If the system is built will it be maintained and used for at least the next 15 years?" If the system will not be maintained it should not be built because it will have the potential for creating large amounts of erosion if not properly used. The existing traditional terraces have been responsible for creating much of the severe erosion problems of the Basin because of its ability to concentrate surface runoff.

For this reason, the first step in designing a terrace system is always to design the grassed waterway system for surplus water disposal. This can be either an existing noneroding waterway or one specifically designed and constructed for the purpose. It is important to note, that the waterway system is both the first thing to plan and the first measure to build. The waterways must be grade stabilized and sodded prior to the need to carry runoff from the bench terraces or severe erosion may occur.

There are two types of bench terrace systems based on the disposal of runoff. One is the gradient terrace with a constant usually about 1 percent gradient towards the waterway, or a variable gradient that increases as it approaches the waterway. It is recommended that all bench terraces also be reverse sloped (5 percent) towards the riser with a small 20 cm x 15 cm channel to carry off surplus water. The other type of bench terrace is the common level terraces used for flooded rice paddies. This type of terrace is not recommended for slopes of over 25 percent unless stability studies are conducted to determine the engineering soil properties of the specific soils. However, there is always a danger that the farmers will modify any bench terrace for use as flooded bench for rice production in the wet season.

Bench terracing is an expensive method of protecting cultivated land, and total costs can exceed Rp. 1,000,000 per ha by the time the land is in full production. Cost is primarily a function of vertical interval, although slope has an effect. The problem associated with use of minimum vertical intervals is that the terraces are narrower than necessary so a trade off has to be made. One of the needed studies for project development is a combination engineering and economic study to determine the most efficient design for various slopes. Preliminary indications are that for a 15 percent slope the vertical interval should not exceed 100 cm and calculation show that this will require a cut of about 1,380 m^3/ha which has an estimated average cost of Rp. 508,750 for construction including the associated waterways and drop structures, as shown in Table F-14. For slope of 25 percent the most economical terrace would have a 1.2 m riser and would require an average cut of about 1,356 m^3/ha and has an equivalent estimated cost of Rp. 539,750 per ha (Table F-15). This type of bench terrace requires a 90 cm soil depth, which may not be available in any specific area. It might be noted, that while the above two examples have very similar total costs, the 15 percent slope would result in a net croppable area of about 7,114 m^2/ha while the 25 percent slope would result in only 6,114 m^2/ha of croppable bench. This reduction croppable area is an important feature of bench terraces and is one of the reasons it is so important to have a complete program of technical inputs that will permit the farmer to produce more food crops on the reduced area to the point that his net return is increased with his adoption of the conservation farming system.

F.6.4.f. Gully Stabilization

Gullies are active producers of sediment over much of the watershed, as previously discussed. The erodibility of a gully is influenced by the nature of the side and bottom materials, channel gradient, and channel alignment. All of these factors also affect the type and cost of the control methods that should be used. There are three components to controlling gully erosion: stabilization of head cut; grade stabilization; and revegetation to stabilize the bare soil. Another way of solving the gully erosion problem is to divert the water away from the gully, but this water must be carried in diversions to natural non-erosive stream channels. Figure F-5 is an example of using a diversion channel for this purpose.

Bamboo wattling drop structures are the most common type of drop or check used in gully control. The average bamboo wattle check with an effective height of 0.4 m and a width of 2.0 m costs 8,976 Rupiah each (Table F-16) and the same size structure with a stone dissipator is estimated to cost Rp. 9,090 (Table F-17). Where stone is available, small rock drops or checks with 1.0 m^3 of stone can be built for Rp. 11,250 (Table F-18); larger check drops with 4.5 m^3 of stone have an estimated cost of Rp. 46,875 (Table F-19). More difficult sites may require a rubble masonry headcut structure, which will cost about Rp. 155,275 for treating a gully head with an average depth of 2 m and a width of 7 m (Table F-20). This same basic structure can be used as a check in small streams for rural irrigation system diversions.

For large and difficult gully headcuts or streambank erosion protection, stone gabion structures may be required. An estimated 7.0 m^3 gabion retaining wall would cost Rp. 162,500 or about Rp. 23,200/m^3 (Table F-21).

F.6.5. Protection of Noncultivated Slopes

Noncultivated slopes with erosion problems are generally adjacent to developed areas and the problems are the result of timber harvesting, road construction, village area runoff, or the runoff from cropland. In general, the forestry and plantation areas of the Jratunseluna Basin have low erosion rates except during periods of disturbance, such as timber harvesting, the cropping period permitted during reforestation, and the plantation establishment period. Because their problems are less intense, noncultivated slope features are often ignored because of the larger magnitude of damages on cultivated lands, but they should receive treatment to prevent them from getting worse.

Erosion problems on noncultivated slopes are so varied that generalizations are impossible. Each specific peroblem area will require a specific analysis and a rehabilitation plan for it to be effective. Perhaps more importantly, the area will also require a long-term maintenance program to ensure that the project features remain effective.

F.6.5.a. Recommended Forestry Program

The forests in the Upper Watershed area constitute one of the nation's most valuable natural resources. For these resources to serve the best interests of the Jratunseluna Basin and the national economy, good conservation practices must be incorporated into the forest plantings and the adjacent upland farming areas. People in the upper watersheds should be encouraged to recognize, through an extensive educational program, the importance of good forests to their economy and their dependence on the good management of this resource for their fuel wood lumber and water supplies. Forestry regulations should be fair, well developed, and strictly enforced. Financial incentives should be provided to encourage active participation in agroforestry, reforestation, silvicultural and conservation practices.

Stabilized and clearly marked boundaries are needed to prevent undesirable and illegal conversion of forest lands to agricultural lands, particularly on lands with over 40 percent slopes. Because of pressures for land, farmers are moving into small forest or other government tracts and then claiming these as private lands, many of which are now in court dispute. There are numerous areas in the critical erosion zones where encroachment is very active, and greening project lands are often used for crops for many years.

A survey or study should be made to determine those areas that are in small forest tracts that could be traded or exchanged for some of the critical private lands. This would tend to block out larger forest areas for better forest management and place the critical eroded lands into permanent forest management. Many of these lands are too steep to cultivate and would require extensive conservation measures to control erosion and fertility losses. The land currently in plantation and production forests should be carefuly managed during harvest and strict conservation plans developed for the after-the-harvest period to prevent deterioration during the reforestation.

An inventory of all forest resources should be conducted through an integrated approach that would involve all governmental agencies with an interest in natural resources. A diversification of agencies is suggested because the survey should not include tree resources alone, but also wildlife, soil and land resources, genetic resources, and recreation.

A quick review of the production from forest reserves indicates that much better use could be made of the forest resources by multiple use planning for the harmonious use of the land for many purposes. Forest use has been primarily focused on the extraction of timber, gum, and other commercial products such as oils, waxes, and turpentine. Paper production is being considered. Research should be undertaken to determine what better and more rapid growing tree species are available or could be developed or introduced.

Considerable attention should be given to the production of fuel wood. Calliandra is being planted for fuel wood, but in view of volume of fuel wood required, the area planted and volume produced are not sufficient to meet the local demand. Other species, such as Accacia aurecleformis, Leucaena leucocephala and Casuarina equistifolia, that are fast growing and assist in improving the fertility of the soil and should be tried. These trees also provide a high degree of protection to the soil, and, hence, reduce erosion.

Shortage of water during the dry season in the upper watershed magnifies the need to manage some areas for municipal and domestic water for the small villages in the upper watersheds as well as for flood mitigation and sediment control. Forests produce the best quality of water, and this will bring a premium in the years to come. Such areas should be carefully managed and developed to increase this essential resource.

The objective of the Forest Service and Perhutani is to manage the forest on a sustained yield principle, and should be reflected in the equilibrium between harvest and reforestation. The forests set aside as a natural resource must be protected as this will affect the prosperity of the Indonesian people for years to come.

Many forest products can be satisfactorily harvested under close management and supervision. New systems of management should be tested and new methods of planting and harvesting will need to be developed if the forest lands are to meet the challenge of the future. Forest management practices such as new species and methods of planting, thinning, and logging, should be conducted to reduce and prevent erosion. With higher prices for petroleum products the forest areas will need much larger supplies of fuel wood in the future.

Uneven age silvicultural practices are not used as much as they should to improve the forest production. Currently, silvicultural practices are designed primarily to produce teakwood, mahogany and pine for gum. Very little attention is given to other forest values. Thinning practices do allow fuel wood to be cut and harvested during the rotation. In producing a teak stand for market, other products could be developed or raised underneath the stand during a part of its growth. For example, grass and other harvestable legumes could be grown and harvested but this requires good supervision and care. The tumpangsari system has been used for reforestation and food crops provision. With good management, some food crops could be grown and would not interfere with the teak growth, even in the later years of the silvicultural cycle. As population pressures grow this type of multiple-use may be necessary to feed the people of the upland areas.

Roads and trails need improvement. The lack of adequate roads and trails for proper forest supervision creates one of the greatest management problems. Roads and trails now in use are sources of excessive sediment production because they are not properly drained and graded. Carefully planned road and trail systems should be developed and constructed in accordance with project goals.

Logging practices cause tremendous erosion and channel headcut development. The practices of skidding logs through stream channels and along drainage ways should be discouraged. Not only are these practices producing large amounts of erosion, but they are destroying most of the younger growth trees.

One of the greatest gaps in our knowledge of sediment in streams is the ecological impact on the forest environment produced by logging and other destructive practices. Without this type of data it is impossible to accurately determine what damage the increased sediment loads are having on environmental conditions both upstream and downstream. No attention is being given to the importance of gravity and erosion energy. Logging trails are made down steep slopes because it is easier to drag logs down the slopes than across the slopes. Gravity is a critical factor in the movement of sediment on steep slopes.

Most of these recommendations can be adequately implemented by existing Perhutani, forestry and other governmental organizations. Some of the programs are now partially financed through regular channels such as Perhutani, the Greening Program, and Reforestation Programs. They will require augmentation to solve the many problems that will be encountered with an active watershed management program, but because the problems on forest lands are so much less than on upland cropland, no additional budget is proposed for the initial project period.

F.6.5.b. Stabilization of Cut and Fill Slopes

There are two main methods of protecting cut and fill slopes: vegetative planting and diversion ditches. If proper care is taken in its establishment, vegetation is the most beneficial and durable soil stabilizer. It forms a protective cover that shields the ground surface from the direct impact of falling rain, and its roots bind and secure the soil particles. It also controls runoff by slowing the flow of water along the soil surface, and by enabling the soil to absorb more water, thus decreasing the ability of the water to remove and carry away detached soil particles.

Longterm vegetative stabilization is accomplished by the proper planting of various combinations of grasses, legumes, shrubs and trees. The type and mixture of individual plant species to be used in a specific situation will depend on soil and moisture conditions, climatic conditions, slope, aspect, erosional stresses, and adjacent land use.

Diversion ditches are used to divert water from a cut or fill slope. Runoff is intercepted before it reaches the slopes, and is disposed of at safe velocities. In handling concentrated flow, the objective is to detain the runoff by: (a) increasing the flow distance, (b) decreasing the flow gradient, and (c) obstructing the flow. structures (including checks, energy dissipators, riprap line drainageways, chutes, etc.) are generally necessary to control the velocity of the runoff.

Cut and fill slopes must be stabilized as soon as possible to control erosion and allow revegetation. Rill erosion, which occurs rapidly under the normal high rainfall conditions, is very difficult to protect against and it can become a series of gullies within a year. Gullies require structures for control. Rill erosion is also responsible for the removal of the most fertile portions of the soil profile.

Brush, wood or mulch cover can be used on cut and fill slopes to permit the establishment of vegetative cover. Brush can be pegged down or held in place by low wattlings. Eroded slopes (rills) can be reworked and protected by brush or other mulching materials individually or in combination with wattling or benching.

Drainage from roads must be controlled by erosion proofing the drainage ditches; water must be carried across the road in culverts or in protected dips. The outflow areas must also be protected.

The cost of protecting cut and fill slopes cannot be generalized with any degree of accuracy. Site conditions vary too much to allow the use of generalized costs.

F.6.5.c. Treatment of Road and Trail Damages

This section describes some of the methods to be used in the control of accelerated runoff and erosion on and below the bare spots created by road and trail construction or by improper maintenance. The foremost method is to change the common practice of continually removing all vegetation (below the ground level) from the roadsides and road ditches.

Damage from runoff and erosion occurs both on the road and below it. Unpaved road surfaces, side ditches, the cuts, overcuts, and fill slopes all have soil loss. Mud washed onto the road surface may make it dangerous for travel; slides may entirely block the road and require costly repairs. Below the road, gullied hillsides and gouged stream channels commonly result from runoff originating on the road or the slopes. This runoff and the debris carried by it increase flood and deposition damages downstream. Villages, farmlands, irrigation works, domestic water supplies, and other improvements are damaged by the deposition of silt and rock washed down from roads. Altogether, the flood and deposition damages downstream may be far greater than the erosion damage to the road itself.

The control of runoff and erosion on road surfaces and in road ditches is an engineering problem that can be solved largely by preventive location, design, and construction, or by installation of adequate drainage structures as the road is built. The average cost for constructing and erosion proofing one kilometer of district road is estimated at 8.78 million Rupiah (Table F-22). The most economical and effective control of erosion is provided by plant growth and litter. Morover, such plant growth is needed to hide the unsightly scars of road construction. The establishment of plant cover on road slopes, together with the installation of such temporary mechanical aids as may be required to make establishment possible is very important in reducing the sediment load in streams.

There seems to be general lack of understanding of the need for erosion proofing of roads and the associated drainage structures. The following discussion is designed to provide the correct name for structures or problem areas together with a brief description of the practice used on roads, trails, logging spurs, and skid trails. The erosion problems of roads and trails should be readily apparent to even a casual observer.

(i) Slope Stabilization

Three requirements must be met before road slopes can be stabilized by planting: the road must be located on soils that do not become exceedingly saturated in wet weather; the slopes must lie at or below the angle of repose of the soil or rock material from which they are built; and drainage facilities must be provided to prevent concentrations of runoff from discharging onto unprotected slopes.

Road location on soils that remain reasonably stable during wet weather is a requirement of good engineering, yet it is often overlooked. Examples include roads built on soil types noted for instability when wet, and construction across slopes of sliding talus or through deeply fractured, loose bedrock. Both examples suggest the need for careful studies of location so that the cut, overcast, and fill slopes may be stabilized by vegetation, insofar as possible, without the aid of cribbing or other engineering structures.

Reducing slope steepness to or below the angle of repose in loose soil is essential to permit the establishment of plants. Slopes steeper than the angle of repose will slough off and prevent the effective establishment of vegetation. Moreover, it is impractical to apply topsoil, sometimes needed to help plants gain a foothold, to slopes that are steeper than the angle of repose. For loose soils, this angle is approximately 30 degrees, a slope of 1.5H:1.0V, whereas most of the cut slopes along existing roads are nearly vertical.

Adequate drainage must be provided to handle runoff from the road surface, the cut slopes, and the hillsides above, without letting this runoff spill onto the slope to be treated. Slope stabilization measures can take care of the rain that falls on the treated area, but they cannot resist concentrated flows.

The nature of the exposed soil and rock material and the steepness of the terrain traversed by the road govern the requirements for treating cut slopes. Cuts in solid rock will stand nearly vertical, and they are usually stable without treatment. Cuts in shattered or weathered bedrock will often stand on 1:1 or steepr slopes; although they yield erosion debris, planting of such slopes is usually difficult if not impractical. Cuts in soil that is easily eroded and gullied should be sloped to gradient of

1.5H:1.0V or less, and planted immediately or when available soil moisture will support plant growth.

Deep cuts through soil in steep terrain are especially hard to control because back sloping them to 1.5H:1.0V may require excavating an extensive area of the mountainside above the road, a process which creates an even more-serious erosion problem. In such places, a wall or crib may be required to raise the toe of the slope to permit gradient reduction without extensive excavation.

(ii) Overcut and Fill Slopes

Because they are built of excavated material, overcast and fill slopes are composed of loose soil and rock more or less compacted during construction. The surface is loose and erodible. Such slopes are not difficult to control because they contain some topsoil which can have favorable soil and moisture conditions for plant geowth. They should be treated by covering with litter, wattling, or other means as the final step in road construction, and should be revegetated as rapidly as possible.

(iii) Road Shoulders

Road shoulders serve as collecting areas for rainfall, and paved roads' shoulders are often gullied by runoff from the road surface. The conditions are aggravated when the shoulders are wide, and where vegetation is prevented from growing.

(iv) Gully Treatment

Road slope gullies are of two classes: those developed at places where channels are permanently needed to carry runoff as a part of the road drainage system; and those cut by runoff that will be diverted and controlled upon the installation of adequate road drainage facilities. Gullies of the first type should be classed as watercourses and equiped with culverts or suitable drains in accordance with approved road construction and drainage practices. After this repair work, areas of disturbed soil will be covered with litter, seeded, and planted as needed to prevent accelerated erosion. Gullies of the second type will be filled and treated for surface control along with the rest of the slope.

(v) Cross Dip

This consists of a broad, shallow depression in a road at a stream crossing designed to spread the water in a wide, thin sheet that is easily forded. The gentle slopes of this dip cause minimum jolting of vehicles. In steep terrain, a retaining wall and channel stabilization measures may be required at the dip outlet. The dip surface is sometimes paved to evenly spread the flow and prevent road surface erosion. Such dips may be used on roads or trails.

(vi) Grade-Dip

This short section of trail, generally not over 2 or 3 m long, is built with a grade slightly adverse to the prevailing grade of the trail. The trail is outsloped at the low point in the dip so that water flowing down the trail can be diverted. Such dips are most satisfactory when built during construction so that the designed grade allows for the sections of adverse grade. When grade-dips are built into existing trails, the upper portion is usually too steep for proper maintenance. Instead of building dips in an existing trail, it is customary to build waterbars.

(vii) Waterbar:

Waterbars are generally made with a log of small diameter laid at a slight angle to the trail tread and staked in place. The tread downgrade from the waterbar is flush with the top of the log while upgrade the tread is kept well below the top of the log. The outside edge of the trail immediately uphill from the waterbar is cut down to spread the water on the natural slope below the trail. Waterbars cannot be used effectively on trails traveled by motorcycles or trail bikes.

For runoff and erosion control on logging spurs and skid trails, the commonly used road and trail-drainage structures will be too costly for installation. Morover, the carefully designed structures required on a maintained road or trail are not needed to divert runoff from spur roads and trails that are abandoned. Instead, simple ditches dug across the traveled way at frequent intervals will suffice. Such ditches are defined according to their size and manner of construction. This is not true, however, where area is cleared and upland crops are permitted for three years. These areas require a more intensive erosion proofing of roads and trails.

(viii) Cross-Ditch

A small ditch is dug at an angle across the tread, with the excavated earth piled along the downslope edge of the ditch. Such ditches are quickly made; they divert small flows of water and prevent damaging concentrations of runoff. Ditches are usually spaced 10 to 30 m apart, depending on the steepness of slope and the amount of runoff to be controlled.

(ix) Culvert Outfalls

On some roads the repair or erosion-proofing of culvert outfalls, properly the duty of the road-maintenance organization, may have to be constructed by the erosion control crew to halt or prevent slope undercutting. This condition cannot be seen by casual inspection from the road. The downhill position of culvert outlets makes this difficult to observe, and therefore, special time must be taken to climb down the slope and closely inspect them.

F.6.5.d. Maintenance and Repair

Constant inspection and maintenance of erosion control works on non-cultivated areas are especially important during the first rainy season after construction. At this time, the sown and planted vegetation is in the early stages of development, and mechanical treatment must carry the entire burden of control. By the second season, damage from drainage failures should have been repaired, the plant cover should have a good grip on the soil, and the plants should be well established.

Immediate repair is essential where failures occur. Failures commonly cause two types of damage: gullied slopes resulting from spillovers of road surface water where drainage is inadequate or where drainage structures have been plugged by debris; and slides and slumps resulting from saturation and slipping of the soil mass. Culvert outfalls and the vegetation plantings should be inspected frequently and maintained as needed

F.6.6. Stream Channel Improvement and Stabilization

F.6.6.a. General

Channel stabilization involves the reduction of gradient, adjusting the flow distance through changes in alignment, and obstructing the flow. The principles are similar to controlling flows in gullies, but the size and complexity of structures are increased, and a specific engineering design is usually required. Riprap becomes larger as the force of water becomes greater. Vegetation can only be established on stream banks, due to the wet condition in the stream. Revetments are often required to protect stream banks. Riprap, gabions, and sand bags are also used for bank protection. Permanent control structures constructed from reinforced concrete are sometimes required.

Two methods are used to stop streambank erosion: First, the bank can be reinforced so that the velocity cannot erode it. Secondly, the fast current can be moved away from the bank.

Generally, it is of primary importance that continuity in river improvement is followed; that is, the improvements are provided over long reaches of river so that improvements in one reach do not cause damages in unprotected reaches either upstream or downstream. However, in upland valleys one may be able to tolerate spotty control -- control of a short reach next to a bridge or town, for example. There are not enough benefits to justify controlling long reaches of river. Each river problem must be assessed individually. Delaying channel improvements in reaches not yet troubled is less costly than making improvements in expectation of problems.

In designing river channel improvements and stabilization projects, full consideration should be given to the interrelated factors of river hydraulics, flood peak frequency, flood volume frequency, stream bank and bed materials, and suspended and bed-load transport.

Finally, there is the important consideration of maintenance. In rivers, small maintenance problem usually grow into large problems if timely repairs are not made. Therefore, an organization with adequate maintenance forces and budgeted money is necessary. If stream channel improvements are not to be maintained they should not be constructed, because their failure usually causes very large damages.

F.6.6.b. Channel Control Structures

The names used to describe river structures are not universal. Hence, the ASCE definitions and descriptions are included to provide a standard [26].

(i) Revetments

These are structures designed to protect the bank from erosion. The bank is sloped and shaped to the desired align, and then covered to resist the flowing water. Generally, revetments are of three types: blanket, pervious, and solid fence.

Blanket revetment is constructed with rock, concrete, asphalt, masonry, or mats of vegetation. In some cases, the revetment extends to the thalweg of the stream to prevent undercutting. In other cases, the revetment is keyed into the riverbed at the bank. Then, if the thalweg moves to the bank, the revetment does not fail. Probably a combination of gabion and rock riprap is the most feasible in this watershed. Reports indicate that gabions can be destroyed by impact from gravel, cobbles, and boulders. If so, then rock riprap can be used near the bed and gabions higher on the banks.

Pervious revetments consist of open fence, pile structures, cable connected jacks or baskets and similar materials placed along the desired alignment to prevent bank erosion and to build up the bank by deposition. Pervious revetments work best in streams carrying much suspended load, such as the Jragung and its tributaries.

Solid fence, usually one or more row, are used on steep stream slopes and must have strength to resist the large flow forces.

(ii) Groins

Groins are short, usually solid, structures extending from the banks at approximately right angles to the flow. Groins keep the high velocities away from the bank. They promote some deposition in the lee between groins.

Rock groins capped with concrete are often used. The nose of the groins must be designed to resist very large velocities in steep mountain streams. Moreover, the foundation for the nose must be below the scour level that occurs at the nose. As with all river structures, maintenance is especially needed after floods.

Dikes are similar to groins but extend farther into the channel. Dikes guide the flow in a manner such that an effective channel is scoured and maintained along the desired alignment.

(iii) Rock Windrow

Dumping rock in a windrow along the desired bank alignment and then having the rock fall into the river as the bank erodes has been successfully used. The prerequisite is that the banks be noncohesive.

Use of rock windrows is probably not warranted in Indonesia since there is plenty of opportunity to work in the rivers during the dry season.

(iv) L-Head Revetment

To conserve length on fence-type revetment, gaps are left in the fence. Then, the revetment has the configuration "L" with the extremity of one leg attached to the bank, the same leg normal to the flow and the other aligned in the downstream direction.

(v) Check Dams

Check dams promote deposition in the pool created by the dam. Check dams are used as sediment traps and as structures to prevent riverbed degradation and gully advancement. Just about everything has been used to build check dams. However, engineering principles must be adhered to. Otherwise failure of the sediment trap means all is wasted; the sediment trap has merely postponed movement of the sediment.

Very small bamboo wattle check dams are used successfully to stop small gullies from advancing. Larger gullies require costly structures so they won't fail and be overtopped by floods.

The best place to employ check dams is at the point where the gully begins. Sometimes the whole basin upstream can be saved from erosion by one structure.

F.6.6.c. Streambank Protection

Protection and stabilization of streambanks, gullies, or excavated channels against scour and erosion is generally a large and costly undertaking. Vegetative or structural means or a combination of the two have proved to be effective approach in stabilizing streambanks, gullies, and excavated channels. There are two general types of bank protection: those that retard flow along the bank and thereby promote deposition; and those that through some from of vegetation, protect the bank from direct erosion and scouring.

Vegetation plays an important part in the control of streambank erosion. There are two problems to consider in using vegetation for protection: establishing a vegetative stand or cover; and stabilizing that section of the bank below normal water surface so that vegetation will not be undercut.

Vegetation is used most successfully above the waterline on properly sloped banks and on the flood plain to retard velocity. Vegetation should be used back of revetments and jetties in the area where silt deposition occurs, on the banks above design flows, and on slope protected by brush mats. Many species of plants (shrubs and trees) are suitable for streambank planting.

(i) Boulders and Branch Cuttings

Properly placed rock or boulder riprap is an effective method of gully or streambank protection. This, combined with branch cuttings of bamboo or trees like *Glericidia sepium* and *Leucaena leucochephala*, make a good combination of biological and structural erosion control. Boulders may be costly because of the difficulty of quarrying and transporting, but when these are locally available, erosion control can be effective.

The required size and gradation of the rock riprap depends upon size and magnitude of gully and streamflow. However, strict rules cannot be given. The recommendations below are empirical values derived from gully treatments in the Colorado Rocky Mountains and should be evaluated accordingly to suit local conditions [25]. As a general rule, however, rock diameters should not be less than 10 cm and 25 percent of all rocks should be within 10-14 cm in size. The upper size limit will be determined by the size of the gully. Large gullies can include large rocks. Flat and round rocks should be avoided [25]. Both types slip out of a structure more easily than rocks, which anchor well with each other. In general, large gullies and flows will require larger rock sizes than small gullies. An effective rock gradation would call for distribution of size classes as follows:

Size	Percent of Total
10 - 14 cm	25
15 - 19 cm	20
20 - 30 cm	25
31 - 45 cm	30

Freshly cut branches should be planted between these boulders. This is usually done a little before the onset of the rainy season. The fill slope should be shaped from the top to the bottom. Guided contour lines should be laid out on the slopes. Staking (of fresh branches) should be started from the bottom of the slope where boulders were placed as part of the structure, with intervals of about 1.5 m between rows and 1.0 m within each row. One ha may require 6,600 branch cuttings. The length of the branch cuttings (stakes) depends on the slope's overcasting materials; 1 m or 1.2 m length is sufficient. The diameter of the stakes should be 5 cm to 6.5 cm. All branch are sharpened at the bottom end for easy staking.

The correct angle for driving the stakes through the ground is approximately perpendicular to the inclined slope. A maximum of

15 cm is allowed to stick out of the ground. Any split ends should be sawed off.

(ii) Grass Sod and Branch Pitching

Grass sod and branch pitching is one of the cheapest methods of erosion control. It does not require factory-produced materials or highly specialized skills to perform the job.

This erosion control measure, just as any other measure, requires evaluation of the area prior to the start of any activity. Once this is accomplished, restoration work can start. Clearing and smoothing the area by constructing some sort of steps in the form of small terraces are essential.

On slopes that are relatively gentle, about 20 degrees or less, the construction of steps furnishes a convenient place for planting grasses. The worse the conditions for grass growth, the wider and deeper the steps must be built and tilled [25]. If the steps are too wide and too closely spaced, much of the slope has to be cut off or excavated, thereby increasing the hazard of erosion. The standard vertical space between the steps is 1.0 to 1.5 m. If the slope is gentle and the soil is fertile, no downward soil support is needed. If the slope is steep, live stakes from tree branches with a diameter of 5 to 6.5 cm are used on the lower side of the step or terrace. Branch cuttings are sharpened at the bottom ends for ease in staking. The terrace should be 1 m wide for steep slopes and about 3 m wide on more gentle slopes. On these terraces, grasses are planted to initiate early establishment of soil cover. Kikuyu grass, Bracharia brizantha, star grass, para grass, napier grass or any grass that easily grows on the site is desirable for planting on eroding banks. On steep slopes, grasses could be planted about 20 to 30 cm apart between and along rows. The stakes could be about 1 to 2 m along rows (usually on the lower edge of the terrace) and 1.5 m between rows or a total of 6,600 stakes per ha.

Gentle slopes require fewer branches for staking along rows with 1 m spacing and 3 m between rows and require about 3,330 cuttings per ha. Using 20 to 30 cm spacing for grass, i.e. Bracharia brizantha grass, about four truck-loads are required per ha.

This type of critical area planting is estimated to have an average cost of 622,200 Rupiah per ha (Table F-5).

(iii) Grass Sod and Mats

In providing stabilization and stream channel protection against scour and erosion by vegetation, the principal causes of erosion should be considered. These may be classified as geologic, climatic, or hydraulic although there may be a very close relationship between them [27]. Living vegetation provides effective and relatively cheap materials for protecting, matting and stabilizing stream channels. Before going into the actual job of placing the protection materials, investigations on the behavior of the stream conditions should be conducted.

As part of streambank and channel improvement and stabilization the removal of such debris as stumps, fallen trees, sediment bars, or other obstructions is essential. Leveling the surface is important prior to the planting of grasses. It is much better to plant perennial grasses than to plant annuals. Many species of grasses are suitable for protection planting. Using mats with grass plantings will give very good results but it requires the use of some fastening materials to hold the mats in place

The construction procedure first requires placing a rock toe, using it as base for the mat. Hence brush or bamboo mat is recommended. The rock toe should be carried to the point of the channel and be at least 45 cm thick to remove the danger of displacement during flood flows. It is not practical to use a rock toe in streams subject to channel scour during flood flows because it is seldom feasible to place enough rock to compensate for the downward movement caused by the temporary deepening of the channel [27]. The cleared channels or sloped bank should be planted before the mat is placed. The best time to plant is during the early part of the rainy season.

The mat should be placed over the exposed soil as soon as possible after planting grasses. Grass plantings should be spaced about 20 cm apart between and along rows or a total of 25 hills per m^2. The mat should be 15 to 45 cm thick, depending upon the size of the channel. The mat is held in place by driving stakes at an angle across each other in pairs or by driving stakes straight into the ground with a spacing of about 70 cm on center and interlacing with three mm galvanized wire [27]. After the wire is attached, the stakes are driven deeper, which tightens the wires and firmly binds the mat.

F.6.7. Inspection and Maintenance of Structure

The success or failure of properly designed and constructed erosion control structures, terraces or diversions depends upon proper and timely maintenance. When terraces, waterways and diversions are constructed and permanent seeding or sodding cannot be completed, a seeding of a temporary cover crop is recommended. Vegetation on all filter strips requires regular cutting of the vegetation and fertilizer to maintain uniform plant cover.

The first two or three years after construction are the most critical for maintenance problems with most structural measures. Therefore, physical periodic inspections by supervisory staff should be scheduled for at least the first two years after construction. For bench terraces this should include a careful supervision of the crops grown to prevent the use of unstable terrace areas for flooded rice production.

After each major storm, all structures (including terraces) are to be inspected by project personnel, their damage evaluated and repairs initiated. Concurrent with terrace construction, farmers should be trained in inspection, proper use, maintenance and repair of terraces, drop structures, and waterways on their property.

Periodic checks should be made of all gully control works. The following maintenance practices are important:

1. Protect all vegetative plantings from grazing or harvesting until established and then allow limited use;
2. Eliminate competition from undesirable weeds and grasses in vegetative plantings;
3. Protect all plantings from trampling excessive livestock use and fire
4. Make immediate repairs of breaks or low spots in terraces, diversions, or structures;
5. Remove trash from drop inlets of weirs;
6. Sod or seed spot failures in vegetative plantings;
7. Apply fertilizer to vegetation as required; and
8. Inspect sides, corners, and wingwalls of all structures and repair cracks caused by settling, rodent burrows, dry weather, etc., before the structure is weakened.

Considerable damage, as well as loss of structures may result from failure to protect and properly maintain the structures. Providing minor maintenance in a timely manner often saves costly repair jobs when an unusual storm occurs.

TABLE F-9

COST ESTIMATE FOR DETAILED SOIL SURVEYS 1/

(January 1980 Rupiah Values)

Daily Costs	Rupiah
Labor Costs	
One technical (Team Leader)	1,600
Two non-technical workers (1,000 Rp/day x 2)	2,000
Labor Cost	3,600
Equipment Cost 2/	
Estimated one pickup and soil survey equipment at 5,000 Rp/day	5,000
Laboratory Analysis 3/	
Assume 5 ha per sample to be analyzed	
$= \frac{4 \text{ ha/day}}{5 \text{ ha/sample}} \times 3{,}000$ Rp/sample	2,400
Total Daily Cost	11,000
Cost Per Hectare	
Assuming 200 Field days per year, each soil survey team could provide detailed soil surveys on 800 ha per year at the average rate of 4 ha/day	
Average cost/ha $= \frac{11{,}000}{4} =$	2,750
Estimated cost for base maps, aerial photographs and drafting is 1,250/ha	1,250
Total Estimated Cost/ha	4,000
Estimated Supervision and Adm. (15%)	600
Estimated Total Cost/ha	4,600

1/ Auger boring density is 20 borings per hectare, for noncropland 10 borings per hectare. A team could accomplish an average area of 4 hectares per day.
2/ Includes transport vehicle and soil survey equipment.
3/ Laboratory analysis includes chemical, physical & engineering analysis.

TABLE F-10

COST ESTIMATE PER HECTARE FOR CRITICAL AREA PLANTING

WITH GRASS AND BRANCH CUTTINGS
(January 1980 Rupiah Values)

Item	Unit	Unit Cost	Quantity	Cost Rp/ha
Materials				
Grass for sprigging	m^2	12	10,000	120,000
Brushwood	pc	5	25,000	125,000
Fertilizer	kg	70	500	35,000
Hauling materials for 10 km @ 400 Rp/m^3/km	m^3	4,000	20	80,000
Total Materials				360,000
Labor				
Land Preparation	md	500	100	50,000
Sprigging	md	500	117	58,500
Brushwood planting	md	500	110	50,000
Total Labor			317	158,500
Total Estimated Cost				518,500
Contingencies (10%)				51,850
Engineering Design (5%)				25,925
Eng. Supervision & Adm. (5%)				25,925
Total Cost				622,200

Note: This is equivalent to Rp. 65 per m^2 for critical area planting on small areas.

TABLE F-11

COST ESTIMATE FOR A KILOMETER OF DIVERSION [1/]
(January 1980 Rupiah Values)

	Rupiah/km
Materials	
Grass for sprigging 2,000 m^2 @ 12 Rp./m^2	24,000
Stone for drops 3.0 m^3 @ 7,000 Rp./m^3	21,000
Bamboo 45 pcs. @ 600 Rp./pc.	27,000
Hauling materials 6 m^3 for 10 km @ 400 Rp./km/m^3	24,000
Total Materials	96,000
Labor	
Excavation 408 m^3 @ 2 m^3/md = 204 md @ 500 Rp. [2/]	102,000
Trimming estimated at 26 md @ 500 Rp.	13,000
Sprigging 2,000 m^2 @ 50 m^2/md = 40 md @ 500 Rp	20,000
Foreman estimated at 10 md @ 1,000 Rp./md	10,000
Total Labor	145,000
Total Estimated Cost	241,000
Contingencies (10%)	24,100
Engineering Design (5%)	12,050
Engineering Supervision and Administration (10%)	24,100
Total Cost	301,250

1/ Design criteria was 10 year frequency rainfall of 110 m/hr and a runoff coefficient of 0.35 (Q = 2.78 CIA) = 107 l/s/ha. Assuming the average area drained by the diversion to be 3.0 ha the capacity requirement would be 321 l/s.

2/ Typical parabolic grassed waterway with a top width (t) of 1.7 meters and a channel depth (d) of 0.30 meters that would have an area of 0.34 m^2 (A = 2/3 td) and a peak discharge capacity (Q) of about 400 l/s with a velocity of 1.2 m/s based on a 3% slope and a Manning's "n" of 0.045.

TABLE F-12

HILLSIDE DITCHES COST ESTIMATE FOR USE ON A 40 PERCENT SLOPE

Item	Unit	Unit Cost	Quantity	Cost Rp/ha
Labor				
Surveying and Staking in Field	md	750	4	3,000
Hillside Ditch Construction 1/	md	500	35	17,500
Constructing Needed Waterways and Structures	md	500	5	2,500
Total Labor				23,000
Materials				
Bamboo For Drops and Staking (6 m length)	pcs	600	5	3,000
Total Estimated Cost				26,000
Contingencies (10%)				2,600
Engineering Design (5%)				1,300
Engineering Supervision and Administration (10%)				2,600
Total Cost				32,500

1/ Based on an average Vertical Interval of 4.3 meters and an average Horizontal Interval of 10.75 meters there would be 930 meters of Hillside Ditch. If the average cut is 0.15 m^2 it would require about 140 m^3/ha, or 35 md/ha based on a production rate of 4.0 m^3/md.

TABLE F-13

CONSERVATION TERRACE COST ESTIMATE FOR A 15 PERCENT SLOPE AND A 2.9 METER VERTICAL INTERVAL

Item	Unit	Unit Cost	Quantity	Cost Rp/ha
Labor				
Field Preparation - Surveying	md	750	5	3,750
Staking Fields	md	750	3	2,250
Terrace Construction 1/	md	500	40	20,000
Constructing Waterways and Diversions	md	500	8	4,000
Constructing Drop Structures	md	500	2	1,000
Revegetating terrace channels and waterways	md	500	3	1,500
Total Labor				32,500
Materials				
Bamboo for Drops and Staking (6 m length)	pcs	600	6	3,600
Stone (used only if available on site)				
Grass for Sodding and Sprigging	m^2	12	50	600
Total Materials				4,200
Total Estimated Cost				36,700
Contingencies (10%)				3,670
Engineering Design (5%)				1,835
Engineering Supervision Administration (10%)				3,670
Total Cost				45,875

1/ Based on an average Vertical Interval of 2.9 meters and an average Horizontal Interval of 19 meters this would require 526 meters of terrace channel per ha. The volume of cut is assumed to be 160 m^3/ha. At a production rate of 4 m^3/md this would require 40 man days For Construction

TABLE F-14

BENCH TERRACING COST ESTIMATE FOR

15% SLOPE AND 100 cm VERTICAL INTERVAL

(January 1980 Rupiah Values)

Item	Unit	Unit Cost Rp.	Quantity	Cost Rp/ha
Labor				
Field Preparation-Surveying	md	750	40	30,000
Staking Fields	md	750	8	6,000
Terrace Construction 1/	md	500	460	230,000
Constructing Waterways and Diversions	md	500	33	16,500
Constructing Drop Structures	md	500	40	20,000
Revegetating Waterways and Terrace Risers	md	500	45	22,500
Total Labor			720	325,000
Materials				
Bamboo for Drops and Staking (6 m length)	pc	600	40	24,000
Stone 2/	m^3	7,000	4.0	28,000
Grass for Sprigging Risers and Waterways	m^2	12	2,500	30,000
Total Materials				82,000
Total Estimate Cost				407,000
Contingencies (10%)				40,700
Engineering Design (5%)				20,350
Engineering Supervision and Administration (10%)				40,700
Total Cost				508,750

1/ Based on 1,380 m^3/ha at the rate of 3.0 m^3/md from the design specifications.

2/ Stone cost estimated at 3,000 Rp/m^3 cost, plus hauling 10 km @ 400 Rp/km/m^3 = 4,000 Rp, for total of 7,000 Rp/m^3.

Note: Terracing one ha of 15% slope with a 120 cm vertical interval and a horizontal interval of 666.67 cm requires 1,500 meters of bench per ha. With an effective crop width of 499.2 cm, and a 5% allowance for waterways, the net croppable area is about 7,114 m^2 per ha bench terraced, or 71% of the gross area.

TABLE F-15

BENCH TERRACING COST ESTIMATE FOR

25% SLOPE AND 120 cm VERTICAL INTERVAL
(January 1980 Rupiah Values)

Item	Unit	Unit Cost Rp.	Quantity	Cost Rp/ha
Labor				
Field Preparation-Surveying	md	750	40	30,000
Staking Fields	md	750	8	6,000
Terrace Construction 1/		500	445	227,500
Constructing Waterways and Diversions	md	500	55	27,500
Constructing Drop Structures	md	500	65	32,500
Revegetating Waterways and Terrace Risers	md	500	73	36,500
Total Labor			696	360,000
Materials				
Bamboo for Drops and Staking (6 m length)	pcs	600	50	30,000
Stone 2/	m^3	7,000	7.0	49,000
Grass for sprigging Risers and Waterways	m^2	12	3,000	36,000
Total Materials				115,000
Total Estimated Cost				475,000
Contingencies (10%)				47,500
Engineering Design (5%)				23,750
Engineering Supervision and Adm. (10%)				47,500
Total Cost				593,750

1/ Based on 455 md/ha from Panawangan terracing, or approximately 1,356 m^3/ha at the rate of 3.0 m^3/md from design specifications.

2/ Stone cost estimated at 3,000 Rp/m^3 cost, plus hauling 10 km @ 400 Rp/km/m^3 = 4,000 Rp, for total of 7,000 Rp/m^3.

Note: Terracing one ha of 25% slope with a 120 cm vertical interval and a horizontal interval of 480 cm requires 2,083 meters of bench per ha. With an effective crop width of 308.9 cm, and a 5% allowance for waterways, the net cropable area is about 6,114 m^2 per ha bench terraced, or 61% of the gross area.

TABLE F-16

COST ESTIMATE FOR THE CONSTRUCTION

BAMBOO WATTLE CHECKS 1/

(January 1980 Rupiah Values)

Average height and width of check = 0.40 meter and 2 meters.

		Rupiah/Structure
Materials		
8 pcs. of bamboo at 600 Rp./pc.		4,800
2.0 kg of tie wire at 500 Rp./kg		1,000
	Cost of Materials	5,800
Hauling		
Regular load per truck is 250 pcs. of bamboo hauled an estimated 20 km @ 400 Rp./km = 8,000 Rp./load or $\frac{8,000}{250} \times 8$		256
Labor		
Excavation volume of 0.25 m^3 would require 0.25 md @ 500 Rp./md		125
Installation of bamboo wattles with bamboo dissipators is estimated at 2 md @ Rp. 500/md.		1,000
	Labor Cost	1,125
	Total Estimated Cost	7,181
Contingencies (10%)		718
Engineeering Design (5%)		359
Engineering Supervision & Administration (10%)		718
	Total Cost	8,976

1/ A bamboo wattle check with average effective dam height of 0.4 m made of mature native bamboo (average 6 m length).

TABLE F-17

COST ESTIMATE FOR THE CONSTRUCTION

OF BAMBOO WATTLE CHECKS WITH STONE DISSIPATORS

(January 1980 Rupiah Values)

Average height and width of check = 0.4 meter and 2 meters.

	Rupiah/Structure
Materials	
6 pcs. of bamboo at 600 Rp./pc.	3,600
2.0 kgs of tie wire at 500 Rp./kg	1,000
0.25 m^3 of stone at 3,000 Rp./m^3	750
Cost of Materials	5,350
Hauling	
Regular load per truck is 250 pcs. of bamboo hauled an average of 20 km @ 400 Rp./km = 8,000/load or $\frac{8,000}{250}$ x 6 pc.	192
Hauling stone 10 km @ 400 Rp./km/m^3 for 0.25 m^3	1,000
Total Hauling	1,192
Labor	
Excavation Volume = 0.25 m^3. Utilize 1 laborer at 500 Rp./day with one cubic meter/day output.	125
Installation of wattles & stone dissipators. Utilize 2 laborers for 1 day at 500 Rp./day wage rate	1,000
Labor Cost	1,125
Total Estimated Cost	7,667
Contingencies (10%)	767
Engineering Design (5%)	384
Engineering Supervision & Administration (10%)	767
Total Cost	9,585

TABLE F-18

COST ESTIMATES FOR GULLY CONTROL BY SMALL ROCK DROP/CHECKS (1.0 m^3)
(January 1980 Rupiah Values)

	Rupiah/Structure
Materials	
1 cu.m. of boulders 7,000 Rp. at site 1/	7,000
Labor	
Excavation and trimming of surfaces vol. = 0.7 m^3, will require about 1 manday of labor	500
Hauling of boulders from dumping to the site will utilize 1 laborer @ 1.5 cu.m. per day per laborer = 0.67 manday	335
Laying of boulders, backfilling and compaction will require approximately 1.33 mandays labor.	665
Foreman ½ md @ 1,000 Rp./md	500
Labor Cost	2,000
Total Estimated Cost	9,000
Contingencies 10%	900
Engineering Design (5%)	450
Engineering Supervision and Administration (10%)	900
Total Cost	11,250

1/ Based on a cost of 3,000 Rp./m^3, plus 4,000 Rp./m^3 for hauling to the dump site at an estimated 10 kilometers.

TABLE F-19

COST ESTIMATES FOR GULLY CONTROL LARGE ROCK DROP/CHECKS 1/

(ESTIMATED AVERAGE VOLUME 4.5 m^3)

(January 1980 Rupiah Values)

		Rupiah/Structure
Materials		
4.5 m^3 of boulders @ 7,000 Rp./m^3 2/		31,500
Labor		
Excavation and Triming of surfaces, Vol. 2.0 m^3 @ 2 m^3/md = 1 md x 500 Rp./md		500
Hauling of boulders from dumping area to the site, utilize 3 laborers @ 1.5 m^3/d for 4.5 m^3 = 3 md x 500 Rp./md		1,500
Laying of boulders, 3 laborers @ 1.5 m^3/d for 4.5 m^3 = 3 md @ 500 Rp./md		1,500
Backfilling, compaction and revegetation 1 man days @ 500 Rp./md		500
Foreman 2 md @ 1,000 Rp./md		2,000
	Labor Cost	6,000
	Total Estimated Cost	37,500
Contingencies 10%		3,750
Engineering Designs 5%		1,875
Engineering Supervision & Administration 10%		3,750
	Total	46,875

1/ This loose rock check/drop structure has an average effective dam height of 1.20 meters; average dimensional values taken from .30 m to 2.10 m, as minimum and maximum height respectively, and with an average volume of 4.5 m^3/structure.

2/ Based on a cost of 3,000 Rp./m^3 plus 4,000 Rp./m^3 for hauling to dump site.

TABLE F-20

GULLY HEADCUT TREATMENT 1/

COST ESTIMATE FOR RUBBLE MASONRY

(ESTIMATED AVERAGE VOLUME 7.0 m^3)

(January 1980 Rupiah Values)

Materials		
Cement	= 40 kg sks @ 2,000 Rp./sk x 9 sks	18,000
Sand	= 3.4 m^3 @ 3,500 Rp./m^3 at construction site	11,900
Rubbles	= 8.4 m^3 @ 7,000 Rp./m^3 at construction site	58,800
Delivery of cement	= 50 km @ 800 Rp./km/t for 360 kg	14,400
	Materials Cost	103,100
Labor Cost		
Hauling of material from the main dump to the site 4 mandays at 500 Rp.		2,000
Construction of rubble masonry 1 mason with 4 helpers @ 3.5 days = 17.5 md at 750 Rp.		13,125
Excavation est. 10 m^3 (5 laborers for 2 days = 10 md at 500 Rp.)		5,000
Backfilling, 2 mandays at 500 Rp.		1,000
	Labor Cost	21,125
	Total Estimated Cost	124,225
Contingencies (10%)		12,420
Engineering Design (5%)		6,210
Engineering Supervision & Administration (10%)		12,420
	Total	155,275

1/ Headcut treatment structures assumed to control a gully head with an average depth of 2 meters and 7 meters wide with an average volume of 7 m^3.

TABLE F-21

GULLY HEADCUT OR STREAMBANK EROSION TREATMENT 1/
COST ESTIMATE FOR GABION RETAINING WALL
(Estimated Volume 7 m^3)
(January 1980 Rupiah Values)

Material Costs	**Rupiah/Structure**
Boulders at 7,000/Rp./m^3 x 7 m^3 at site	49,000
Material for Gabions	
Dimension = 1.2 m x 0.80 m x 0.50 m = 0.48 m^3	
No of Gabions = $\frac{7}{0.48}$ = 14.6 units say 15 units	
Estimated at 7 kg of wire/gabion @ 500 Rp./kg x 15 units	52,500
Materials Cost	101,500
Labor Cost	
Cost of excavation (3 mandays @ 500 Rp.)	1,500
Fabrication of 15 gabions, 4 laborers with output of 5 gabions/day (4 x $\frac{15}{5}$ x Rp. 500)	6,000
Hauling boulders to site from main dump, 4 laborers with capacity of 1.5 m^3 per laborer = 4 x 1.5 x Rp. 500/md	3,000
Filling and laying of gabions, one supervisor and 5 laborers with a capacity of 5 gabions per day (Labor = 6 x $\frac{15}{5}$ x 500 Rp.)	9,000
Backfilling & Compaction - Est. 2 md @ 500 Rp./md	1,000
Foreman estimated at 8 md @ Rp. 1,000/md	8,000
Labor Cost	28,500
Total Estimated Cost	130,000
Contingencies (10%)	13,000
Engineering Design (5%)	6,500
Engineering Supervision & Administration (10%)	13,000
Total	162,500

1/ A gully headcut with average dimensions of 3 m. deep by 4 m wide will require an average volume of 7 m^3 gabions.

TABLE F-22

COST ESTIMATE PER KILOMETER OF DISTRICT ROAD
FOR CONSTRUCTION AND EROSION PROOFING
(January 1980 Rupiah Values)

Item	Project	Villagers	Total
Labor			
Field Surveying and Staking (30 md @ 1,000 Rp./md)	30,000		30,000
Construction Road Embankment (5,400 md)	1,500,000 1/	1,200,000	2,700,000
Installing Culvert and Drops or Checks to Erosion Proof Road (300 md) 2/	30,000	120,000	150,000
Collecting 1,800 m^3 Stone for Surfacing and Drop Structures (2,700 md)	500,000 1/	850,000	1,350,000
Road Surfacing (Stone) 4,000 m^2 (2,000 md)	500,000 1/	500,000	1,000,000
Total Labor	2,560,000	2,670,000	5,230,000
Hauling			
Hauling Stone 1,100 m^3 for 2 km @ 400 Rp/m^3/km	880,000		880,000
Hauling other materials 50 m^3 for 20 km @ 400 Rp/m^3/km	400,000		400,000
Total Materials	1,280,000		1,280,000
Materials			
Culverts	432,000		432,000
Cement 40 kg sks @ 2,000 Rp/sk x 25	50,000		50,000
Sand 10 m^3 @ 3,500 Rp/m^3	35,000		35,000
Total Materials	517,000		517,000
Total Estimated Cost	4,357,000	2,670,000	7,027,000
Contingencies (10%)	435,700	267,000	702,700
Engineering Design (5%)	351,350		351,350
Engineering Supervision and Administration (10%)	702,700		702,700
Total Cost	5,846,750	2,937,000	8,783,750
Percent	66.6	33.4	100.0

1/ Estimated road subsidy rates

2/ Includes sodding of cut slopes and road shoulders with local grasses.

F.7. PROPOSED PLAN FOR JRATUNSELUNA BASIN

F.7.1. Introduction

A conceptual plan for the Jratunseluna Basins is by definition concerned with concepts (thoughts, ideas, notions) to provide a general idea or understanding of the needed soil and water conservation program for reducing erosion damages. As such, Section 2. Technical Approach is really the conceptual plan for the Basin; but many specific suggestions need to be expressed, which is the specific function of this section.

Perhaps the most important concept (and the hardest to impress on government officials) is that the individual farmer is a rational being upon whom the ultimate success or failure of the project rests. The farmer and/or land owner must believe in the soil and water conservation program to the extent that he asks for assistance. He must also be a part of the planning and decision making process because he will be the person to put the plan into full and successful operation. It is only when the program becomes a local project of the people, rather than another government project, is there a real chance for permanent success. The concept of solving problems from the bottom (the farmer) up (the government agency) instead of from the top down will recognizably be slow to gain acceptance in government agencies that have always worked the other way.

Time did not permit a detailed examination of all the specific conditions and data that will be required to develop a complete soil and water conservation development program, even less a total watershed management program. At a very minimum it will take at least ten years to truly begin solving the watershed management problems that have been developing over the last fifty years. Then constant vigilance and a permanent maintenance program will be required to ensure that deterioration of the watershed condition dces not begin again.

Existing erosion control and development programs in the Basin are complex, costly, and not documented in a manner that permits an analysis of the extent of programs or the total annual expenditures. After considerable effort, the consultant determined that this analysis was not feasible and perhaps not relevant to the program development concepts. Although this approach could lead to suggesting some duplication of effort it is unavoidable. Since the primary direction of activities is through the Bupati any duplication will not be serious, because he and his staff can make needed corrections in the specific budget allocations.

A complete upland soil and water conservation program system requires special techniques and direct assistance to the land operator and is more complicated than downstream irrigation and water management programs. The costs and risks involved are determined by the soils, hydrologic requirements, and the conservation measures required to control the destructive factors of erosion, sedimentation and flooding within the watershed. The cost of implementing such a program will depend on how rapidly the farmers can accept and apply conservation measures and development, which in turn is a function of their individual resources (physical, human and economic) availability. To attempt to move faster would very likely be waste of funds, other limited resources, and possibly a loss of the program.

Overcoming the relatively high erosion rates presents great challanges in both immediate and longer term development periods. Minimizing the gravity of the problem would serve no purpose. The farmers' poverty and lack of technical knowledge are linked to the unavailability of capital and lack of land conservation and improvement programs. All resources must be mobilized to reduce the effects of the past unwise use of the land. Appropriate fiscal and monetary policies will be necessary for establishing and implementing a continuing land and water conservation program. This program must include an attempt to develop the farmers' willingness to cooperate and to provide the information and knowledge that will enable local groups to correct past soil and water misuse.

Improving those social, economic, and physical resources will also improve production and will improve the general health of the people in the farm communities. The investment programs must also give an increasingly higher priority to education and health. The investment in upgrading human resources will certainly improve the farmers' productivity and general quality of life.

A complete soil and water development program requires a reoreintation of the whole structure of education and assistance to the land user. The land owner must be made a part of the decision making process because he will be the person to put the plan into full and successful operation. This is paramount to the success and management of the watershed.

The Government should encourage the farmer to understand his soil and water resources and their proper management. He will then be able to use more of the scientific and technological developments available. The farmer can overcome many of his problems with a soil and water conservation program that incorporates well defined, immediate and long-term goals. The integration and implementation of all social, educational, economic and technological activities designed to better meet the needs of the farmer and his family, will also improve the structure and stability of the communities and will increase the appreciation of the success of cooperative approaches to their problems.

The farmers' welfare requires that the entire land and water resources conservation development program be analyzed to make certain that the farmer's operations can continue to satisfy the needs of both his family and the land with the resources available. To accomplish this community action by all local people will be required. Government cooperation of both technical and administrative personnel, together with educational assistance and developement incentives will be required to carry out a unified soil and water resource development program. However, all of the financial and technical assistance that can be provided by the government will be of little value if the support and cooperation of the provincial, district, village authorities, and the farmers themselves is not first obtained. The Panawangan Pilot Watershed Project of the Citanduy Basin has shown that, to be successful, project features must be adopted by the farmers as their own rather than as the government's project. To accomplish this it is absolutely necessary that the project features be developed from the farmer level upward, rather than the common government practice of developing projects from the top downward.

As previously stated, a review of the needs and problems of the upper watershed program clearly discloses that the present governmental organizations and current programs for solving the watershed problems do not meet its needs. There are a number of reasons for this, but foremost among them is the multiplicity of program involved. There are literally so many programs that it is almost impossible for the Bupati or the planning board to keep track of them. Secondly, all of these programs are underfunded and understaffed with qualified people. Since each of these programs must show progress, each attempts to show that it is successful and to conceal any failure from the officials at higher levels in the government. The technical knowledge and potential benefits from the greening programs are not passed on to the farmers, the assistance in maintenance is given for only two years; land taxes are still levied at agricultural cropland rates, and ultimately much of the land is back in upland crop production without conservation practices.

In addition, many Perhutani officials tend to regard forest products as a means of income and tend to allow timber harvesting where it would be better to preserve the timber resources. The people's traditional use of wood for fuel in their households or manufacturing activities (tiles, lime, brick making, etc.) is widespread and requires the clearing of a significant area of forest or plantations each year. There is a real need for a program to develop fast growing fuelwood species for revegetation activities. There also needs to be a concurrent program to show farmers of steep upland areas that they can make good returns on a system of agroforestry, providing they have sufficient land. Where the land units are too small the government programs will need to focus on providing the farmers with economic units.

F.7.2. Management Plan

F.7.2.a. Introduction

In order for a soil and water conservation development program to succeed it must assemble and train a highly motivated team of qualified specialists for planning, operating and providing technical supervision of the program. These experts must be qualified to take the leadership role in problem identification, the search for solutions, the assessment and evaluation of solutions, the integration and sequencing of physical components, and the implementation of activities for an integrated watershed management program.

F.7.2.b. Project Staff Organization

The project management and staff must first develop the team concept for successful project execution. This requires the development of a team of individuals who are dedicated to the interdisciplinary approach to solving problems and who process the mature judgement and experience to forsee and solve both expected and unexpected problems.

Since this type of staff does not exist within any known governmental organization in Indonesia it is strongly recommended that the Jratunseluna Basin Integrated Watershed Management Program be initiated by hiring a fully qualified consulting firm to assist in the selection, organization, and training of the needed project staff. While this greatly increase the initial cost of the project it can permit a much more rapid project initiation, and provide a means of training the staff in both their individual specialities and the team concept.

If an expatriate consulting firm is used the following specialists would be required for initial implementation of an integrated watershed management program:

- Project Sponsor (Principal-In-Charge)
- Project Manager (Watershed Manager)
- Soil Conservationist
- Agricultural Engineer
- Soil Scientist
- Agronomist - Upland Crops
- Forester
- Agricultural Economist
- Socio-Anthropologist
- Agricultural Extension Specialist
- Credit, Marketing, and Institutional Development Specialist
- Other Specialists as Required:
  - Hydrologist
  - Geologist
  - Livestock Specialist
  - Fisheries Specialist
- Home Office Support Staff

The following professional personnel will be required from the project office to support the various phases of the integrated watershed management project, from inception through the initial project period and to take over when the consultant leaves:

- Project Manager
- Agricultural Engineers (3)
- Agronomists (3)
- Soil Scientists (3)
- Foresters (3)
- Agricultural Economists (3)
- Sociologists (2)
- Agricultural Extension Specialists (3)
- Assistant Agricultural Extension Specialists (6)
- Agricultural Credit and Marketing Specialists (2)
- Institutional Development Specialist (1)

The following paraprofessional support will also be required to support the watershed management program:

- Surveyors (3)
- Engineering Aids (9)
- Socio-economic Enumerators (10
- Laboratory Technicians (6)
- Typists (bilingual) (10)

F.7.2.c. Duties and Functions of Expatriate and Project Staff

In addition to the following duties and functions, all team members will be responsible for maintaining close coordination with their counterparts to ensure timely and proper implementation of project components and activities. With the exception of the Consultants Project sponsor the position descriptions apply equally well to the expatriate or project staff. Figure F-14 provides a preliminary staff organization plan for an integrated watershed management project.

Project Sponsor

The use of a Project Sponsor (Principal-In-Charge) ensures that, at all times, consultant firms management will be intimately familiar with the Integrated Watershed Management Project. If the project is approved, the Project Sponsor will also be the senior management liaison between the company, the department selected to manage the watershed program and the financing organization or agency.

Project Manager

The consultant team will be headed by a Project Manager who will reside in the project area for the duration of the project. The Project Manager will be responsible for overall management and coordination of all activities for the Integrated Watershed Management Project. The Project Manager and the Project Sponsor will coordinate and maintain liaison with the government and with the local Project Manager and staff. The consultant Project Manager and his counterpart will coordinate all activities to assure timely sequencing.

The Project Manager should be an experienced watershed manager, agricultural engineer, or soil conservationist who has extensive experience in erosion control, in watershed project development, and in working with an interdisciplinary team.

Other tasks assigned to the Project Manager include:

1. Planning and monitoring all study activities to ensure timely execution of project activities;
2. Participation in the evaluation of alternatives;

3. Coordination of report preparations;

4. Coordination of data collection, management, and preparation of statistics;

5. Assistance in model development and computer studies;

6. Coordination of feedback to team members concerning project effectiveness and other information;

7. Coordination of technical activities with the local project manager and staff;

8. Assistance in the development of training programs; and

9. Arrangement of, and preparation for progress meetings and reports.

Soil Conservationist

The soil Conservationist will coordinate soil erosion control activities in each of the pilot demonstration areas or small hydrologic units--specifically, those activities relating to conservation education, planning, and development scheduling. The Soil Conservationist should assist the team by:

1. Coordinating the research work required to define the nature, extent, and progress of erosion in relation to land-use and management practices as they are affected by soil types, slope, rainfall, and farming practices;

2. Assisting in the development of alternative techniques of erosion control works in relation to the degree of experienced erosion, land use, and other factors;

3. Assisting the researchers in setting up systems to measure the long-term effects of watershed treatments on soil erosion and sediment transport;

4. Assisting the agronomist in developing conservation farming techniques and cropping systems;

5. Developing effective low-cost erosion control measures that can be built with local materials and labor;

6. Assisting in the organization of farmers' groups for demonstration watersheds and small hydrologic units;

7. Assisting in the preparation and conducting of training programs for both staff and farmer leaders; and

8. Maintaining close coordination with, and soliciting effective cooperation from, all professionals to ensure proper sequencing of components and activities.

Agricultural Engineer

Tasks assigned to the Agricultural Engineer include:

1. Coordinating the needed topographic and cadastral surveys for the watershed areas;

2. Supervising the design and installation of erosion control structural measures;

3. Supervising the development, or rehabilitation, of small irrigation systems in the watershed;

4. Assisting the agronomist and his counterparts in developing accelerated land preparation minimum tillage, relay planting, and rotational cropping systems;

5. Surveying and reviewing literature on conservation structures and land preparation methods that have applications in the project watershed;

6. Assisting in preparation and conducting of training programs; and

7. Soliciting effective cooperation with other professionals to ensure an integrated and effective development program with timely sequencing of activities that least disturb farm operations.

Soil Scientist

Tasks that will be assigned to the Soil Specialist include

1. Supervising soil surveys and land classification work;

2. Evaluating soil analyses, plant tissue analyses, and plant growth characteristics as a means of making fertilizer recommendations;

3. Assisting the agronomist and economist in determining the optimum fertilizer rates for maximum economic returns to the farmer;

4. Supervising the establishment of a regional soil and plant tissue analyses laboratory and the training of technicians to perform the analyses required to make optimum fertilizer recommendations;

5. Assisting in in the preparation of training programs and conducting formal classroom and on-the-job training of staff;

6. Developing erodibility classifications for the major soil groups in the watershed and assisting in the development of the best conservation measures to apply to these soil groups;

7. Coordinating activities with other professionals to ensure the timely sequencing of activities and components;

8. Evaluating conservation tillage and minimum tillage practices for their applicability; and

9. Assisting in the development of soil-water-plant production estimates.

Agronomist

The agronomist assigned to an integrated watershed management project sould be trained and experienced in upland crop production practices and problems. Tasks assigned to the Agronomist would include:

1. Assisting in the determination of existing cropping patterns, crop rotations, cropping intensities, yields, methods of planting and harvesting, and specific production problems;

2. Reviewing literature on tropical crops, cropping systems, varieties and other existing agronomic research for application to the specific watershed project area;

3. Evaluating available crop varieties, variety interaction studies, cropping intensities, and cultural practices for application to the watershed conditions;

4. Leading the development of conservation cropping systems that will maximize net returns to the watershed farmers while protecting the land from erosion;

5. Working with the forestry specialist in the development of agroforestry cropping systems to maximize the return from lands requiring permanent vegetative cover;

6. Activity participating with counterparts in all phases of program development and implementation;

7. Projecting crop yields for with- and without-project conditions;

8. Assisting in the development of crop production cost and return budgets for present and projected (with- and without-project) conditions;

9. Assisting in the development of fertilizer, insecticide, and rodenticide recommendations, assuming a leadership position in ensuring effective coordination with other professionals for timely sequencing of conservation activities to least disturb farming activities; and

10. Assisting in the development of training programs and conducting formal classroom and on-the-job training.

Forester

Depending upon the specific severity and extent of the reforestation, afforestation, or forest management problems, the forestry activities require specialists in trespass control, nursery operations, silviculture, fuelwood production, agroforestry, timber harvesting, watershed management, or revegetation. The tasks assigned to the Forestry Specialist include:

1. Assisting Perhutani officers in the development of management plans for existing forest lands to maximize production of all forest products while protecting the watershed condition;

2. Assisting Forest Department officials in the development of plans to limit forest tresspassing by marking forest boundaries, to control illegal harvesting, and to control shifting cultivators' clearing for crop production;

3. Assisting in the development of forest access roads for timber harvesting and supervision so as to minimize soil losses from construction and from use of the roads and trails;

4. Providing leadership in developing agroforestry and fuelwood production programs with the watershed residents;

5. Where needed, assisting in developing fire control, nursery, and revegetation programs to solve specific problems in the project watershed;

6. Assisting in the determination of areas suitable only to forest or permanent vegetative cover and in the development of needed land use conversion plans;

7. Assisting in the development of training programs and conducting formal classroom and on-the-job training; and

8. Maintaining close coordination with forestry and greening (P3RP-DAS) officials and other professionals to ensure proper sequencing of components and activities and to help stabilize the production of forest areas of the watershed at present or higher levels.

Agricultural Economist

Tasks assigned to the Agricultural Economist, or Farm Management Specialist, include:

1. Reviewing existing economic data;

2. Collecting, reviewing, and analyzing data on the agricultural economy as well as on agro-related institutions;

3. Assisting in the preparation of the socio-economic survey questionaire, and in the summarization and analysis of the obtained data;

4. Establishing the normal farm input and output price relationships for present conditions in the watershed and developing detailed crop budgets for existing conditions;

5. Developing projections of the proposed program's economic costs and benefits with and without the program;

6. Conducting economic and financial analyses for the project, in-including cost/benefit studies and internal rate of return analyses;

7. Determining possible project repayment systems, system costs, and collection potential;

8. Defining secondary and intangible benefits of the proposed integrated watershed management project;

9. Conducting sensitivity tests of project alternatives and adoption rates of agricultural technology;

10. Assisting in developing simple, easy-to-understand crop production cost and return information to provide comparisons between present conditions and conditions under conservation farming methods;

11. With the assistance of the local staff, preparing training programs and conducting classroom and on-the-job training for staff and watershed residents;

12. Assisting the Socio-Anthropologist in developing socially and culturally acceptable programs for adoption of conservation farming and for regional development;

13. Maintaining close coordination with all personnel to ensure the development of a truly integrated watershed management program and to ensure timely sequencing of all components and activities; and

14. With the assistance of other staff memebers, developing a system of incentives that will enable the farmers and other watershed residents to adopt the desired conservation farming methods and to make the needed land use changes for watershed improvement.

Socio-Anthropologist

The tasks of the Socio-Anthropologist, or Rural Sociologist, include:

1. Assisting the expatriate and counterpart staff in conducting field studies to identify people problems and in analyzing factors important to farmers' present conditions in the watershed areas;

2. Taking the leadership in the design, testing, conducting, collating, review, and analysis of the socio-economic base-line survey of the watershed area;

3. Reviewing available cultural, institutional, sociologic, and other studies of the watershed or similar areas for insights into the causes and potential solutions of the people problems;

4. With the assistance of the local staff, preparing training programs

and conducting classroom training of staff members to assist them in understanding the probelms of the watershed residents as an aid in developing programs for their solution;

5. Assisting in the determination of constraints to adoption of conservation farming techniques by the farmers of the watershed lands; and

6. Analyzing the socio-cultural feasibility of the proposed integrated watershed management program and suggesting more feasible alternatives.

Agricultural Extension Specialist

The Agricultural Extension Specialist will assist the team in gaining acceptance of the Integrated Watershed Management Program through the following activities:

1. Providing the leadership for all training programs focused upon the watershed residents;

2. Advising and assisting counterpart personnel in the preparation of staff and farmer training programs, farmer meetings, seminars, training manuals, and implementation manuals and guidelines;

3. Providing leadership for the education of farmers in conservation farming techniques, erosion control methods, cropping practices, cropping intensity, improved irrigation methods, related agricultural inputs, and essential institutional practices;

4. With assistance of the other professional staff, developing the educational program to enable the watershed residents to understand the erosion problem and what they might do, as individuals, to reduce or control the damages; and

5. Assisting in the development of courses in resource conservation, farm management, upland agronomy, conservation education, and other courses needed to train local staff to develop an integrated watershed management plan and carry it through to a successful conclusion.

Credit, Marketing, and Institutional Development Specialist

This regional development specialist is responsible for developing farm credit, improving marketing systems, developing new industries, and assisting in promoting farmer organizations or other institutions as a means of accomplishing the objectives of the integrated watershed management program. The Credit, Marketing, and Institutional Development Specialist's activities will include:

1. Assisting in the evaluation of rural credit demands, the availability of credit, and the extent to which it constrains production;
2. Assisting in the assessment of the credit worthiness and repayment capacity of the watershed farmers;
3. Assisting in the development of detailed rural credit implementation plans;
4. Providing leadership in analyzing the marketing structure for farm products and in developing cooperative organizations or other marketing systems to improve the returns to watershed farmers;
5. Providing leadership in the development of cottage or other industries in the watershed to supplement farm incomes and provide other employment opportunities;
6. Assisting in the development of small irrigation projects, hydroelectric power systems, or other economic developments that would improve the regional economy; and
7. Maintaining close coordination with counterparts, professional staff, and government agencies on policy development, flexibility, and sequencing of activities and components.

Other Specialists as Required

The requirements for other expatriate specialists will largely depend upon the size and extent of specific watershed problems that exist or may develop. These may include, but are not limited to, specialists in hydrology, geology, livestock, fisheries, road and trail building, processing of agricultural products, and various forestry or revegetation specialists to solve special problems of certain watersheds.

F.7.2.d. Training Programs

The training of the professional and non-professional staff for an upper watershed management project is one of the more critical items for project implementation. If the professional staff members do not understand the causes and effects of soil loss, the proper use of bench terrace and other conservation measures, and the agronomic techniques for increasing upland crop production while protecting the land the proposed integrated watershed management project cannot be accomplished. More important, the staff needs to be truly interested in helping the upland farmers and the rural communities to solve their problems and in educating all of the people to recognize the erosion problems of the watershed. Perhaps the most difficult problem to overcome is the natural elitist attitude of the college graduate to the point where he personally works directly with the farmers to develop a true multiple-use plan for the demonstrations farms that reflect the farmers' viewpoint. Exclusive communication between technical professionals is very satisfying, but it will solve very few problems for the upland farmers. Only when all of the staff really work with the farmers can the training and motivation of the farmers be accomplished.

There are very few trained people in the field of upland agriculture. In fact, there are only a few courses in the best universities that can be directly recognized as essential in producing the professionals required to lead a large scale program. Therefore, it must be recognized that several years will be required to develop a cadre of people who are well qualified to lead the integrated Watershed Management Program.

(i) Foreign Training

There is a real need to train managers and technical staff to supervise and train others for the implementation of an integrated Watershed Management Program. These people should all b intermediate level executives of the Indonesian Government. Staff chosen for this training should initiate their advanced technical or administrative training program in the early years of the project so that they would be able to assume executive positions while the consultants are still available for advice an further training.

It is recognized that local educational institutions have not been able to satisfy the demand for highly trained specialists in some fields, and that there is no program to specifically train upland agronomists, watershed managers, resource economists or agricultural engineers for solving the special problems of upland watersheds. Most of the foreign training component should occur in these fields. It is not uncommon, however, to find overtrained experts who discover that their skills learned in the United States, or other developed countries, cannot be applied in their home country. This situation should be avoided by a careful training program specifically designed to train the individual for a specific position. There should also be a commitment by both the Indonesian Government and the trainee that the individual selected for training would serve in the specific position for a certain time period. It does little good to train a person in a specific field, than make a general administrative staff member of him. At the same time this should not be allowed to discourage the development of the individual's managerial capabilities.

The foreign training program is concerned with human development, and the specific courses and type of training should be tailored to fit the qualifications and requirements of each candidate. Where possible, training in upland agronomy, forestry, and conservation practices should be conducted at a school which specializes in tropical conditions. The University of the Philippines is a notable example, with the advantage that it would be possible to send about twice as many people for a specific cost.

(ii) Staff Training

The specific program for staff training can be developed by the Provincial Conservation Development Coordinator and the Senior Training Officer only after the Project has been funded and most of the staff hired. To a large extent the same problem will be faced by the district training officers, but they will have the provincial training program to assist them. In general, the staff members will all need considerable training in the interdisciplinary approach to watershed management and improvement in upland crop production together with the specific knowledge of the causes of erosion and the available means of reducing it.

The training component will have to be conducted by the available technical staff, the consultants staff, individual specialists from the research station, and to some extent by the university specialists. Staff training is a continuing need, both to aid in the development and promotion of existing staff to position of greater responsibility, and to train new staff as they enter the system.

Staff training as will be primarily a function of the provincial training office and center. It is strongly suggested that these training centers be established within the Watershed.

The specific reason for using provincial training centers is that they are less expensive than district operation. While staff training and retraining is the principal function of the provincial training centers, they should be used to develop conservation handbooks for staff training and to develop special educational materails for schools.

It is very important that the staff training program attempt to develop an interdisciplinary approach using all technical field of knowledge to solve the farmers' problems, and to develop among the staff a respect for the capabilities of the other disciplines providing a contribution to the program

(iii) <u>Farmer Training</u>

The farmer and family training program should be relatively continuous and low key, and it should always be pitched at the individual level of understanding and vocabulary. The initial training program should concentrate on directly benefiting the farm family by methods that are within the resource capabilities of the individual family, or by using the assistance available from government incentive programs. If the program shows some success, even though small, it can do much to sell the later phases of the watershed management program.

The demonstration farm is a valuable farmer training device, which is the reason why it is so important that it be successful. The governmental declaration, plus a sign signifying the fact, does not make a demonstration farm unless it happens to be a demonstration of what not to do. The Panawangan Pilot Watershed experience shows that constant interest, dedication, and application of many technical specialists are required for the demonstration farm to be successful.

(iv) School System Training

Some districts already have a conservation education program in their school system, which is very important because children teach their parents by discussing what they have learned in school. Therefore, it is very important that the teachers of conservation receive adequate training and educational materials to make the children's education and understanding of erosion and surface runoff problems factual and interesting. Without this training and availability of training materials, conservation education in the schools often amounts to only a tree planting exercise.

F.7.3. Integrated Watershed Management Program Development

An integrated soil and water conservation program requires an interdisciplinary approach and the coordination of all government and private groups or agencies toward the concurrent development of the physical land resources, the human resources, and the local, district, provincial, and nation infrastructure. No single existing agency, group, or department of government has the expertise or administrative jurisdiction required to improve the physical and social conditions necessary to conduct the required soil and water development program. For Indonesian conditions, however, it is strongly suggested that this program be accomplished by strengthening the existing governmental structure and not by creating a new agency to solve the erosion problems of areas such as the Jratunseluna Basin.

It should be recognized that for lasting improvement, the first step in planning a soil and water conservation development program, is to improve the economic and social well being of the farmers and the community as a group. This often involves improvement in the educational level of the people so that they can understand the necessary improvements and the need for the conservation approach.

For lasting improvements it is necessary that the people become involved in the total program so that it can become their program.

One of the first major activities of the watershed program development is to make an inventory and analysis of the resource base upon which the development programs must be based. This base-line data not only provides the basis for optimum project development, but it is also the standard from which to base an evaluation of project accomplishments during the project period. Fortunately, Satya Wacana University at Salatiga has experience at performing Socio-agro-economic baseline surveys and research. A baseline socio-agro-economic baseline survey should be initiated on each pilot watershed or demonstration farm area as soon as possible after they are selected. This will provide a startin point of program development, for infrastructure development, and identification of people problems. After project implementation a great deal of soils, land capability, agronomic, animal husbandry, fisheries, forestry, and farm management data will be required. This is one reason why it is very important to research the available data to avoid duplication of effort and waste of limited funds.

The use of existing governmental line organization through the provincial governor and the Bupati's will prevent duplication of effor from different agencies at least to some extent. Nevertheless, this is almost certain to be a problem in the early phases of the program development, and it will require strong leadership on the part of the governor's and the Bupati's to minimize the problem of interagency conflict.

A complete soil and water resource development program requires a reorientation of the whole structure of extension education and assistance to the upland farmer. In part, it may be an advantage that this has been non-existant because the program can be developed from inception. The land owner and/or the operator must be a part of the decision-making process because he will be the person to put the plan into operation. This cooperative approach with the farmer can enhance and smooth the implementation of all economic, social and education activities together with the new cropping practices, bench terraces, erosion control structures, and other technological improvements. Improvement in the standard of living of the farmer and his family will also improve the structure of the communities and their ability to use the cooperative approach to solving their problems. The objective of this approach is to get an Integrated Watershed Management Project developed from the bottom up instead of by edict from the government bureaucracy.

The conceptual plan for the Jratunseluna Basin's soil and water conservation program is based on the concept that the primary control of soil and water problems is exerted by vegetation and that all efforts at improvement should be based on increasing the vegetative cover for control of erosion and runoff. Even land that is bench terraced will suffer erosion damage if it not protected by a good vegetative cover. It should be noted that the real reason for bench terracing is to improve the condition of the land resource for crop production. Terraces are not built to prevent erosion, they are built to increase the production of food crops over the long-term. Unfortunately, the building of terraces actually reduces the net croppable area so that it is necessary to use a complete agronomic development package to produce the desired increase in net production.

A reduction in erosion rates (soil Loss) is accomplished by protecting the soil with vegetation or other cover, and/or by reducing the velocity of moving water. The agricultural program must also recognize that the increased erosion rates in the Basin are caused by man-caused imbalances between vegetative cover and the soil-climate-landform conditions of the watershed. The agricultural development program is, therefore, directed at improving the educational attainment of the farmers as a primary means of reducing the losses from soil erosion and of improving the quality of life for the watershed residents.

F.7.3.a. <u>Multiple-Use Planning</u>

In looking at the complex problems of the Jratunseluna Basin it is apparent that the government action programs to date have not been sufficient to solve the problems of these areas as they develop. There is no specific assurance that the proposed integrated watershed management program will solve the problems of the Basin; its success depends upon long term commitment to the program with sufficient funding and staffing by qualified administrators and technical people.

As previously stated, the Integrated Watershed Management Program proposed for the Basin will require multiple-use planning to fully utilize the resources of the basin in solving the upland watershed problems. It is also recognizably difficult to bring the upland farmer into the multiple-use planning process; consequently this term, "multiple-use", probably should not be used with farmers. The importan feature that should be stressed to the farmer is that this planning provides a possible means for him to do a better job of farming so his family can live better. In this context, multiple-use planning can be seen as making maximum use of the farmers' resources, while at the same time protecting the environment and reaching as many specific governmental goals as possible. The important goal of the process is that with the farmer's knowledge of the reasons why he is making the changes it becomes <u>his</u> plan. Therefore, the government's objectives will not be reached rapidly, but the gains that are made are more apt to be permanent.

In the initial stages the multiple-use planning should concentrate on planning for the small hydrologic unit of the demonstration farms, then expand to other farm groups that also wish to participate in the planning and application of conservation measures and improved agronomic practices to their farms in the mini-watershed area.

F.7.3.b. Research and Demonstration

A research and demonstration program is needed to develop an understanding of the relationship of climate, soil and land use factor to runoff and erosion as well as to determine the best methods of reducing damages to the environment. But a larger need exists to develop additional high yielding crop varieties and cropping systems that produce a maximum income to the upland farmer while providing better ground cover and reducing soil losses from erosion. Also there is a need for a great deal of farm management information on costs and returns for specific production practices on all of the upland for both traditional and upland crops. Information is also needed on the specific benefits and costs that can be expected from bench terracing various slopes in different parts of the watershed. Social surveys to determine program acceptability and development progress are also a must for the watershed management program to succeed.

Demonstration of research results is perhaps as important as the research itself. This is one of the reasons why the research farm should be implemented in the Jratunseluna Basin even though the specific direction for the program would be at the national levels. It is very important for the district technical staffs to visit the experimental farm areas and to obtain the newest information and varieties from the research staff. The research staff must document its results and publish the results of both successful research, and the failures that always occur and are so often kept a secret. Current and complete knowledge is important, both for the implementation of successful practices and to prevent the use of conservation practices or crop varieties that are known to have failed.

Recent area-based donor-funded projects such as the Solo Project, have already provided some of the "field research" results for the soil and water conservation aspects, as has the Panawangan Pilot Watershed Project. Research and project evaluation studies from other developing countries can also provide valuable guidance. A major upland watershed management research program should be established to pursue the following tasks:

1. A synthesis of existing information on soil conservation and upland area resource use, especially that already available from various area-based rural development and soil conservation projects that have been completed;

2. Analysis and synthesis of information -- from Indonesia, other tropical countries, and world research centers -- that can be adapted to local conditions;

3. Establishment of an applied adaptive research effort for existing conditions with an emphasis on upland crop production and of methods and techniques that will increase economic returns while protecting the soil resources.

4. A continuation and expansion of small watershed studies at Solo, Panawangan and other pilot watershed areas with the data carefully analyzed abd published to make it available to field staff as soon as possible.

5. An evaluation program to determine the relative effectiveness and cost-effectiveness of erosion control structures and land treatment measures.

The research program needs a study of the socio-economic constraints to the adoption of new technology, together with recommendations for the best ways of solving the problems of low profit, high risks, lack of credit, and inadequate knowledge or skills. The individual researcher must become aware that the human element in farming or watershed management is generally more limiting to production than are physical or biological elements.

The development of an interdisciplinary research program and research station is very difficult even in developed countries, which is one of the reasons why the specific direction should be handled at the national level. The inclusion of socioeconomic researchers in the staff will bother many of the older traditional staff members, as will the procedure of reviewing and testing the results of other countries' research for specific applications to the upper watershed areas. Dedicated applied researchers are needed who are needed and who are looking for specific ways to help the upland farmers -- not researchers who are looking for the opportunity to do earth-shaking basic research that will establish their reputations. It is also very important that the interdisciplinary staff of the station be officed together to foster communication between the technical specialities so they can make a maximum contribution towards improving the well-being of the watershed residents.

The qualifications of the Agricultural Research Institute at Bogor (Lembaga Pusat Penelitian Pertanian or LP_3) are well known. The consultant has not made a recommendation for an organization to supervise the research experiment station because this decision should be made by the central government of Indonesia.

Criteria that should be considered in the selection of the research station site for the upland watershed include:

1. Eroded areas should be representative of major soil types and land capability classification units;
2. Variation in slope should be great enough to include the steeper slopes as well as the intermediate and flatter slopes;
3. The most difficult land conditions should be on the research station site, or on specific substations;
4. The research station should not be located in or near a densely populated area;

5. A dependable water supply is needed;

6. Access to the station headquarters should be by an all weather road; and

7. Station site conditions must be representative of the Upper Watershed area.

In summary, specific research is needed for an upper watershed program to be successful, and it should be undertaken by research people trained in the fundamental techniques and procedures for evaluating and analyzing data, so that the results will be realistic and reproducible. Perhaps the most important feature of the research program, however, would be the review and documentation of past efforts together with an analysis of their applicability.

F.7.3.c. Participation Incentives

Participation incentives are recognized as being essential to securing cooperation in the application of many conservation practices, and in some cases for the adoption of new crop varieties or cropping systems. They are easily justified if the Project requires a farmer to make a change that may not be advantageous to him. Hence, the government should compensate the farmer for any losses he may incur. The government is also interested in the long-term use of resources while the farmer has a much shorter term viewpoint. In the United States and other developed countries it has been found that this cost sharing or participation incentives sometimes amount to one-half the total cost of the conservation practices application. This should probably be considered the general cost limit of incentive participation for the upper watershed farmers, but only experience will show the necessary incentives to accomplish the specific project objectives.

The participation incentives should definitely be kept to a minimum level that will encourage the farmers to participate because of the danger that the farmers may decide that it is a government project, whereby it will also be the government's responsibility to perform maintenance, repairs or even operate the system. This is the reason why the government's contribution to the cost of bench terracing was set at Rp. 135,000 out of a total estimated cost of about Rp. 300,000 per ha (Table F-31). But the specific cost sharing rates should remain flexible until enough experience is gained to identify the individual beneficiaries of the practice with sufficient accuracy to determine the proper cost allocation. Certainly, in the case of upland farmers the ability to pay is a definite criterion. Most farmers are extremely limited in their ability to pay for purchased inputs, but they may be able to provide much of the necessary labor for installation of project conservation measures.

Obviously, the smaller the government incentives the more project measures that can be installed with the limited funds available. At the same time smaller incentives prevent the farmer from expecting continued incentive payments after a practice has become adequately established. In many cases, after the farmers begin to adopt a practice on their own, the incentive payment should be completely discontinued because this practice pays for itself and there is no need for the government to encourage its continued adoption.

F.7.3.d. Complementary Supporting Activities

To broaden the scope of the work in the watershed from strictly an erosion control project to that of a true integrated watershed management project will require the addition of many supporting activities. Included in the primary project support activities would be the research experiment station costs, nursery costs, farm credit program, and the general category of infrastructure improvement costs. All of these special purpose programs and activities will be needed to support the establishment of the conservation works in the watershed.

In a sense, all of the National, Provincial, and Kabupaten staffs also provide a form of support activity to the direct application of project measures.

Since the upper watershed area provides only a subsistence standard of living for most of the population, the growth in application of conservation measures correlates with the success of the project in raising the standard of living. The farmer must have at least the potential for a surplus above his basic needs before he can accept the risk involved in adopting new practices. The present trend in the upper watershed area is towards a constant soil degradation due to exploitive land use. If this type of use continues, the productive capacity of much of the land will be irrevocably lost through erosion and soil destruction.

The challenge in overcoming the relatively high erosion rates is great in both the short and long term development period. National awareness of the erosion problem on upper watersheds is growing but there is a serious tendency to underestimate the problem and to believe that all that is needed is a good program and the streams will run clear again. In watersheds such as the Jratunseluna Basin, this can never happen because population pressures are too great. In fact, without a long term commitment to the integrated watershed management program, together with the appropriate fiscal and monetary population management policies, there will not even be a long term reduction in erosion damages.

Education, health and population control are the most important complementary activities to the watershed program, and they must be given increasingly higher priorities in the government programs. The economic and social benefits from this investment in upgrading human capital will be considerable, including the assurance of better use of all the potential and available resources of the Watershed.

An adequate physical infrastructure providing roads, water, electricity, and local manufacturing industries is obviously necessary for economic growth in the area and the long-term improvement in the quality of life of the residents. One of the serious social problems of the area is the lack of economic opportunity outside of agriculture. Therefore, all infrastructure development programs are complementary to the watershed management program.

The importance of expanding employment opportunities exclusive of agriculture cannot be overemphasized. Village employment opportunities can be expanded by the creation of an electric supply to run sewing machines or to develop cottage industries. Small hydro-electric systems are a good example of the needed development. These units, plus a distribution system, reportedly cost 3.5 million rupiah and provides electricity for up to 250 families, and during the day can provide the electric power for threshing rice. There are many sites in the upland where a diversion weir and a low head-electric generator system can provide low cost electricity and greatly improve the standard of living of the villagers. Other infrastructure development projects of this type should be developed as a part of the total economic development program for the upper watershed areas.

F.7.3.e. Farmer Education and Training Programs

The educational activities and methods required to facilitate and expedite the planned conservation program in the upper watershed area are only partially known. The organization and education of the farm families living in the watershed is the responsibility of the district and provincial government, and of the Agricultural Extension Agents (PLP) or the Greening Movement Agents (PLP) of the Ministry of Agriculture. Initially, however, the conservation supervisor and extension training office of the watershed management project should have a very important role in establishing conservation demonstration farms and in teaching and training the people of the pilot watersheds in the need for conservation activities and the necessity of reducing erosion with attendant soil fertility losses.

In essence, the local Bupati is in charge of all educational activities and training for watershed management. The Watershed Development Committee and demonstration farm concepts discussed herein are only indications of the educational methods that can be used to achieve the primary objective, which is to develop a thorough understanding among the people for the need of a total program of conservation on their farms and throughout the Basin. To do this, the local people must accept responsibility for participating in planning, application, and maintenance of conservation measures. This understanding is necessary for the adoption of any extension program. As noted in the Technical Approach section, the extension program must:

1. Involve the people in action programs,
2. Be based upon conditions that actually exist in the watershed or village,
3. Work through an understanding of the culture and encompass all local political groups and farmer organizations,
4. Be aimed at people's needs and desires, not at those of the project staff,
5. Use local leaders as much as possible,
6. Help people to recognize their problems and needs,
7. Use any possible method of teaching, and
8. Value people more than things.

While this list is not exhaustive, it does establish a basis for organizing the demonstration farms and other activities and for using them as educational tools to achieve the desired level of soil conservation in the upper watershed areas.

The organization at the farmer level must have concise objectives and specific guidelines that cover all sectors of the conservation program, and they must show how the conservation practices may be applied to the family farm. The goal of the demonstration farms in subwatershed areas is to formalize a program of helping farmers with their problems, which will vary with each farmer group. It is very important that the focus of all the extension activities be towards helping the farmers solve the problems that they recognize, not necessarily the problems seen by the project staff. With time the farmers will also recognize the technical soil conservation problems, and this will occur at a time when they will be receptive to the program for solving those problems.

It is planned that each demonstration farm have its own farmer organization, referred to as the Kelompok Conservation Action Unit, altough it may well take some other form of organization in the actual application of the program. It is necessary to have an organization of local farmers to assist the staff in setting up meetings or seminars and to have a group responsible for obtaining and working with the owners of the demonstration farm. This farmer organization is necessary for the self-operating concept which provides a means for the transfer of knowledge and skills required for conservation farming, production inputs, marketing facilities, and other factors that are needed to increase incomes and family living standards.

If the education aspect of the project is to succeed, it must be organized so that the individual farmer is the recipient of the education, and (where possible) all of the education materials should be written in his dialect and matched to his level of educational attainment. The farmer cannot be expected to travel long distances to attend formal lectures and demonstrations. Instead, the program must be designed to utilize demonstration farms and programs in the individual village, or in smaller hydrologic units.

The most important function of the demonstration farm is to provide a system of communication with the people in the upland farming area villages. The villagers are the principal land users in the watershed, and therefore, they have the most to gain from the erosion control and educational features of the project. Through this system the total educational program for soil conservation can be organized and implemented at the local level. It is important to recognize that the Desa Conservation Technicians and the demonstration farms provide a nucleus for developing a soil conservation program that is oriented to the people rather than to the government.

Conservation education, making and using soil surveys, resource planning, engineering design, proper construction of structural measures, soil fertility management, improved crop varieties and conservation farming techniques can all be demonstrated effectively in the farmers' own neighborhood. To his extent, the demonstration farm is a natural place for many of the farmer training sessions to take place. It is also the place where the farmer will naturally come to ask questions once he has been shown that the practices used on the demonstration farm really work. Conversely, there will be a lasting adverse effect on the farmers if many unsuitable crops and techniques are attempted because of poorly trained or misguided local staff. Experience in other areas of the world has shown that the failure of results on demonstration farms becomes known over a wide area and may in fact result in the failure of the total conservation program.

The demonstration farm and farmer education program will also introduce the individual watershed farmer to the measures and practices necessary for an effective conservation program, particularly to the necessity for maintenance of conservation measures. The individual farmer must also understand how the forest affects the income potential of the people in the watershed, and particularly, how it affects his own livlihood. It is especially important for the people to understand the damages to and losses in soil fertility caused by clearing steep forest lands and planting cassava without conservation measures and farming methods.

The size of the demonstration farm areas is important. Experience with the 6.1 ha Panawangan Pilot Demonstration Farm of the Citanduy Basin indicates that they should definitely be small hydrologic units, two to ten ha, with an average size of 5 ha. Large demonstration farms may be thought of as government-initiated, sponsored, and financed projects, an attitude which may cause local farmers to delay adopting soil conservation measures in order to take advantage of government payments. Further, the effectiveness of larger projects may be exaggerated by the visitation of dignitaries and upper echelon government officials. Instead, the atmosphere should suggest that visitors are looking at the farmers' project, not at just another government project.

By using small 5 ha demonstration farms in a hydrologic unit, one Desa Conservation Technician can actively supervise most of the conservation activities. By establishing smaller demonstration units in more village areas, there will be greater community involvement and permit the farmers to see the results of conservation measures without travelling great distances.

Developing a schedule for initiating demonstration farms is beyond the scope of this report, but it should not exceed two farms for Year One and a total of 10 for the first five-years. This is much slower than envisioned by some Indonesian Government officials, but it is predicated on quality of results and the careful training of the staff to implement the demonstration farms.

F.7.3.f. Improving Technology Adoption Rates

The organization of the Kelompok Conservation Action Units, demonstration farms, and the provision of Desa Conservation Technicians is only one step in developing an effective means of disseminating all elements of a conservation and family living improvement program to the individual farmer. First of all, those who are planning and implementing the program and those for whom the program is planned must develop two-way communication. When the program begins solving local people's problems, the foundation of a training program can be established that will provide the farmers with an understanding of the seriousness of the erosion processes in the upper watershed areas. Without this communication the program will be just another government project, and the only local interest will be in what help, or jobs, it will provide while it is active.

Although discussions in this report do not address the problem of improving the family living standard, such a goal will be an essential part of the final program. It is just as important to improve the knowledge and efficiency of the wife as a homemaker as it is to improve the farmer as producer of upland crops and livestock. The final program will also need to have a section concerned with improving knowledge of forestry and encouraging the development of industries from the forest products.

The Bupati must take the lead in developing the specific training program for his district in consultation with the Farmer Advisory Boards. Specific plans will be required to educate and train both local leaders and technicians to carry out the objectives of the watershed management program.

The local people should also contribute to the planning and budgeting of the conservation activities in their villages. Local people's participation should be encouraged as a means of training and developing a greater interest in their own affairs. With the technicians' help, the Watershed Development Committee should develop a coordinated local budget for the works of improvement on the individual hydrologic units, and they should schedule all works of improvement on the farmers' fields because they understand the local situation much better than government planners.

F.7.4. Conclusions

The investigations leading to the development of the conceptual plan for the Jratunseluna Basin was limited in scope but enabled the consultant to reach the following conclusions:

1. The erosion rates in upper watershed areas, such as the Jragung River, are so severe that portions of the watershed have eroded beyond the point where it is possible to return the land to economic production. Much of the upper watershed area is approaching this critical point and it is imperative that a corrective program be initiated in the near future.

2. The real problems of the watershed are "people problems" related to the high population density. These people problems have severe technical, economic and physical constraints on their solution because of the very limited land, economic and human resources available to the upland famer.

3. One of the major problems is that the present size and productivity of the upland farms is so limited that neither the physical nor economic conditions for a conventional conservation program exist. The farmer's low productivity, lack of resources, lack of technical knowledge, and limited access to improved seeds fertilizers and insecticides prevent him from participating in the "green revolution" or joining the modern economic society. These problems must be at least partially solved before the upland farmer can become a conservation farmer.

4. There is general lack of understanding that the first line of defense against erosion is a good vegetative ground cover. Structures by themselves do not act to reduce erosion and, in fact, may act to increase erosion many times if they fail because structures tend to concentrate the water in one place.

5. Data knowledge is not available to precisely define the problems of the Jratunseluna Basin or the feasible solutions. Therefore, the consultant cautions against the rapid implemetation of a "crash" program to solve the erosion problems of the watershed. The specific recommendations are included in the following section of the report.

F.7.5. Recommendations

The recommendations have been divided into three broad categories: First are the program objectives; these are the action levels the programs should be striving toward. Second, organizational improvements: changes which the consultant feels are important in effectively developing a soil and water conservation program within the existing governmental system. Third, infrastructural and institutional improvements; these improvements are suggested to provide inputs to the organizations responsible for conducting the programs through increased funding and technical assistance.

F.7.5.a. Program Objectives

1. Development of an integrated multidisciplinary plan for solving the "people problems" of the Jratunseluna Basin should be the primary objective. This effort should be focused on solving the real problems of the upland farmers rather than attempting to solve the physical manifestations of the problem. This is to say that erosion is not the real problem; the problem is that there are too many upland farmers trying to feed their families in the upper watershed areas, and that these farmers lack the necessary knowledge and resources to adopt the needed conservation farming methods. Solving this problem will require the cooperation and coordination of all agencies and political subdivisions in all departments from the ministerial level to the village level.

2. Individual farmers and government officials must be given an appreciation of the real nature and condition of the problems they face and program developed to solve these problems. It is very important that this process involve the local people in the decision making process and thereby teach them to improve their individual decision making ability. This approach emphasizes the "better farming for better living" concept and attempts to show the farmer that soil and water conservation and improved cultural practices

can enable him to make maximum use of his resources to improve his family's standard of living.

3. The staff must learn to recognize that the first line of defense against erosion is always the improvement of vegetative cover on the land. Soil conserving structures are more impressive and satisfying, but if not maintained they can fail and cause more damage than would have occurred if they had not been built. Vegetation is more permanent and even in failure, or removal, there is additional soil and fertility remaining.

4. The integrated watershed management program should capitalize on all soil conservation works previously installed. Traditional terraces can be slowly improved, and by installing grassed waterway systems for surplus water disposal they can materially reduce erosion rates. The staff should encourage the best of traditional cropping methods and show the farmer better ways of doing other agronomic practices. The program should emphasize methods of improving existing soil and water conservation systems and in the use of simple structures that can be built with local materials and labor.

5. Fruit, livestock, fish, or bee production are examples of supportive systems for increasing the family income or improving diets. Livestock production provides a use for grass grown on the terrace risers and agroforestry areas so it should be encouraged, aided with loans, and improved through better breeding and management programs, but care must be taken to prevent overgrazing that can create serious erosion problems.

6. The adoption of improved soil and water conservation methods and improved agronomic cultural practices should be encouraged by system of demonstration farms. Since the farmers often cannot read, and will not travel far, the demonstration farms must ultimately be scattered throughout the upper watershed areas. However, care must be taken not to expand this program beyond the availability of funds and trained technicians to train and assist the farmer, and supervise the program at all levels. The fundamental principle with demonstration farms is that success convinces people to follow the example, but failure breeds contempt and knowledge of it travels very fast and far. Building a cadre of professional workers for improving upland agriculture requires a combination of university training, short technical training session, and a major program of on-the-job training for all staff members. This program should also emphasize the promotion potential for exceptionally capable field workers. Farmer advisory group should be definite part of the government structure so that their perspectives can affect management decisions. The central government's pronouncements on "the right way to solve problems" never work, but the direct participation in the field with the farmer has been

proven to work in limited cases, here in Indonesia and other countries. The important feature of these successes was that the project become a local one rather than a government project.

F.7.5.b. Organizational Improvements

Based on the consultant's review and analysis of prior soil conservation efforts in Indonesia, it is believed that future efforts could generally benefit from a few, but important, organization improvements, primarily because the governmental organizations directly concerned with solving the upstream land and water resource degeneration problems lack coordination and tend not to focus on solving the people problems of the upper watershed. Instead they have worked attempting to solve the symptoms, such as denudation and visible erosion. Further, these programs are developed from the national level downward and have little or no relevance to the upland farmers' problems. Organizations created to deal with the downstream irrigation and riceland farming problems neither understand the problems facing upland farmers nor currently provide any real assistance to those farmers. More precisely, the past soil conservation efforts have suffered greatly from the lack of continuity and linkages among the individual program elements, and th consultants believe that this can only be achieved by an improvement program that is developed from the farmers' level upward. Specific recommendations include:

1. Rather than creating a new organization to accomplish the watershed management objectives, the consultants strongly suggest that the existing central governmental authorities be given the staff and funds necessary to solve the problems at the local level, with the farmers' cooperation. This approach has the advantage of not creating a new bureaucracy with the attendant overhead costs. The Indonesian national government and the Jratunseluna River Basin Project should provide the management goals: staff training assistance; consultant and other technical guidance; and funds for additional staff, equipment, farmer incentives, and materials. Direct management of the watershed development program should rest with the affected kabupaten or kecamatan, with guidance from farmer advisory boards and supervision from the provincial offices.

2. At the national level, a ministerial level council is needed to develop specific soil, water, and renewable natural resource policy for Indonesia. This group would meet infrequently to consider reports or programs, review and make policy decisions, and evaluate progress. The coordinating body would provide the necessary linkages between programs of the separate government agencies that affect the soil conservation problem. The council should also need a day-to-day coordinator to carry out the wishes of the council and to follow up on decisions.

3. A more effective direction and coordination of soil and water development and management programs in the watershed should be provided for. A much greater and more deliberate effort should be made at all administrative levels to provide continuity of participation in the soil and water development programs for improving watershed conditions. New programs and staff should be developed in the light of past experience (including mistakes) to ensure that future programs do not repeat mistakes made in other parts of the watershed or country.

4. A major effort should be initiated to improve the soil and water research and basic data collections systems, and to expand the upland crop and seed improvement program. Research and basic data collection should be placed high on the priority list because it is the only way to evaluate the effectiveness of projects and programs. This program should include a synthesis of existing information from the various areas-based rural development or watershed programs in Indonesia. Information from neighboring countries should be analyzed for applicability to Indonesian watershed management projects and recommendation made for its use. Similarly, all new plant varieties that have shown promise in comparable situations should be investigated for introduction to Indonesian's upland farmer or watershed areas.

F.7.5.c. Infrastructural and Institutional Improvements

Local differences in resources, infrastructural development, political organizations, and people's attitudes towards development are too diverse to permit a common program approach to infrastructure and institutional changes in the upper watershed areas. The need for too many different improvements prohibits the use of a single approach for the total upper watershed area. The general recommendations are discussed below, but specific project assessments will need to be developed after project implementation.

1. Development of additional nonagricultural employment opportunities is a critical need in the upper watershed area. Specific infrastructural development programs should concentrate on the promotion of labor-intensive activities, using local resources in their production.

2. Improvement of the transportation network is essential to the development of a market economy in the watershed. Villages with the most pressing economic, social, and land deterioration problems often are the most difficult to reach. The farmers from these villages must face uncertain market prospects in the village or must hand carry their produce from the upland farms to market centers in lowlands for sale or trade.

   Because the need for road and trail improvement is so severe the immediate program should concentrate on erosion proofing and surfacing of existing roads and trails as a primary means of reducing erosion that will also reduce transportation and vehicle maintenance costs, while reducing future road maintenance costs and downstream floodwater and sediment damages.

3. The long-term success of the upper watershed improvement program necessitates development of a practicable farm credit program to enable upland farmers to purchase the technology that will permit them to participate in the green revolution's methodology for increased crop production.

4. Assistance programs for upland farmers should be redefined and expanded to assist in solving the real problems or initially what the farmers perceive to be their problems because in this way they will learn to rely on the project staff. This will require the addition of many agricultural technicians with broad backgrounds in solving local problems and needs; through knowledge of community economic development methods, extension education programs, and conservation farming techniques. Planning and coordination programs between existing government agencies should be improved to reduce the number of infrastructural bottlenecks created by the lack of fertilizers, improved seeds or planting materials, and other factors.

5. The training of all project staff members should concentrate on the team approach to solving the upper watershed problems, as well as developing a respect for the opinions and abilities of the upland farmer and his family. It is only when the farmer believes that the staff members are trying to solve his problems that there is any real chance for a long-term reduction in the erosion rates of the Basin.

6. Conservation education programs should be developed to reach both sexes, all age levels, and economic groups. The programs should also stress economic and social development programs to improve the economic position of the upland watershed residents.

People selected and trained for the local technical staff and as Desa Conservation Technicians should, where possible, come from the project area because they must understand the local culture and the institutional strengths and weaknesses that will permit them to be more effective in motivating the local people to action. A program should be initiated to locate, recruit, train, and continuously upgrade the training of the needed conservation technicians for optimum project development. This training program should emphasize cooperative planning methods, management skills, upland cropping practices, and yield improvement methods, as well as the necessary conservation farming techniques.

7. The upland farmers' leadership ability and their sense of cooperation and mutual assistance must be strengthened if they are to adopt the watershed management program and to commit themselves to long-term conservation farming methods and maintenance of project measures after the government assistance is stopped.

8. Implementation activities of the upper watershed management program should concentrate on upland farmers' organizations (Kelompok Conservation Action Units) that are based on small hydrologic units. These organizations should function as the primary mechanism for farmer conservation education; planning of conservation activities; organization of labor for terrace and waterway construction; and, ultimately, in community development and the provision of watershed management program guidance to the project staff, using representatives of the individual action units.

F.8. PILOT WATERSHED DEMONSTRATION AREAS

F.8.1. Introduction

This part of Appendix F contains the basic soil and water conservation project plan for two Pilot Watershed Demonstration Areas in the Tuntang Subbasin of the Jratunseluna Basin at Gunungsari and at Watuagung (Figure F-14). As such, it is primarily a generalized conservation plan for the two areas that was developed without the needed socio-agro-economic knowledge, soil and land capability surveys, aerial photographic coverage, and detailed topographic mapping. While somewhat limited in scope the two Pilot Waterwhed Demonstration area development plans included in this section should, if initiated, provide an extremely useful reservoir of data and experience for developing the project plan for an upper watershed management program for the Jratunseluna Basin. It should be noted that all cost estimates are January 1980 Rupiah values and that no attempt was made to provide for economic contingencies related to inflation or devaluation.

F.8.1.a. Objectives and Scope of Work for The Pilot Demonstration Areas

According to the stated objectives of the expanded Tuntang River Basin Development Plan Contract No. B.58/CES/79 the objective was to "prepare detailed designs for an erosion control scheme for a pilot demonstration area within the Jratunseluna Basin." The Scope of Work amplified this by stating that it would include preparation of a detailed design for a 100-hectares pilot area; and that the project design would consist of drawings of the area showing the location and types of erosion control measures to be constructed. These drawings were to be sufficient detail to allow construction of the erosion control measures to be carried out. The contract also specified that provision would be made to install a sediment measuring device in the design of the pilot demonstration

This approach has an unfortunate focus on the design of conservation structural measures rather than working towards a complete soil and water conservation development program that is focused on improving the well being of people. The consultant has attempted to follow the terms of reference in the contract, but it should be noted that the pilot demonstration areas included here-in do not follow the guidelines recommended in the conceptual plan for the Jratunseluna Basin. The consultant specifically recommends that a member of these technical and human relations deficiencies be rectified upon project implementation. The most important feature is to make certain that all of the people in the demonstration areas be informed of their tentative selection to be included in a demonstration area, and that they are informed of exactly what this will mean if the project is initiated. Then the project should only be initiated if it is requested by the local people. Otherwise, it will become just another governmental project that has a high probability of failure.

F.8.1.b. Constraints

During November 1979, two pilot demonstration areas, (at Desa Gunungsari and Desa Watuagung), with a total area of approximately 100 ha were selected and topographic mapping at a scale of 1:2000 (with 2.5 m contour intervals) was initiated. The preliminary maps were available upon the arrival of the Watershed Erosion Control Consultant at the end of February 1980. Unfortunately, these surveys did not cover complete watershed areas and they did not show the features necessary for conservation planning. In fact, for final location and design of conservation measures the topographic surveys shoul be at a scale of 1:500 with 0.5 or 1.0 m contour intervals for areas with less than a 40 percent slope. These topographic maps should be made by experienced survey crews using plane table and alidade, and care should be taken to show all the needed features of the terrain. These maps plus field observations will enable the accurate location and design of the needed conservation measures.

The original mapping for the Gunungsari Pilot Watershed Demonstration area covered only about 20 ha of small watershed areas, which was expanded to include the 54.4 ha in the six selected small watershed areas with one small exception. A more detailed map with a 1:500 scale, and 1.0 m contour intervals is being prepared for the demonstration farm and adjacent areas, but this map was not available for conservation planning. Therefore, it should be recognized that the conservation measures for the Gunungsari Area, included in this report are designed within the limitations of 2.5 m contour intervals.

The Watuagung Pilot Watershed Demonstration area maps did not include any complete small watershed areas, and since time constraints did not permit completing the needed surveys it was decided to include only a limited program for this area in this report, together with suggestions on how to complete the project when surveys are completed. This project program is discussed very briefly in Section 11 of this report and includes details for less than 10 hectares of the potential project area. Time limitations and other constraints forced the consultant to virtually ignore the Watuagung Pilot Demonstration Watershed Area. It is felt, however, that much of the agroforestry type of conversion in land use can be initiated without specific detailed plans. It is very obvious that 70 percent slope lands are not suited to upland agriculture. Thus, the project designs in this report cover only about 60 ha rather than the proposed 100 ha listed in the terms of reference.

The other specific constraint of the designs for the two pilot watershed demonstration areas contained in this report is that they contain no direct information as to the historical land use, cropping systems, crop yields, number of farmers involved, or the human resources available to solve the problems. The collection of this information is one of the essential first steps for project implementation.

F.8.2. Gunungsari Pilot Watershed

F.8.2.a. Location and Watershed Condition

The Gunungsari Pilot Watershed is located in the Tuntang River Subbasin in the area immediately south of the Gunungwulan Damsite near Repaking (Figure F-15). The pilot watershed area contains 54.4 ha within six small watershed planning units (Figure F-16). The watershed area is bordered on the western side by the Kali Losari which is a tributary of the Kali Bancak and thence into the Kali Tuntang. On the north and northeast side it is bordered by the Kali Bendungan, and the watershed includes the confluence of the two streams. On the east and southeast it is bordered by a road to Desa Gunungsari from Wonosegoro that runs along the watershed divide. Desa Gunungsari is on the east side of the watershed area and is not specifically included in the project area.

The Gunungsari Pilot Watershed is located in Kecamatan Wonosegoro of Kabupaten Boyolali of the Province of Central Java. The area was specifically selected for a demonstration area because of its long term erosion problems in an area with very similar problems.

Prior to about 1942 this area was a "Serat Nanas" fiber plantation. Since that time it has been used for upland farming until it is so eroded that much of the land is abandoned and produces only weeds and poor pasture. The land surface is generally partially covered by an "erosion pavement" of small stones left when the soil size materials were eroded away. The surface is rilled and there are many small gullies. The main stream channels have mostly been eroded to bed rock and are reasonably stable.

Under present condition only about eight hectares of the watershed is being cropped and these areas are producing only very limited crop production because the severe erosion in the past has removed all of the fertile topsoil from the sites. The rest of the watershed area has generally been abandoned to the poor quality native grass and weed cover There are some limited areas with a poor stand of teak and other forest trees, and some small areas with mango, banana and other fruits.

As a generalization, the watershed condition is poor, but only a few areas have become so eroded that it is impossible to return them to some type of economic production.

F.8.2.b. Climate

The climate of Java is primarily influenced by the trade winds which are, in turn, influenced by the monsoons. The monsoons are steady winds of low to moderate intensity that blow from the northwest and southwest. The rainfall associated with the northwest monsoon, from November through April, is the wet season with about 75 percent of the annual precipitation. The southwest monsoons of May through October are significantly drier with only about 25 percent of the annual precipitation.

Precipitation above the Gunungwulan Damsite, as shown in Appendix A - Hydrology (Part I), is as follows:

	Month	mm	%
Wet Season	Nov	256	9.5
	Dec	341	12.6
	Jan	387	14.4
	Feb	345	12.8
	Mar	384	14.2
	Apr	296	11.0
Subtotal		2,009	74.5
Dry Season	May	215	8.0
	June	116	4.3
	Jul	81	3.0
	Aug	59	2.2
	Sep	63	2.3
	Oct	154	5.7
Subtotal		688	25.5
Total		2,697	100.0

January is typically the wettest month with an average of over 380 mm, and August is typically the driest month with an average of less than 60 mm of rainfall. Rainfall records in the Tuntang Subbasin show three cases of monthly precipitation exceeding 600 mm. Conversely, many dry season months have experienced zero rainfall.

The Tuntang Subbasin is characterized by nearly constant temperatures throughout the year. This constancy of temperature is due to the tropical waters which surround the relatively small island of Java. The average temperature is approximately 27° C, with a range of from about 26.1° C in October.

The relative humidity is high and relatively constant throughout the year as a result of the warm tropical water surrounding Java.

The average relative humidity in the Tuntang Subbasin is estimated to be about 70 percent.

Winds are very uniform throughout the year and there are almost no high velocity winds. The annual average wind run is 250 km/day at the Semarang Airport, and is nearly constant from month to month. Semarang is of course influenced by sea breezes as well as the regional winds associated with the monsoon.

F.8.2.c. Land Use and Land Ownership

Information on land use for the Gunungsari Pilot Watershed is not available for Desa Gunungsari, but it is available for Kecamatan Wonosegoro. The 1978 land use for Kecamatan Wonosegoro was as follows:

Land Use	Hectares	%
Riceland		
Irrigated (Technical systems)	408	4.6
Irrigated (Rural Systems)	58	0.6
Rainfed Riceland	1,222	13.7
Not Plantec	57	0.6
Subtotal Riceland	1,745	19.5
Upland Areas		
Homeyards	1,488	16.7
Upland Crops	4,413	49.4
Pasture Lands	44	0.5
Forest Lands		
Private	-	0.0
Government	1,149	12.9
Plantations	-	0.0
Other Us	87	1.0
Subtotal Upland	7,181	80.5
Total Area	8,926	100.0

The same report indicates that Kecamatan Wonosegoro has about 9.6 percent of the land area of Kabupaten Boyolali, but only 7.2 percent of the riceland areas. This is in itself an indication of the relative poverty of the area.

As shown on Table F-3 in Section F.3. there were 7,331 ha of critical land outside the forest in Kecamatan Wonosegoro at the start of Pelita II and that 7,752 of this area was treated during Pelita II leaving a total of 2,579 ha at the start of Pelita III. No critical areas were shown for lands within the national forest areas. The 2,579 ha of remaining critical lands amounts to only about 36 percent of the upland area of Kecamatan Wonosegoro which would appear to be very low from a visual inspection of the area. Again, this is probably a matter of definition within the P_3RP-DAS program as against the consultant's view point.

F.8.2.d. Soils and Erosion Problems

The soils of the Gunungsari Pilot Watershed were classified by the Soil Research Institute, Bogor in 1962 as being a complex of grey regosol and dark grey grumosols formed from limestone and napal. The soils are typically so eroded that the surface is covered with an erosion pavement of both small and large stones that were in the original soil profile.

The upland soils are generally vertisols, which are clayey soils that produce cracks when dried and have a high bulk density in place. These soils when dried develop wide cracks which help increase the water intake rate during initial rainstorm periods, but basically, these soils have low infiltration rates, hence, high runoff rates. On cut-banks, and sometimes on the surface of cultivated soils, drying produces a crumbling of the surface that provides a surface layer that is highly susceptible to erosion during initial rainstorm periods. These soils are also susceptible to puddling by raindrop splash which greatly reduces the infiltration rates.

The soils of the Gunungsari Pilot Watershed have been subjected to so much erosion that there is almost no sign of the original soil development under the natural forests of the area. As a generalization, the watershed has no soils that show developed horizons and they can generally be classified as being subsoils or decomposed parent material. Fortunately, auger borings show that in most of the areas of less than 40 percent slope there is at least one meter of soil. This will permit bench terracing and with long term conservation farming and erosion prevention a nutrient cycle may be created that will ultimately permit a true soil develop.

F.8.2.e. Vegetation and Cover Condition

The vegetative cover of the Pilot Watershed is generally sparse and low growing, which is an indication of an extremely low level of fertility. Except for the limited areas planted to teak, other forest species, and fruit trees the ground cover is mostly low growing grasses and pioneer species of forbs and browse plants. The abandoned cropland areas are mostly used for livestock pasture and there is a definite overgrazing of the available forage. Proper conservation use in this case would call for leaving approximately one-half of the total forage produced. An occular estimate of ground cover indicates about a 30 percent ground cover, which is one of the major reasons for the high erosion rates experienced even on the noncropped areas of the watershed.

F.8.2.f. Socio-Economic Factors

Time did not permit the collection of the needed socio-economic data to identify the problems of Desa Gunungsari and the Pilot Watershed area. Therefore, this is one of the first major activities to be undertaken in the project implementation phase.

Population figures for Desa Gunungsari for 1977 and mid-year 1978 show the following numbers:

	Adult		Children		Total	
	No.	%	No.	%	No.	%
1977 Population						
Male	527	47.9	404	52.9	931	49.9
Female	574	52.1	360	47.1	934	50.1
Total	1,101	100.0	764	100.0	1,865	100.0
%	59.0		41.0		100.0	
1978 Population						
	1,096		799		1,895	
	57.8		42.2		100.0	

The high percentage of children and relatively low percent of adult males indicates that there is an out migration of adults to work in other areas. This is in line with the observed general poverty of the area.

Limited contact with the local people indicates that they are worried by the decline in upland crop production from erosion, and that they would be interested in a soil and water conservation project to improve their conditions.

F.8.2.g. <u>Crop Yields and Farming Methods</u>

Crop yields are very low in the Pilot Watershed area but no specific yield data has been obtained to date, the primary upland crops are cassava, maize, ground nuts and limited areas of homeyard crops. These crops are mostly grown in the traditional fashion with old poorly constructed out-sloping terraces or planted up and down slope without any conservation measures. There are, however, some well constructed and productive terraces on relatively flat lands near Desa Gunungsari. This is a definite indication that the extension workers have introduced some aspects of conservation farming to the upland farmers of the area.

F.8.3. Watuagung Pilot Areas

F.8.3.a. Location and Watershed Condition

The Watuagung Pilot Watershed is located in the Tuntang Subbasins immediately east of Rawa Pening (Figure F-15). The Pilot Watershed is located in Kecamatan Tuntang of Kabupaten Semarang of the Province of Central Java.

The Watuagung Pilot Watershed has had only a small portion of the upland area surveyed (Table F-31) and the total watershed area is not known. The Watuagung Watershed is formed by a series of three main channels that drain the north face of a mountain that flanks Gunung Payung which has a crest elevation of 718 m MSL. The high point of the Watuagung Pilot Watershed is not known but the top of the mountain has extensive upland crop areas that have become severely eroded.

The Watuagung Pilot Watershed Area is divided into three main segments. First, the upper watershed which has been extensively developed for cropland. This has a considerable area, 5-8 ha, that is good quality land and should be bench terraced. The area has all been terraced to some extent and some of them may be bench terraces of the traditional outslope type. The main difficulty for this segment will be developing a good waterway system. While this upper area needs treating it will never be suitable for a demonstration area because it is too inaccessible. The intermediate area which is very steep mountain slopes has gradient of about 70 percent. This area has many scattered patches of cassava and homeyards and is being severely eroded. The only long-term solution to use of the area is a land use conversion to a forest and grass type of agroforestry that will not support many farmers. The lower, or third segment, of the watershed is a flatter area of riceland. The only severe erosion problem in this area is related to the large streams that come from the mountain area and cross the riceland in large deep channels.

The general watershed condition is not as poor as might be expected from the extreme pressures on the available land resource. This is probably a function of the relatively permeable soils and the occurrence of large rocks of volcanic material that tend to stabilize the main-stream channels from erosion.

F.8.3.b. Climate

The climate of the Watuagung Pilot Watershed is nearly identical to the previously described Gunungsari area, except that the higher elevations produce higher precipitation rates as a result of orographic influences.

F.8.3.c. Soils and Erosion Problems

The soils of the Watuagung Pilot Watershed were classified by the Soil Research Institutes, Bogor in 1967 as being Red Latisols formed from tephrite and volcanic tuff. The term latisols is applied to a group of soils that are deeply weathered and strongly leached, and which show no clear horizon definition. These soils have a low content of primary minerals and nutrients, and they are generally very acidic. The organic matter content is typically rather low. These soils have a high accumulation of sequioxides from the leaching of silicia, which generally gives these soils a friable consistency.

These soils are relatively infertile when eroded. They will require large amounts of fertilizer to produce either good crop production and tree growth. In the past the upland areas of this watershed were reasonably productive because the people used shifting cultivation practices that left the land fallow for a number of years. Thus, while the ground was covered with tropical forest the fertility level was restored. Then the land was cleared and farmed for a few years and abandoned. The larger population of upland farmers has disrupted this cycle and now farmers attempt to raise nearly continuous crops. Also, as the land deteriorates cassava is the only crop that will grow so it is extensively planted, and this crop is known to use up soil nutrients to a high degree. The common practice is to remove all of the roots and growth so very little organic matter is returned to the soil.

Because these soil are deeply weathered and undifferentiated it is difficult to observe the ravages of erosion in the field. The effect on fertility is easy to observe, however. There is a marked difference in the crops grown in the relatively level homeyards as against those on the steep mountain slopes.

F.8.3.d. Vegetation and Cover Conditions

Cover condition on the steep mountain slope are from fair to poor, and there is an urgent need to convert all of the lands greater than a 50 percent slope to some type of permanent cover. Trails up the mountain and gullies along property boundaries are suffering severe erosion.

F.8.3.e. Socio-Economic Factors

Time did not permit the collection of the needed socio-agro-economic data for the Watuagung Project area. Therefore, this is one of the first major activities to be undertaken the project implementation phase.

Observations of the Watuagung Village indicate that the upland farmers are very poor and most would be poorly educated. This emphasizes the need to develop new industries in the village or provide for relocating some of the farmers to more fertile lands. The land resources are simply not available to support the present population, and a soil and water conservation program cannot increase short-term upland crop production to any extent in this area.

F.9. PROJECT IMPLEMENTATION REQUIREMENTS

The basic project implementation requirements for Pilot Demonstration Areas were covered in Sections 3 and 8 of the Conceptual plan for the Jratunseluna Basin under the Technical Approach and the Proposed Basin Plan. Therefore, this section of the report is brief and is designed to emphasize important points in implementing the very limited program of two pilot watershed demonstration areas wihtout a definite commitment for a total basin program.

F.9.1. Project Funding at an Adequate Level

The most important feature of any demonstration watershed is that it be funded at an adequate level to ensure success in all phases of the activity. The Greening Program (P_3RP-DAS) is an example of a program that has obviously been hampered by limited funding which has prevented the hiring of needed technical staff and in providing only limited training and supervision of the project farmers. To be successful the demonstration watersheds must be funded to a level that will enable the staff necessary to fully accomplish the project objectives.

It might also be noted that the budgets prepared for these demonstration watersheds assume a high level of farmer participation and the minimum of government funding consistent with a probability of success.

F.9.2. Organization for Pilot Watershed Projects

F.9.2.a. Project Level

Because the two proposed Pilot Watershed Demonstration Areas are very small and have a small budget there obviously cannot be a very formal organization for managing the projects. The consultant would suggest that most of the coordination be by a committee that includes representatives of the Jratunseluna Basin Project Office and the Boyolali and Tuntang Bupati's offices as a minimum. If the Central Java Governor's office is interested they should also be involved. The specific organization can only be developed as the projects are funded and implemented.

F.9.2.b. Village Level

It is suggested that a Desa Conservation Committee be formed for the overall management of the soil and water conservation activities in the pilot watershed area. This organization would provide for coordination of planning and construction of conservation measures in cooperation with the Lurah and the Bupati's staff. They would coordinate the activities of the farmers in the demonstration farm area and each of the organized small hydrologic units. If desired, this coordinates work could be assumed by some existing Rural Social Committee.

Each demonstration farm or small hydrologic unit would need to be organized into a specific group such as the previously described Kelompok Conservation Action Units that should not exceed 20 families in size. One key farmer should represent each Kelompok Conservation Action Unit for planning, operations and scheduling conservation assistance. The Kelompok Conservation Action Unit is essential because there are many potential conflicts where grassed waterways on terraces split up a farmer's fields. The solution of these problems requires a formal organization to work with the planners and the Lurah to ensure that the soil water conservation measures are applied as rapidly as possible with a minimum of conflict. It is important to note the planning in this case must be done with the farmers not for them, and the farmer must understand the reason for the structures or farming methods he is being asked to adopt.

F.9.3. Project Staffing and Training

F.9.3.a. Project Staffing

The limited budget for the two Pilot Watershed Demonstration Areas does not permit an extensive recruitment program to hire the qualified people needed for project implementation. Instead, most of the people involved will be people presently on the Jratunseluna Basin Project of Bupati's Staffs. They will be promoted to the specific assignments or be given supervisory responsibility along with new staff to assist them.

The new positions will mostly be some of the extension workers (PPL's or PLP's) and the Desa Conservation Assistants that will be assigned directly to the project areas. To the extent possible these people should be familiar with the project area or areas with similar problems.

F.9.3.b. Staff Training

A definite effort should be made to train the staff in the inter-disciplinary approach and in the "bottom up" planning approach. The importance of the staff's recognizing the need to involve the farmer in the planning process cannot be overemphasized.

If possible the staff training program should include available training programs from universities, local consultants and special national training programs. The material included in the Jratunseluna Basin Conceptual Plan of this appendix is, in part, designed as a text-book for conservation planning and applications. Appendix D - Protection of Cultural Slopes from the Citanduy Upper Watershed Management Project is also useful in this respect [24]. It is being specially furnished to the project office in limited numbers by the consultant.

F.9.3.c. Farmer Training

In a very real sense the objective of the entire project is to train the upland farmer in a soil and water conservation program and to assist the farmer in applying it to his farm. The development of the needed complete farmer training program would require the services of several specialists and is only possible if the entire basin project were to be implemented. The experience in working with local farmers on the Panawangan Pilot Watershed of the Citanduy River Basin provides some valuable guidelines to be used in training local farmers and in gaining acceptance of the program [8].

F.9.3.d. School System Training

A conservation education program should be initiated in the local school system if at all possible. Children take the ideas home and discuss them, and it is one of the best ways of spreading conservation concepts if a qualified teacher is available for the program.

F.9.4. Preparation of Accurate Base Maps

The importance of accurate base maps for planning purposes cannot be over-emphasized. As a minimum the individual demonstration watersheds, small hydrologic units or other planning area needs to have accurate topographic survey at a scale of 1:500 with 0.5 or 1.0 m contour intervals together with land ownership and land use maps. Aerial photographic coverage is also very useful where available. Copies of these maps should be made available to the Desa Conservation Committee and the Kelompok Conservation Action Units and they should be encouraged to update these maps as changes occur.

F.9.5. Soil Surveys

F.9.5.a. Detailed Soil Surveys

Detailed soil surveys are essential to all conservation planning and application activities. Arrangements should be made for detailed soil surveys as soon as possible after funding is available for the Pilot Watershed Demonstration Areas. As shown in Table F-9 the estimated cost for detailed soil surveys on a large area amounts to about Rp. 4,600 per hectare. For small areas, such as the Demonstration Watersheds, the cost is estimated to be twice this value, or Rp. 9,200/ha. This would amount to Rp. 506,000 for detailed soil surveys on a 55 ha Pilot Watershed.

F.9.5.b. Land Capability Classification

The contract for developing the detailed soil surveys should include the development of a land capability classification system for all major land capability units in the watershed. This will greatly aid the planners in determining the highest or best use of the land, and understanding the limitations on the use of the land even with conservation measures applied.

It should be noted that the application of conservation measures does not change the land capability, it only permits the owner or operator to use the land for a higher use as long as the conservation measures are properly maintained and operat

F.9.6. Socio-Economic Baseline Survey

It is very important to have a good socio-agro-economic survey of all the farm and farm families in the Pilot Demonstration Watershed

Areas both for planning purposes, and to use as a standard to gauge progress of the project. Specific items to be included would be:

1. Attitudes towards soil conservation,
2. Soil conservation practices being used,
3. Family size, income and related information,
4. Crop production practices and yields,
5. Land use on farms,
6. Land preparation mathods,
7. Fertilizer and insecticide use,
8. Extent of landless workers, tenency and methods of payment for labor,
9. The extent of using "gotong-royong" and other cooperative methods of accomplishing group, objectives.
10. Extent of livestock and fish production,
11. Produce marketing systems,
12. Credit availability, and
13. The extent of community planning activities.

This information can then be used to plan for special improvements in the lives of the watershed residents. In fact, it is very important for the project to initially concentrate on trying to solve some local problem that the people feel strongly about, even if it does not specifically relate to the soil and water conservation activities of the project.

Because Satya Wacana Christian University at Salatiga has had considerable experience at this type of baseline survey it is suggested that they be used in making the needed socio-agro-economic study for the two Pilot Watershed Areas. The cost of these studies is estimated at Rp. 500,000 for each project area.

F.10. RECOMMENDED GUNUNGSARI SOIL AND WATER CONSERVATION PROJECT

F.10.1. Demonstration Farm

The need for upland demonstration farms has been discussed in previous sections of this report, and the Panawangan Pilot Demonstration Farm of the Citanduy Watershed [7, 8] has demonstrated the effectiveness of the demonstration farm approach. Because the demonstration farm is so highly related to acceptance by the individual farmers it is not possible to specifically locate the demonstration farm in either of the proposed Pilot Demonstration Watersheds. It is recommended, however, that once the demonstration watersheds are selected that they be given a priority for installation of conservation measures.

For the Gunungsari Pilot Demonstration Watershed it is recommended that the demonstration farm be located on the 5.7 ha southern part of Hydrologic Area A (Figure F-16). This area offers the best opportunity for initial application of conservation works and there is a better chance of developing a productive farm in this area. These conservation plans also call for the development of both conservation and bench terraces in this area, which is valuable for demonstration purposes. The specific location of the demonstration farm should, of course, be left to the decision of the farmers involved and the Watershed Development Committee with the advice of the project technical staff.

The objective of the pilot demonstration farms is to show the actual practice of conservation farming with emphasis on the following:

1. To demonstrate effective land use and land management.
2. To develop cropping systems suitable for upland farming that produce high yields.
3. To demonstrate soil conservation practices and soil fertility maintenance from the standpoint of soil erosion control.

4. To provide a demonstration area for farmers to learn, observe and adopt conservation farming and improved ogee cultural practices, and

5. To determine production costs and economic returns.

The difference between a research farm where the work is conducted by paid technical people, and a demonstration farm where the work is conducted by the farmers should be carefully noted. A demonstration farm is no place to attempt sophisticated replication plots for statistical analysis. Instead the efforts should be concentrated on obtainin the highest practical crop yields per hectare using a variety of agronomic and conservation farming practices. The important feature is that for the demonstration farm accurate physical and economic records should be maintained of all inputs and outputs from the various fields. This will permit the development of crop budgets and yield estimates that will be extremely useful in selling conservation farming in the surrounding areas.

F.10.1.a. <u>Conservation Farming Methods</u>

Conservation farming methods emphasize maximizing the vegetative cover to protect the soil at all times; while attempting to produce the highest crop yields consistent with the economic returns from the crop produced. Most of the crops suited to the demonstration farm area are grown to some extent at present and crops are very diversified at least in the home garden areas.

In order to achieve increased yields, the primary requirement is not research into new methods, but rather the increased application of techniques and practices that are already known or become available during the project period. The difficulty is in finding the technical staff who are knowledgeable of the most productive upland crop varieties and crop production techniques. Increased crop production is primarily a function of improved crop varieties, more fertilizers, more capital, and a reduction of crop wastage from pests and desease. The immediate goal is to increase the crop yields of the existing subsistance agriculture by the application of elementary agronomic and soil conservation practices. It should be noted that the application of conservation farming techniques is not dependent upon the building of terraces or other structural measures. Contour farming, contour strip cropping, crop residue use, mulching, and minimum tillage practices all act to reduce erosion and increase crop yields.

F.10.1.b. Mulching and Crop Residue Use Demonstrations

For the eroded soils of the demonstration watershed areas it is extremely important for the farmers to adopt a program to increase the organic matter content of the soils of their farms as rapidly as possible. All available organic matter should be returned to the soil. Under no circumstances should any form of crop residues be burned as is the traditional practice. Burning causes the loss of both fertilizer elements and the organic matter needed for soil tilth.

If it is not practical to immediately incorporate the plant materials into the soil they should be used as a mulch on the soil surface to reduce the erosion from raindrop impact. Alternatively, these crop residues, or manures, can be composted by placing them in a pit for decomposition and subsequent application to the fields. Specific demonstrations of composting should be made a part of the demonstration farms.

Mulching or stubble mulching demonstrations should be specifically included in the demonstration farm areas. Stubble mulching combined with minimum tillage after crops such as upland rice should be demonstrated. Care should be taken to provide some extra fertilizer to these demonstrations to ensure that there are plenty of nutrients for both the growing crop and to aid in the plant material decomposition.

F.10.1.c. Crop Varieties and Cropping Systems

Terracing or any other type of mechanical practice by itself, generally will not increase crop yields. Because of depleted condition of the soils the timely use of commercial fertilizer will be required to improve crop yields. In addition to the traditional crops (cassava, rice, corn, beans, sweet potato, and peanuts), it would be advisable to try some other dry-season crops that are more drought resistant (such as sorghum). The Panawangan Pilot Demonstration Farm is one source for specific upland farming recommendations, but it should be recognized that the soils on that project area are still relatively deep and fertile.

Root crops should not be planted on the lip of the terraces because this will damage the terrace lip when the crop is harvested. The terrace lip and riser should be planted, where possible, to grass or a grass and legume mixture for use in a cut and carry livestock program.

Crop rotations must be planned with the farmer after taking into consideration soil conditions, the steepness of the land, and the needs of the family. The farmer should understand why it is necessary to retire some land to grass and trees, and why it is necessary to use conservation measures to conserve soil.

Intercropping should be given preference over sequential planting because it usually ensures greater economic returns and a better income stability for the farmer by protecting him against the risk of a total crop failure and against price fluctuations of a one crop system. Relay planting of different crops offers some of the same benefits. Both should confer almost the same benefits as a crop rotation with regards to its effects on the soil. This is especially true if the legume may be removed for fodder. The fine root system with nodules remain in the soil to decay and supply nutrients for following crops.

Results from the Panawangan Pilot Demonstration Farm work by the ECI staff strongly indicate the need for using high yielding crop varieties, obtaining optimum plant populations, using a good fertilizer program, and controlling plant pests and diseases.

In the Panawangan Pilot Demonstration farm it was found that upland rice yields of an improved variety C-22 was about 75 percent higher than for a well established variety Sagi [8]. Upland rice varieties have only recently received much attention from the plant breeders and there is considerable hope that new high yielding varieties will be developed that can be broadcast seeded so as to provide a better ground cover than existing varieties and traditional planting systems. As previously noted, the conversion of bench terraces into the traditional ponded rice terrace should be used with caution on slopes of over 25 percent.

Most of the maize varieties seem to be of local origin, white grain, and they are very low yielding. Improved crop varieties, such as Harapan, Gengah Kertas, BC-2 and H-6, from the Crops Research Institute (CRIA) at Bogor should be tried in comparison with the traditional varieties. For erosion protection maize should generally be interplanted with peanuts, soybeans, sweet potatoes, or palawija crops.

Sorghum is a drowth resistant crop that can offer good ground cover for reducing soil losses. While farmers tend to regard it as a low class supplementary food with a limited market it should be tried experimentally, particularly as a dry season crop on terraced areas, or as an interplant with maize or cassava. Millet is also a good drought resistant crop for dry season planting that provides good soil protection.

Peanuts of the Gajah and Kidang varieties should be planted both in monoculture and interplanted systems. Peanuts should also be experimentally relay planted behind upland rice with minimum tillage.

Sweet potatoes should definitely be included in the experimental plantings because they are a good food source and the plants provide excellent ground cover as they mature. Sweet potato cuttings such as LP3, Maura, No. 396 and other varieties from CRIA should be planted about 20 cm apart for yield tests.

Cassava is extensively grown in the watershed, but as traditionally planted it is the reason for much of the erosion and soil deterioration.

Because the goal is to provide a better standard of living for upland farmers all types of vegetables should be tried on the completed upland terraces by both flat bed and raised bed cropping systems. Included are: green beans, cucumbers, tomatoes, bell peppers, long red cayennes, chili peppers, chinese cabbage, squash, cauliflower, eggplant, green onions, leeks, beets, garlic, onions, melons, watermelons, and any other types that are considered suitable on the demonstration farms.

F.10.1.d. Fertilizer and Insecticide Trials

Because the fertility levels in the pilot watershed areas is very low it is very important to develop a fertilizer program to ascertain the fertilizer application sites that will provide the greatest returns to the upland farmer. At the same time it will be useful to attempt to determine the fertilizer application rates for obtaining maximum production from the upland farms of the demonstration watersheds.

Fertilizer recommendations for rice and maize at Panawangan [8] are 150 to 200 kg/ha of urea applied in equal portions about one month apart, and 100 kg of Triple Super Phosphate (TSP) applied at planting.

For peanuts the recommendation was for 50 kg/ha of urea and 50 to 100 kg/ha of TSP to be broadcast on the surface and hoed into the top 15 cm of soil. The Panawangan work also found potassium fertilization to be beneficial, but the fertilizer is not generally available in the project area. Because the pilot demonstration watershed areas are severely eroded these recommendations are probably a minimum amount for any upland area and it is suggested that approximately twice this amount be tried on newly terraced areas.

Fertilizer inputs should be provided by the Government for a predetermined number of years as an incentive for the farmers to participate in the program. It is suggested that free fertilizer be provided the first two years after construction for practices such as terracing. Rates of application should change after experimental data are available, however, it is known that farmers quickly recognize the benefit of fertilizer, but they may not be able to afford it even at the government subsidized price of Rp. 70/kg.

F.10.2. Water Management

Water management is very important to the design of a soil and water conservation system for any watershed area. Any increase in infiltration amounts will reduce the surface runoff, and this automatically reduces the potential for erosion. This can be accomplished by increasing the vegetative cover of the soil, increasing the soil tilth to increase natural infiltration rates and by artificially decreasing the slope of the land through practices such as bench terracing. The true water management system is very complex (Figure F-2) and affected by climatic factors, soils, crops raised, fertilizer applications, and agronomic practices that are all integrated into the upland agricultural production system. Improvement in the entire physical system is necessary to reduce the water and soil losses from the system.

One of the most important features of the water management program is to ensure that all surplus, or runoff, water is disposed of in a manner that produces a minimum amount of channel or gully erosion. This almost always requires the installation of designed grassed waterways on diversion channels. Generally, it will also be necessary to provide checks or drops in these channels to reduce the natural gradients and maintain a nonerosive velocity in the waterways.

If the designed water management system is to be operated and maintai over time it is absolutely necessary for the farmer on the land to understand the reason for the structural system and why it must be maintained. The farmer must also understand both how the system benefits his crops and all of the downstream water users. Therefore, the conservation farming, and soil and water management program must focus on the adaptability of technology to conditions that the farmer under stands and can achieve. More importantly, he must be reasonably certain that it will pay him to adopt the conservation farming approach.

A particular advantage of a modern upland water management program is that it has a considerable amount of water management built into it and the farmer is automatically led to correct decisions in the application of soil and water conservation measures. A farmer will make fewer mistakes with a well planned conservation structural system with good grassed waterways than a farmer lacking the technical input regarding water management. Continued focus on improved upland water management must become a new way of life for the upland farmer if he is to continue using the upper watershed soils.

F.10.3. Land Use Adjustments

As shown on Table F-23 an estimated 9.6 ha (17.6 percent) of the Gunungsari Pilot Watershed has a slope of greater than 40 percent. These lands are almost totally unsuited to upland crop cultivation because of erosion problems. From a soil conservation viewpoint all of these lands should be returned to the natural forest cover that prevailed before man disrupted the ecosystem.

This is not possible because natural forests take a long time to grow, and the upland farmers must feed their families. The solution lies, at least in part, with a relatively new science--agroforestry--which combines food growing with sound forest management. It will not, however, solve the overpopulation problem of the demonstration watersheds. These upland areas simply have more people than can obtain a living from the available land resource. Therefore, the solution to the watershed problems must include a total program of transmigration, population control, industrialization and the development of irrigated areas to reduce the population dependent on upper watershed areas for a living.

F.10.3.a. Agroforestry

The areas selected for agroforestry have long since been nearly denuded of trees and most are so eroded as to be essentially useless for upland agriculture without some form of conservation treatment. As previously noted most of these areas have slopes of greater than 40 percent.

If agroforestry is defined as the production of food crops, trees, shrubs and domestic animals on the same piece of land the best example is frequently the homeyard areas of any village. These areas generally have high production rates because they are close to the village where they get attention and of course they are often on more productive land. Never-the-less home yards tend to combine the features necessary for successful agroforestry production; the term agroforestry does not imply that all possible uses will be made of each hectare, only that they should be considered. Some areas can logically be used only for the production of grass or trees to the exclusion of other uses. It is not possible to specify the tree; grass and legume species to be planted on the agroforestry areas, but they can be selected in consultation with the farmers and the technical agronomist. Included are:

Common Name	Scientific Name
Teak	Tectona grandis
Mahogany	Swietenia macrophylia
Sonokeling	Dalbergia latifolia
Pine	Pinus merkusii
	Leucaena leucocephala
	Calliandra talopthirsus
	Malaleuca leucadendron
	Acacia decurrence
	Accacia auriculiformis
	Albizzia falcataria
	Cassaurina equistafolia
	Eucalyptus alba
	Eucalyptus deglupta
Yemane.	Gemlina arborea
Fruit Trees	
Petai	Parkia speciosa
Jackfruit	Artocarpus integra
Mango	Mangifera indica
Cashew	Anacardium occidentable
Kapok	Eriodendrom anfractuosum
Coconut	Cocos nucifera
Sawo	Archas zapota
Clove	Eugenia aromatica
Avocado	Persia americana

Common Name (Cont.)	Scientific Name
Grasses	
	Bracheria brizantha
	Bracheria decumbens
Elephant grass	Pennisetum purpureum
Kikuyu Grass	Pennisetum claudestinum
Pangola grass	Digitaria decumbens
Setaria grass	Setaria sphacelata
Guinea grass	Panicum maxicum
Pakistan grass	
Legumes	
	Colopogonium celebrium
	Centarasirium klumare
Archer	Macrotyloma axillare syn Dalichosaxillaris
Centro	Centrosema pubescens
Greenleaf desmodium intertum	Desmodium intortum
Silverleaf desmodium	Desmodium uncinatum
Siratro	Macroptilium artropurpureum syn Phaseolus artropurpureus
Stylo	Strylosanthes guyanensis syn S. gracilis
Kudzu	Pueraria phaseolides

For the areas needing conversion to agroforestry there are two possible combinations of treatments: installation of hillside ditches followed by agroforestry planting and straight agroforestry planting.

(i) Hillside Ditches with Agroforestry Plantings

As shown in Figure F-20 and Table F-24, a total of 3.5 ha in five areas are suggested for installation of hillside ditches and agroforestry plantings. The actual desigr of the individual areas should be checked with the Greening Program Office (P_3RP-DAS) because hillside ditches are very similar in design to their normal credit terraces and greening program plantings.

The vertical interval of the hillside ditch can be determined by the equation

$$VI = 0.035\ (XS + Y)$$

where: VI = vertical interval in meters

X = variable with a value of 0.3 for humid conditions

Y = value depending on soil erodibility that varies from 1.6 to 4.0. The value of 2 is recommended for hillside ditches with agroforestry

S = Land slope in meters per 100 meters

For a 40 percent slope this becomes

$$VI = 0.305\ [40(0.3 + 2.0)] = 4.3 \text{ meters.}$$

The horizontal interval (HI) between hillside ditches is computed by the equation

$$HI = \frac{VI}{S}\ (100)$$

Therefore, the horizontal interval for a typical 40 percent slope would be 10.75 m so there would be about 930 m of hillside ditch per hectare on a 40 percent slope.

The grade along the hillside ditch should be a one percent drop towards the grassed waterway to ensure water movement.

Assuming that the average hillside ditch has an average cut of 0.15 m^2 it would require about 140 m^3/ha of excavation. Based on a production of 4.0 m^3/md (26.7 m length) for simple hillside ditches it would require 35 md/ha to build the hillside ditches on a 40 percent slope. As shown in Table F-12 this type of hillside ditch system is estimated to cost a total of Rp. 32,500 per ha including all costs for grassed waterways and engineering or administrative costs. For planning purposes average installation hillside ditches is taken as Rp. 21,000 per ha for actual construction. The cost of grassed waterways is estimated separately because the waterways also serve the terraced areas.

Without detailed topographic, soil and land capability maps it is impossible to precisely define the agro-forestry planting for specific areas, the following generalized cost estimates were applied:

	Rp
400 trees/ha @ Rp. 150/tree	60,000
Grass for Sprigging 12 Rp. 150/tree	12,000
Fertilizer 400 kg @ Rp. 70/kg	28,000
Land Preparation and Fertilizing	10,000
Planting	25,000
Total	135,000

The following areas (Figure F-20) were assumed to have a combination of hillside ditches and agroforestry practices applied for planning purposes.

Conservation Practice No. 1/	ha
B-HD-1	0.4
C-HD-1	0.7
E-HD-1	1.2
E-HD-2	0.3
F-HD-1	0.9
Total	3.5

(ii) Agroforestry Planting

Certain areas of the Gunungsari Pilot Watershed area so eroded that there is not enough soil remaining to ensure the establishment of trees. This is evidenced by the very scattered teak and other species from previous plantings. It is suggested that the primary plantings in these areas be grasses and legumes, and that they be harvested by the cut and carry system to feed the livestock in the homeyard area. The area already has more cattle and goats than it can provide with forage, without creating erosion, so there is some market for the forage. The specific species to be planted cannot be selected with the soils information available, but most of the grass and legume species should be planted experimentally to determine the mix that works the best on the Gunungsari site.

1/ The first letter of the conservation practice Number is the hydrologic area designation from Figure F-16.

The areas selected for agroforestry planting include:

Conservation Practice No.	ha
A-AF-1	0.2
A-AF-2*	0.5
A-AF-3	0.4
B-AF-1*	1.6
D-AF-1	3.2
F-AF-1	0.1
Total	6.0

* Some critical area planting is needed in this area.

When these areas are planned for construction the farmer and the Kelompok Conservation Action Unit may decide that they want to use hillside ditches and a combination of trees and grass in those areas. This change should be encouraged because the above land use changes are judgement estimates only.

For planning purposes the cost of applying agroforestry plantings was estimated at Rp. 155,000/ha.

F.10.3.b. Critical Area Plantings

The land requiring intensive rehabilitation, or critical planting is rather small for the Gunungsari Demonstration Watershed; as shown in Table F-24 it totals only about 0.5 ha. It is all located in the agroforestry areas as noted in the previous section. Critical area planting is estimated to cost Rp. 622,200/ha treated (Table F-10). The actual cost can vary considerably depending upon the severity of the problem and the urgency of its solution. If contour wattling (Figure F-21) is necessary to stabilize a steep slope and provide a place for soil to collect it may be very expensive, but in the areas of the Demonstration Watersheds that have been observed, revegetation can generally be accomplished by grass sprigging and planting brush cuttings. These plantings must be fertilized and protected from use by livestock for several years, or until the ground cover approaches 100 percent. This is the point where no soil is visible looking straight down at the area, and is seldom ever found except in mature forests or heavily fertilized pasture areas.

F.10.4. Terracing

The specific design criteria and instructions for layout and construction of terraces is rather completely covered in Appendix D - Protection of Cultivated Slopes of the Citanduy Upper Watershed Management Project [24], and sufficient copies are being furnished to allow the design team access for reference purposes. Also, since the detailed maps with a scale of 1:500 and a contour interval of 1.0 m were not available during the work period of the ECI Watershed consultant no detailed terrace designs were made. Instead the basic terrace area location and layout pattern was developed as shown in Figure F-19. It is strongly recommended that at least some of the terrace areas be field staked and constructed using this generalized plan rather than attempting the specific office design with the available maps, which do not provide the complete topographic information needed. The instructions for field staking of terraces is contained in Annex D-3 of Appendix D [24].

It should also be noted that soil surveys are at least as important to terrace design as topographic surveys because the limit of vertical interval between bench terraces is set by the available soil depth. Fortunately, the Gunungsari Demonstration Area (in spite of having suffered extreme erosion damage) generally seems to have sufficient soil size material to permit bench terracing. The general rule for determining maximum vertical intervals is to subtract 30 cm from the available soil depth and multiply by two. This is because 30 cm is a minimum soil depth for giving crops and only about one-half of the vertical interval is cut.

Because the topography of the Pilot areas is very undulating it is also specifically recommended that the width of the terrace benches be permitted to vary rather than to attempt construction of parallel terraces with uniform bench widths. This greatly increases the volume of cut and is of little value as long as the cultivation is done manually rather than with power equipment.

F.10.4.a. Bench Terracing

The planning and layout of bench terraces should always include a careful field examination of the project area to determine specific topography, slope, soil depth, soil texture problems, erosion, the presence of rocks, land use and future planned land use. For the Gunungsari Pilot area the maximum vertical interval of the bench terraces probably should not exceed 1.2 m although terraces with 1.8 to 2.0 m would probably be reasonably stable. For the flatter slopes of less than 15 percent the vertical interval should not be more than 1.0 m because the benches become wider than necessary and the volume of cut is excessive (Table F-25). For a 15 percent slope a one meter vertical interval gives a horizontal interval of 6.67 m and a useable bench width of 5.0 m.

Figure F-22 provides a cross section of a bench terrace and waterway with stone drops to illustrate the relative position of each. If bamboo wattle checks with some stone dissipators are used in the waterways they would be constructed as shown in Figure F-26.

Figure F-23 provides a detailed diagram of the necessary definitions, dimensions and properties of bench terraces. Table F-25 provides the numerical specifications for some of the possible reverse slope bench terraces that could be constructed in the Pilot Watershed Areas. The more important dimensions can be defined as follows:

S_1 = Original ground slope

S_2 = Cut slope which is 200 %, or 1H:2H

S_3 = Riser Slope which is 200%, or 1H:2V

S_4 = Reverse slope of the bench = 5%

C = Width of safety strip between the cut slope and riser slope = 30 cm

VI = Vertical Interval

HI = Horizontal Interval

b_1 = Width of terrace channel area at the rear of the terrace bench = 55 cm

b_2 = Width of terrace lip = 20 cm

W_e = Effective crop width

A_e = Area of croppable bench per hectare bench terrace within the specific S_1 and VI specifications

V_c = Volume of cut per hectare terraced

Almost any potential terrace area has some form of old traditional terrace already on the land. The challenge to the project planners and technical staff is to make the maximum use of the existing conservation system. While this looks hopeless, at first glance, it is often possible to reduce the amount of cut and fill by fitting the new bench terraces into the old system where it can provide a savings to the farmer and still result in a technically adequate bench terrace systems.

Potential terracing systems, or areas, will essentially never be all in one ownership or will the present boundaries of the farmers land fit neatly into the terrace system. This is the reason for organizing the Kelompok Conservation Action Units. The farmers must work closely together to enable waterways and terrace systems, or the land ownership system, to be modified to benefit all of the farmers. Forcing farmers to accept a terrace system designed entirely by outsiders is a certain way to cause project failure.

The average cost per hectare for bench terracing in the Pilot Watershed area is estimated at Rp. 300,000 based on the calculations shown in Tables F-14 and F-15 for slopes of 15 and 25 percent and vertical intervals of 1.0 and 1.2 m vertical intervals respectively. This cost is for the bench terracing without the grassed waterway outlet system or any of the overhead and design cost. The actual cost may vary considerably, but this can only be determined by building a sizable area of quality bench terraces as a learning experience.

The preliminary bench terracing areas as shown on Figures F-19 and F-20 are as follows:

	Conservation Structure No.	hectare
Area A	A-BT-1	1.4
	A-BT-2	1.4
	A-BT-3	2.0
	A-BT-4	0.4
	A-BT-5	1.0
	A-BT-6	1.0
	A-BT-7	0.3
	A-BT-8	1.3
	A-BT-9	0.9
	A-BT-10	0.2
	A-BT-11	0.3
	Subtotal	10.2

	Conservation Structure No.		hectare
Area B	B-BT-1		2.1
	B-BT-2		0.5
	B-BT-3		0.2
	B-BT-4		0.4
	B-BT-5		0.4
	B-BT-6		0.8
		Subtotal	4.4
Area C	C-BT-1		0.1
Area D	D-BT-1		1.5
	D-BT-2		1.1
	D-BT-3		1.0
	D-BT-4		0.7
	D-BT-5		0.9
	D-BT-6		0.5
	D-BT-7		0.3
	D-BT-8		2.8
	D-BT-9		0.3
	D-BT-10		0.2
	D-BT-11		0.4
	D-BT-12		0.5
		Subtotal	10.2
Area E	E-BT-1		1.4
	E-BT-2		1.5
	E-BT-3		0.9
	E-BT-4		0.9
	E-BT-5		0.6
	E-BT-6		0.4
	E-BT-7		1.1
		Subtotal	6.8

	Conservation Structure No.	hectare
Area F	F-BT-1	2.1
	F-BT-2	1.4
	F-BT-3	0.9
	F-BT-4	2.5
	Subtotal	6.9
	Total Bench Terracing	38.6

The tentative schedule for applying bench terracing in the watershed is shown on Table F-30. The first year goal of 2.0 ha may well be an ambitious objective, but it is important to get started on the demonstration farm area to show progress to the local people. As previously stated, the most desirable area for initiating terracing is on the south side of area A where the topography is relatively uniform and there are reasonably deep soils. This permits building relatively parallel terraces with uniform bench widths as part of the training program, more difficult sites can be developed as the staff and farmers gain experience.

F.10.4.b. Conservation Terraces

Conservation terraces are not common in Indonesia, but they are successfully applied in many similar climates of the world. They are also called by a host of names; including channel terraces, absorption terraces, road base terraces, graded terraces and others. They all have the distinctive feature of an excavated channel to carry of surface runoff, and an embankment on the downhill side formed by the spoil from the embankment (Figure F-24). Appendix D - Protection of Cultivated Slopes [24] has a complete set of design criteria, which will not be repeated in this report.

The 1.7 ha of conservation terraces planned for the Gunungsari

Pilot Watershed are all on slopes of less than 15 percent and are primarily for demonstration purposes. However, if the farmers like them there is a possibility for larger area use. Specific recommendations for these terraces is to use a 0.3 percent channel gradient in initial sections of the terrace which should be steepened to 0.5 percent as it approaches the grassed waterway. The channel sections of conservation terraces should have the same level as the bottom of the grassed waterway at the entry point. The terraces may be broad based on narrow based, but the narrow based terraces are usually easier to construct with hand labor and the broad based are easier to construct with tractors. The cross sectional area of conservation terrace channels is less precisely defined than for other channels and waterways. As a generalization the minimum channel depth should be about 25 cm and this should increase as more water capacity is required in areas near the waterway. A parabolic channel with a depth of 0.25 m and a top width of 1.5 m would have a cross sectional area of 0.25 m^2 which would provide sufficient capacity on the slopes suggested for conservation terracing. As shown in Table F-13 this type of conservation terrace on a 15 percent slope with an average vertical interval of 2.9 m, a horizontal interval of 19 m, and 526 m of terrace channel would have a total cost estimated at Rp. 36,700 per ha including the waterway costs. The average cost for conservation terrace construction in the Gunungsari Pilot Watershed area is estimated at Rp. 28,000/ha terraced.

The areas suggested for conservation terracing as shown on Figure 20 are as follows:

	Conservation Structure No.	hectares
Area A	A-CT-1	0.9
Area B	B-CT-1	0.3
Area E	E-CT-1	0.5
	Total Conservation Terrace	1.7

These areas should be viewed as suggestions only. They are included because this type of terrace is known to be effective in reducing erosion where properly operated and maintained. They are also much cheeper to construct than bench terraces (Rp. 28,000 versus Rp. 300,000/ha for bench terraces).

F.10.5. Other Structural Measures

F.10.5.a. Capacity of Waterways

Waterways or diversion channels are necessary to provide for the nonerosive flows of surplus water from terraced areas, hillside ditches, and the surface runoff from any watershed area where naturally stable channels are not available. The required capacity of these waterways is dependent upon the catchment area, infiltration capacities of the soil, slope of the watershed, cover conditions, and conservation factors such as bench terracing. In theory the determination of each waterway section would require a hydrologic investigation. Unfortunately, reliable figures for short duration rainfall intensities are not available for precise hydrologic studies, and generalized estimates have proven satisfactory for conservation works design.

NEDECO [28] provided an analysis of the maximum rainfall intensities in the Tuntang catchment for the December-March high precipitation period. Unfortunately, these record are for 24 hour periods. The average of the three analyzed stations in the Tuntang Subbasin for the 24-hour, 10-year frequency, rainfall is 147 mm, and somewhat surprisingly the equivalent 100-year frequency precipitation is only about 200 mm for the same stations. An examination of some limited peak rainfall intensities for Indonesian conditions indicates the following short term rainfall intensities for about a 10-year frequency storm would be acceptable for design purposes [24]:

Duration (minutes)	Intensity (mm/hour)
5	300
10	240
15	190
20	180
30	150
40	135
50	120
60	110

The maximum rate of runoff for designing grassed waterways and diversions can be estimated by the "Rational" Formulae which is

$$Q = 2.78\ ACI$$

where Q = Design flow in liters per second (l/s)

A = Drainage area in hectares (ha)

C = Runoff characteristics depending on the soils and watershed condition.

I = Rainfall intensity in millimeters per hour (mm/hr) for a period approximately equal to the time of concentration.

The areas of runoff determination, for small hydrologic units, are generally less than five hectares so the Rational Formulae should work satisfactorily to estimate design capacities.

An examination of the limited data available for "C" values indicates that for heavy soils the following values would be applicable:

	"C" value
Bench terraced	0.15
Hillside Ditch with Agroforestry	0.25
Agroforestry Plantings	0.38
Upland Crop without Conservation	0.50

Determining the time of concentration as a means of determining the proper mm/hr rainfall intensity for the terraced areas is difficult. The Solo project experience suggests that because there is considerable ponding on the terrace the drainage channel will reach capacity in about 5 minutes [30]. The Kerpich formula [28] applied to the grassed waterway system in Hydrologic Area A indicates a time of concentration of about 10.7 minutes based on a length of 605 m and an average slope of 8.4 percent (Table F-26). This would be a velocity of about 0.9 m/s which may be slightly low, but the total time of concentration of 15 minutes should be realistic for hydrologic analysis.

For simplicity of evaluation the time of concentration for a 1.0 ha drainage area is taken as 10 minutes, which gives a rainfall intensity of 240 mm/hour, and for the 5.0 ha area it is taken as 15 minutes with a rainfall intensity of 190 mm/hour.

The results of these runoff calculations for the 10-year rainfall rates are summarized in Table F-26 for areas from 0.5 to 5.0 ha. This analysis indicates that the 10-year frequency present condition runoff from a one hectare area would be about 345 l/s, and by bench terracing the area this could reasonably be expected to reduce the runoff to 100 l/s. Smaller, more frequent, storm events would possibly yield almost no runoff from the bench terraced areas.

F.10.5.b. Waterways and Drop Structures

As previously noted, the design of a conservation plan for a small watershed unit starts with the design of a waterway system to provide for the nonerosive disposal of surplus water. This require the development of a system of grassed waterway outlets for all terraced areas and diversion channels to the point where the water can be delivered to a stable stream channel.

Because the base maps for the Pilot Watershed Demonstration Areas do not provide the detail necessary for specific engineering design of construction plans, the Gunungsari Pilot Watershed waterway plans are generalized as to location and drop structures are not specified. It is, however in sufficient detail to permit an experienced agricultural engineer to supervise field staking for construction. To simplify the design and construction problems all waterways or diversion channels are assumed to be constructed with trapezoidal ditch sections. The side slopes are estimated at 1H to 1V with the knowledge that this approximates the shape of the parabolic ditch section that all grassed waterway develop with use. The maximum permitted channel gradient is 3 percent, to make certain that the design velocities remain below the safe velocity of about 1.2 m/s, although for special situations grassed waterways with wide shallow sections may have gradients of up to 20 percent [8, 24, 31, 32]. The previously mentioned Appendix D from the Citanduy Upper Watershed Project also has a rather complete section on the Design of Hydraulic Channels starting on page D-41.

It should be noted that where there is a continuous flow of water the grassed waterways must be modified to provide a V-shaped stone lined section to carry the permanent flow because grass will be drowned by continuous water in the channel.

Table F-27 provides the specifications for some standard trapezoidal grassed waterways will 1:1 sides and a 3 percent channel gradient with capacities from 50 to 1,000 l/s. As a generalization the depth of the waterway should be approximately twice that required for passing the design flow. Also, for simplicity it is recommended that the minimum size of grass waterways constructed would have a design capacity of about 50 l/s, which requires a 25 cm bottom width and about a 25 cm depth. As can be noted from Table F-27 this size of waterway has a maximum capacity of about 110 l/s or double the design capacity. The cut material from grassed waterways is added to the terrace benches or spread in adjacent areas where it does not prevent water entering the channel.

For sizing actual grassed waterways it is recommended that the total drainage area served by the grassed waterway be determined, which can then be used to determine the maximum design capacity by interpolating Table F-26. The minimum recommended design capacity is 50 l/s and the intermediate sections can be increased linearly along the length to the maximum design at the waterway outlet. Where two waterways join, it is recommended that the joint capacity be made the total design outflow of the two waterways feeding the lower section because the peak flows from each may coincide.

The preliminary grassed waterway and diversion channel system for the Gunungsari Pilot Watershed area is shown in Figure F-18. The grassed waterway design details are summarized in Table F-27. This analysis shows that at least 4,150 m of grassed waterways are needed in the 54.4 ha Gunungsari Pilot Watershed and that those waterways have a natural ground profile with 536 m of elevation change for an average of 12.9 percent slope. To maintain a 3 percent slope in the waterway will require 418 m of elevation change to occur in drop structures. The maximum estimated design capacity is 860 l/s for grassed waterway A-GW-1 which is the principal waterway for Hydrologic Area A and drains 11.3 ha total area. The total area served by the grassed waterways is

42.8 ha, or 79 percent of the total area. The average design capacity is 350 l/s.

For cost estimation purposes it was assumed that the cost per m^3 of cut was Rp. 450, and the cost per meter height of drop structure was Rp. 9,000. The volume of cut was estimated using an equation developed by simple regression analyses of the standard channel sections in Table F-28. Because most of the waterways are in natural drainages, and to account for the variation in size along the length of the waterway where only the maximum capacity is given, the volume of cut per meter of length was adjusted downward to 55 percent of the maximum cross section.

The cost estimation for grassed waterways was determined by the equation:

$$GW_c = (0.242 + 0.001065\ DCP)\ 450\ L + 9{,}000\ Ds$$

Where GW_c = Grassed waterway cost (Rp.)
DC_p = Maximum Design Capacity of grassed waterway
L = Length (meters) of grassed waterway
Ds = Elevation at Drop structures (meters)

The results of the cost calculations for each of the grassed waterways is shown in Table F-28. The total estimated cost of grassed waterways is 4.9 million rupiah, or Rp. 1,184/m of length. The drop structures are a major portion of this cost with 3.76 million rupiah or about 77 percent of the total. This estimate was based on building all drop structures with stone on the basis that the project works would be much more permanent, and require little maintenance. The initial cost would be somewhat less using bamboo drops with stone dissipators, but they would have much higher maintenance costs.

It is extremely important that, where possible, the waterways should be constructed a year before the terraces and diversions that feed into the waterways. After construction the waterways sides and bottoms should be made as smooth as possible and heavily fertilized with equal part of Urea and TSP at a rate of about 400 kg/ha or 40 g/m^2 to restore fertility to the channel area. The fertilizer should be worked into the top 10 cm of the soil and the waterway should be sprigged or sodded to one of the following grasses, or the native sod forming grasses if the introduced species are available:

Kikuyu grass	Penninsetum clandestinum
Setaria grass	Setaria sphacelata
Pangola grass	Digitaria decumbens
Bahia grass	Paspalum Notatum

It is very important that the waterways be maintained with a good grass cover that is never cut shorter than about 15 cm. Livestock grazing of waterways is not recommended.

F.10.5.c. Diversion Ditches

Because a total of 43.8 ha (81 percent) of the total Gunungsari Pilot Watershed is suitable for bench terracing, conservation terracing, or hillside ditches, the soil and water conservation program requires only two diversion channels to protect developments from runoff areas lying above terracing or other features. The possibility of failure for hillside ditch systems may make it advisable to install some additional diversions below these areas during actual construction, or after any problems are experienced. Figure F-25 shows a typical cross section for a diversion channel.

The first diversion channel B-DV-1 in Hydrologic Area F is 100 m in length and drains a maximum of 1.8 ha of land suited only to agroforestry. From Table F-26 this diversion would need a design capacity at the outlet of approximately 400 l/s. Because this area has shallow soils the average capacity of the channel was increased to 400 l/s, with a minimum of 100 l/s and a maximum of about 600 l/s. A channel gradient of 3 percent is recommended to produce sufficient velocity for sediment transport. For B-DV-1 the average bottom width would be 1.0 m and have a design depth of 27 cm to provide a 400 l/s capacity with 1:1 side slopes. The channel should have an average cut depth of 50 cm for an 0.75 m^3 cut/m of length. Because for diversions all excavated materials is placed on the downstream slope, the channel would have a maximum capacity in excess of 1,200 l/s. The cost of this diversion is estimated at Rp. 241/m, or Rp. 24,100 for the 100 m diversion.

The other diversion channel, F-DV-1, is 150 m in length and is designed to have an average capacity of 250 l/s throughout most of its length. This diversion channel receives the runoff from approximately 0.9 ha of planned agroforestry land that is in a severely eroded condition. Based on a 3 percent channel gradient and 1:1 side slopes the bottom width would be 75 cm and the depth of flow would be 24 cm to carry the designed capacity of 250 l/s. As designed, the channel would have a cut depth of 50 cm for a volume of cut equal to 0.625 m^3/m of length. This channel would have a maximum capacity of approximately 950 l/s and is estimated to cost Rp. 36,100.

During field staking it may be found desirable to flatten the gradient of these channels, in which case the channel section should be enlarged to account for the reduced velocity. If experience shows that the waterways will not be maintained it may also be better to increase the size of the channel to prevent overflows.

As soon as the diversion channels are constructed, an effort should be made to vegetate the entire channel and downhill embankment section using the fertilizer application rates and grasses recommended for grassed waterways. The diversion channels should be inspected after major storms, sediment cones should be removed from the channels, and eroding spots relaid. It normally takes about two years for diversion channels to become well stabilized, and during this period they should receive fertilizer applications and be protected from livestock. If grass is harvested from the diversion channels care should be taken to leave about 10 cm of growth at all times.

F.10.5.d. <u>Gully Stabilization</u>

As previously noted most of the main stream channels of the Gunung-sari Pilot Watershed have eroded to bedrock and are stable. Further-more, the general installation of conservation measures in the water-shed will divert water away from many gullied areas, and permit the eroded areas to heal naturally. However, it is not always possible to keep runoff water out of gullies, and then water must be allowed to flow in the existing eroding channel. Restoration in this case will require a combination of vegetation and structures at critical points in the gully.

Gully treatment under these conditions generally requires changing the gradient of the channel to flatter slopes so that the water will be travelling at a nonerosive velocity. Grade stabilization structures may be required at overfalls, gully headcuts, abrupt changes in channel gradient, entrances of branch gullies or other critical points. Basi-cally grade stabilization structures are installed to reduce veloci-ties and gather soil for the installation of vegetation that will stabilize the channel of bed gradient.

To be permanent, a grade stabilization structure must have a stable downstream grade with no degrading after the protective measures are constructed. Care must also be taken to provide sufficient spill-ways in all structures so they will not be overtopped or bypassed.

Care must also be taken in the clearing and excavation of the site because the weakest point of any structure is where it ties into the sides and bottom of the gully.

It is very important to understand that partial gully stabilization programs are never successful, and often end up causing more severe problems than existed before. The reason most gully stabilization programs fail is that the planner or designer did not understand what caused the gully in the first place. One cannot design a control system if he does not know what caused the problem. An analysis of the Gunung sari Watershed strongly indicates the base cause for most of the gullying is the increased rate of runoff from the denuded and eroded upland areas. All of the conservation programs suggested in this section are designed to solve this problem.

It is also important to understand that even in gully control, vegetation is the first line of defense against erosion. It is also true that a bag of fertilizer is almost always more effective than a bag of cement. The purpose of vegetation is twofold. It provides physical protection against scour and also reduces the velocity of flow by increasing the hydraulic resistance of the channel [12]. Care must be taken, however, in planting trees in the channel because a large tree frequently acts to divert the flow against an unprotected bank.

(i) Bamboo Wattle Checks

Bamboo wattle checks are the most common form of grade stabilization structure in most areas where bamboo grows naturally. This is frequently a function of the lack of stone and the cheapness of the bamboo. Figure F-26 provides the cross section drawings necessary for installation of simple bamboo checks. In general, these check/drops are only suited to use where vegetation can take over within the estimated three year life of the structure, or where the structures will be replaced when they deteriorate. Unfortunately, this cannot even be guaranteed where they are used for drops in bench terrace areas.

Based on the calculations in Table F-17 the bamboo wattle checks with stone dissipators can be expected to cost about Rp. 7,667 each. These bamboo checks were not specifically located for design purposes but about eight of them should be installed in small gullies for demonstration purposes. This is estimated to cost a total of Rp. 61,300.

(ii) Loose Rock Check Dams

One of the most effective erosion control or grade stabilization structures is a loose rock check dam. One of the main reasons for this is that they are very porous, as originally constructed, and the water passes through them. This materially reduces the forces acting on the structures, and it also reduces the flow through the spillway area on the crest. Loose rock may be used to build a variety of check dams including loose rock only, or the rock may be reinforced with wire mesh (gabions), steel posts, wire and other materials. The rock may also be hand placed or simply piled into the prepared area.

The basic design of the loose rock check dam is shown in Figure F-27, and specific design criteria can be found in a repor by Heade [25]. The most important feature for installation is to make certain that the structure is properly keyed into the gully sides, bottom and the apron area. The structure should be keyed into the sides and bottom of the gully from 30 to 50 cm depending upon the size of structure. This prevents flow from by-passing the structure. The spillway section should have a cross section area amounting to 2 or 3 times that for the gully bottom. The maximum height of the loose rock structure is about 2.0 m (measured to the crest of the spillway), and the apron area should be 1.5 times the height of the drop for channel gradients of less than 15 percent and 1.75 times for steeper gradients. The end sill should be no more than 15 to 25 cm above the natural gully bottom or it may create turbulence, and care should be taken to be certain that the apron is below the natural gully bottom level.

The loose rock check dam is easily modified to provide for gully headcut control as shown in Figure F-28. The control of head cuts to stop the headward extension of gullies is an important feature of gully treatment. The most important factor in the success of the treatment is to excavate the headcut wall (area b of Figure F-28) to such an angle that the fill materials can be placed in layers of increasing particle size, from fine to coarse sand and on to fine and coarse gravel, and finally a rock surface. This provides a porous inverted filter that leads the water from larger to smaller openings in the initial transition area of the gully headcut control structure. The balance of the structure is a standard loose rock check dam. In the Gunungsari Pilot Watershed no specific sites were observed where this type of structure should be used. Instead the headcut should be treated by diverting the water away from it in the terracing program.

It is important that the rock is well graded with no rocks with less than 10 cm diameter to permit flow through the structures. A recommended rock gradation would be as follows [25]:

10-14 cm	25 percent
15-19 cm	20 percent
20-30 cm.	25 percent
31-45 cm	30 percent

Small loose rock checks with about 1.0 m^3 of material are estimated to cost Rp. 9,000 per structure and large structures with an average of 4.5 m^3 are estimated to cost Rp. 37,500 per structure based on the cost analyses in Table F-18 and F-19.

The loose rock drop structure for the Gunungsari Pilot Demonstration Watershed could not be accurately located on the available 1:2000 scale topographic base map with 2.5 m contour intervals. Most of the gullies concerned are about one meter in depth and are not defineable on the base map. Many of the gullied areas will also be treated as a part of the terracing and grassed waterway construction program. As a result the number of small and large structures for each hydrologic area was estimated by field examination and discussion with the counterpart staff. For costing purposes the following structures are estimated by hydrologic area:

Hydrologic Area	Loose Rock Check Dams	
	Small 1.0 m^3	Large 4.5 m^3
A	2	
B	6	
C	6	2
D	5	3
E	8	2
F	4	
Total	31	7

The estimated 38 loose rock drop structures would have an estimated construction cost of Rp. 541,500.

(iii) Rubble Masonry Checks

The rubble masonry check dam is a more complex structure and requires detail surveys and engineering designs that are beyond the scope of this report. However, this type of structure is well understood by the Jratunseluna Basin staff since it is commonly used for small irrigation diversions on farmer systems. As shown in Table F-20 this type of structure with an estimated volume of 7.0 m^3 of rock would have a construction cost of about Rp. 124,200.

As examination of the Gunungsari Pilot Watershed disclosed only one suitable site for this type of structure. In Hydrologic area D at about elevation 100 m MSL there is a narrow spot in channel that fits the design requirements for a rubble masonry check. This area is eroded into bed rock which makes it easy to key the structure into bedrock.

Morover the development of a check that would raise the water about 1.5 m would permit the irrigation of perhaps 0.3 ha of home-garden area very near the Gunungsari village. Together with the terracing program upstream it is felt that this structures may cause deposition of sediment upstream to the point that it might develop a small water table and aid in prolonging the dry season stream flows. The upstream terracing program would also aid in prolonging streamflow because of the increased infiltration rates.

(iv) Gabion Retaining Wall

Gabion are a rather expensive type of structural measure for most erosion control work, but they are effective in controlling streambank erosion or providing large porous type check dams in poor construction sites where the wire baskets are needed to maintain structural shape with settling and other problems. As shown on Table F-21 a gabion structure with a total of 7.0 m^3 of rock and using 15 small gabions would have a construction cost of about Rp. 130,000 per structure.

There is one area in the Gunungsari Pilot Watershed where this type of structure may be applicable. This is in Hydrologic Area F at the point where the proposed grasses waterway F-GW-2 would discharge into the Kali Losari. This area has over a 2.0 m vertical drop and the bank is currently having problems with severe streambank erosion. This area seems to be unstable with some landslides into the river and there is considerable bank undercutting by the stream at this point. This structure would require a detailed survey and engineering design, and is estimated to cost Rp. 130,000.

F.10.6. Road and Trail Erosion Proofing

The only road in the Gunungsari Pilot Watershed runs along the south east side of the area in Hydrologic area D. This road has been paved with stone, but has deteriorated from lack of maintenance and there is considerable erosion in the roadside ditches. A particularly bad portion of this road is technically not within the hydrologic boundary of the watershed. This section is immediately west of Desa Gunungsari along the west side of the road from about elevation 85 m to 105 m MSL for 140 m. This steep area should receive intensive treatment as part of the demonstration of road erosion proofing for erosion control. There is also considerable erosion from road surface runoff and other problems on about 500 m of this road along the east side of Hydrologic Area D. For at least a portion of this area it is suggested that an attempt should be made to combine the roadside ditch and grassed waterway D-GW-5 in one channel to carry all of surplus water from both the road and the terraced areas. Alternatively it may be possible to divert some of the runoff across the road in a culvert at an elevation of about 122 m MSL where there is a stable natural channel on the east side of the road.

The cost of road erosion proofing would include repairing the stone paving, installing loose rock drop structures in the roadside ditches, revegatating roadside cutbanks, and ditches, and installing needed cultverts to carry water across the roads. Since there is no specific experience to draw upon in this case, and because this section of road does not have severe problems, it was decided to use 10 percent of the calculated cost for building a new district road from Table F-22, or Rp. 702.70 per meter of road treated. Therefore the cost of treating the 640 m of road described above would be Rp. 449,700. If this amount is not required for this section of road it is recommended that a portion of the road from Gunungsari west to Repaking be erosion proofed as part of the project demonstration work.

F.10.7. Estimated Cost Sharing for Conservation Measures

The determination of the needed government contributions to induce farmers of a district to apply conservation measures is difficult to determine without actual experience. However, it is known that if the farmers do not contribute a substantial part of the total cost of conservation works they tend to consider the measures as strictly a government project; then when repairs or maintenance are needed they want the government to pay for the work. The initial installations at Solo, all had this problem of being considered a government project and the farmers did not maintain the terraces or waterways.

Experience in other areas of the world seems to indicate that if the farmer's input is at least one-half of the total cost he is more apt to consider it strictly as his project. Of course various conservation measures provide different benefits to the government or the farmer. Terracing has a high benefit rate to the farmer while streambank protection primarily benefits the government.

In examining this problem it is obvious that the principle contribution the farmer can make towards a project is his labor. The cost sharing rates suggested on Table F-31 were developed by an analysis of each conservation measure. They are designed for the demonstration project only, and should be modified as experience is gained in the installation of specific measures. The goal of this cost sharing arrangement was for the government and the farmers or vaillagers concerned to each contribute 50 percent of the cost of construction. The government was assumed to contribute 100 percent of the cost for contingencies (15 percent), engineering design (8.5 percent), and administration (10 percent). This results in an estimated cost sharing of the 26.3 million Rupiah cost for conservation measures of 37.8 percent (Rp. 9.9 million) by the farmer and 62.2 percent (Rp. 16.4 million) by the government. While this has a high government cost it should be remembered that this is a pilot demonstration area.

F.10.8. Kabupaten Boyolali Costs

The major focus of any integrated watershed management program should be at the Kabupaten level. This permits the Bupati and his staff to coordinate all of the conservation activities within the district with a view towards solving the more critical problems first. This also permits the available resources to be concentrated in villages where the people have learned about the soil and water conservation program, and have asked for assistance in the conservation effort.

The Bupati is already responsible for the day-to-day operation of any land and water development project in his area. It is also recognized that the Gunungsari Pilot Watershed Demonstration Project is a rather small project, but it will require some specific budget allocations to provide the needed staff and inputs to ensure the success of the project. Table F-33, provides an estimated breakdown of the probable cost for the direct assistance to the Gunungsari Project.

The projected costs include one-half of the time for a senior agronomist to supervise the project based on a rate of Rp. 50,000 per month for the position. Other projected personnel costs include up to three full time extension staff (PLP or PPL) to train the farmers in conservation farming methods and to aid in obtaining the best seeds and plant materials for the specific farm operations. This position is tentatively budgeted at Rp. 25,000/month. To directly assist the farmers on a continuing basis it is suggested that there be two Desa Conservation Technicians permanently assigned to the project area. This position was budgeted at Rp. 15,000 per month. The specific personnel costs would of course be determined by staff availability and must be adjusted by the Bupati as necessary.

The agricultural inputs necessary to change the Gunungsari Watershed farmers from subsistence farmers to commercial type conservation farmers is poorly defined because there is no specific experience to serve as a guideline. The improved seeds and plants were estimated on the basis of Rp. 8,000/ha terraced that year, plus a general Rp. 40,000 additional for other areas. The fertilizer input was estimated as 400 kg/ha the year of terracing, 200 kg/ha the year after terracing, and 1,000 kg for other uses priced at the government subsidized price of Rp. 70/kg. The honeybee hives, improved livestock, and fingerling fish are included as possible factors to introduce additional income source to the village. The specific inputs can only be determined as the work progresses.

The training and assistance costs or other costs are included to cover the basic costs necessary for these items. The educational function of the project is the most important part of the program because unless the farmers understand the total conservation program and how it will benefit them they will continue with it when the project has to have the necessary training and transportation funds to be able to accomplish the training objectives.

The total estimated 5-year project cost for Kabupaten Boyolali amounts to 20.5 million Rupiah or 30 percent of the project cost. This is a high cost per hectare treated because it is a pilot project designed for learning how to do it properly. It is also possible of course that the Bupati staff may find that the objectives may be accomplished with less funding.

F.10.9. Other Project Cost

F.10.9.a. Tools for the Demonstration Watershed

A number of special tools, supplies and technical instruments will be required to make the technical implementation of the project efficient and provide some of the basic tools needed for construction. These items are listed on Table F-34 and amount to a total of 1.7 million Rupiah. The survey instruments may be available for some other source and could therefore be eliminated from the budget. However, the surveyors level is nearly essential for staking terraces. It need not be built for great precision, but it must be very sturdy and not subject to damage.

F.10.9.b. Detailed Soil Survey

As previously stated, detailed soil surveys and a land capability classification are essential to the detailed planning of conservation farming methods. Because of the small area involved, these surveys are expected to cost about Rp. 506,000 or Rp. 9,200/ha.

F.10.9.c. Socio-Agro-Economic Survey

As discussed in a previous section it appears that Satya Wacana Christian University at Salatiga is very well qualified to do the baseline survey for the project and it should cost approximately Rp. 500,000 in the initial project year. It is just as important that this study be repeated at the end of the project period to determine the changes that have resulted from the soil and water conservation program in the demonstration watershed.

F.10.10. Rainfall, Runoff and Sediment Measurement

The contract specified that a sediment measuring device was to be included in the design of the project pilot demonstration project. This is difficult item because a true sediment measuring program is only accomplished by a fully staffed group that would be on site when runoff events occur. This is extremely expensive and only justified for a research type program that would be followed for many years. The Panawangan Pilot Watershed Project illustrates this problem; in 1979 after more than two years of project funding no useable runoff or sediment measurement data had been collected [33]. The consultant is also aware of other pilot watersheds with sediment sampling objectives that did not result in useable data. Therefore, the measurement program for the Gunungsari Pilot Watershed attempts to provide a maximum of useable data with as small a potential for failure as possible. This program is described in specific meteorological, runoff and sediment measurement sections.

F.10.10.a <u>Meteorologic Measurements</u>

The minimum meteorological data to be collected for the Gunungsari Pilot Demonstration Watershed would be information on precipitation amounts and intensities. However, it is much more useful if a complete meteorologic section is established, and the data carefully recorded and analyzed. The consultant recommends the establishment of a complete meteorological station which is estimated to cost 2.3 million Rupiah (Table F-35). If only the precipitation data were to be collected the cost would be less than 1.0 million Rupiah.

The cost of operating and maintaining the meteorological station is estimated to be about Rp. 5,000 per month. The weekly changing of the rainfall intensity charts and the reading of the standard rain-gages can be done by a Desa Conservation Technician, but their work must be carefully supervised by the project hydrologist.

F.10.10.b. <u>Runoff Measurements</u>

As previously stated it is hoped that the demonstration farm area and most of the initial construction work can be developed in Hydrologic Area A. This area is basically more suitable for use as a demonstration farm and it is also suited to the measurement program.

If Hydrologic Area A becomes the Gunungsari demonstration farm area the streamflow measuring device should be installed in the channel of grassed waterway A-GW-1 at a point just below where it is joined by A-GW-3 (Figure F-18). This is approximately 136 m up the channel of A-GW-1 at an elevation of approximately 87 m MSL. The actual location of the measuring device should be determined by the project hydrologist and the engineer in charge. At this location the natural drainage area would be about 9.6 ha, but this will be modified by the grassed waterway and terracing system as it is constructed. Therefore, a careful survey must be completed of the actual drainage area above the measuring area for project analysis.

The consultant recommends that a Parshall Flume with a stilling well and automatic water level recorder (Figure F-28) be installed as the measuring device. As shown on Table F-28 the maximum design capacity of A-GW-1 is 860 l/s. To provide additional capacity in the Parshall Flume it was decided to recommend a flume with a 1.22 m throat width and a flow capacity of about 1,500 l/s. It is recommended that the flume be equipped with an Ott Type water level recorder, and that this instrument should be securely housed as shown in Figure F-28. There is some chance of stream flows exceeding this capacity before terrace completion, but larger flumes do not measures small flows at all. The suggested flume would have a minimum flow measurement of about 20 l/s if properly constructed, and the project hydrologist will need to provide a means of estimating the base flow in the waterway. A V-notched weir is more accurate for measurement of low flows but is suggested.

Based on recent experience at Panawangan [7] the recommended Parshall flume can be constructed for about 1.33 million Rupiah. The water stage recorder (Ott Type) would cost an estimated 3.0 million Rupiah. The total cost of the surface runoff measuring site would be 4.33 million Rupiah. The annual cost of operating the streamflow measuring device and analyzing the data would be about Rp. 120,000

To ensure accuracy of measurement with the Parshall flume the following factors should be observed in planning and installation of the flume:

1. The flume should be placed in a straight section of the channel, and it should not be immediately below a construction in the channel. This should not be a problem with the grassed waterway channel which can be modified in the upstream section to provide a straight smooth section.

2. Care should be taken to prevent bypassing the measuring site in high flows, or to provide a means of estimating these flows if they cannot be prevented.

3. The flume must be aligned with the channel and the flume must be level longitudinally and laterally. The staff gages and the water level recorder must zero at the level bed of the flume.

4. The dimensions of the flume should be carefully checked after construction and any deviations should be accounted for by an adjustment in the discharge rating curve or tables.

After installation of the flume, periodic maintenance is required to insure satisfactory operation. Moss may collect on the walls of the entrance section and debris may collect on the floor and they should be removed. The levelness of the entrance floor should be checked after a few months and again at periodic intervals thereafter. Sediment collected in the stilling well should be removed and the inlet tube should be checked for stoppages. The water level recorder should be checked and serviced regularly.

F.10.10.c. Sedimentation Measurement

The objective in attempting to measure sediment production rates on a Pilot Watershed is to show the effects of the treatment program being applied in the watershed area. To have any scientific validity, however, it would be necessary to develop a very long term research program using paired watersheds. Two similar sized watersheds in the region are chosen for their similarity in physical characteristics. Then these watersheds are instrumented and all possible hydrologic and erosion data is collected for at least five years, after which one of the watersheds would be treated with conservation practices and the results compared for a period of perhaps 10 years. This type of program is very expensive and obviously not suited to the proposed projects budget limitations and short time frame. As previously mentioned a number of Pilot Watershed Projects have attempted the combination of field application of conservation measures and research type analysis of results and generally produced no useable results.

Therefore, the consultant recommends that the specific sediment measurement objectives of the Gunungsari Pilot Watershed Project be simplified. The revised sediment measurement objective might be stated as, "to provide a relative indication of the erosion rates experienced in an approximately 10.9 ha pilot area during and after application of a soil and water conservation program. To do this it is suggested that two types of measurements be made: first, a series of erosion transects on land that will be left in agroforestry are not terraced for at least four years, and second, that an earth type gully plug be installed near the outlet of Area A to collect the sediment in the surface runoff from the site.

At least six transects should be selected. Each erosion transect should be constructed with 25 steel rods 0.75 m in length with the top 5 cm painted white. These are placed in a straight line at one meter intervals and driven in the ground to the point where the white paint touches the soil surface. Than the elevation at the top of the rod is taken in relation to a permanent concrete bench mark to allow a reference point to make certain the rods have not been disturbed. The distance from the top of the rod to the ground surface is then recorded and this measurement is repeated at least twice a year to determine the erosion rate on that transect. The cost of these measurements is estimated at Rp. 20,000 per year since they can be made in construction with other surveys on the sediment trap.

The transect rods can be made from 1 cm or larger steel reinforcing rods embedded in concrete, which have the advantage that they are hard for children to remove. The farmers in each organized Kelompok Conservation Action Units must understand the purpose of the erosion transects and be made responsible for the pins in their hydrologic units.

Although there are many other indicators of upland erosion, such as pedestaling of stones or exposure of tree roots, the transect pins provide something that vividly strikes home to the reviewer how bad the erosion problem really is in that area.

The other recommended type of visual erosion measurements is provided by the installation of a large earth fill gully plug (dam) near the outlet of the watershed. This gully plug will collect most of the sediment from the area and provide a visual and reasonably scientific means of measuring sediment being transported. The structure will not trap all of the sediment so periodically a grab sample of water should be taken from the emergency spillway when it is operating to provide an estimate of the amount by passing the structure.

Sediment measurement in the gully plug sediment trap is accomplished by gridding the potential deposition area after construction is completed to provide a measurement point for each square meter. This grid is permanently established by reference points permanently installed on the banks and the reservoir embankment. Care should be taken to include upstream areas above the high water line. Then the grid reference points are surveyed and recorded. Once a year they are resurveyed and the sediment volume collected is determined.

The gully plug site near the outlet of Hydrologic Area A has a limited storage capacity. Based on a measurement of the one meter contour intervals a 1,820 m^3 storage capacity is available at a water depth of 3.0 m and a maximum surface area of about 930 m^2 as shown in the following calculation:

Elevation m MSL	Surface Area m^2		Storage Capacity m^3
84.5	0.0		
85.0	196.8		90.4
86.0	483.9		340.4
87.0	683.8		583.9
87.5	926.6		805.2
88.0	1,169.4		
		Total	1,819.9

Figure F-80 provides the location and design of this gully plug and sediment trap. This site is desirable for a gully plug both because the channel construction reduces the volume of fill required and because the site has a nearly ideal natural emergency spillway location available at an elevation of about 87.5 m MS[illegible]

Because this gully plug will have a contributing area of about 10.9 ha if the terracing system is built as expected, and because up to a 100 mm runoff could occur from a major storm event, the volume of runoff could exceed 10,900 m^3. This is roughly 6 times the capacity of the proposed gully plug so a good emergency spillway is needed. The emergency spillway is 120 m long and has a natural slope of 5 percent. Considering the infrequent use of this spillway this should not present problems as long as the grass is well maintained and the flow is shallow in the waterway. Grassed waterways of this type can stand periodic flow velocities of up to 2.5 m/s. The emergency spillway for this gully plug should be built with a trapezoidal flat bottom section 5.0 m in width, a depth of 0.5 m and 1:1 side slopes. This configuration would give it a capacity of about 2,750 m^3/s with a flow depth of 0.25 m assuming a 5 percent gradient and Manning's value of 0.04. This capacity is equal to 250 l/s per hectare of contributing area. The maximum flow capacity of this emergency spillway at a 0.5 m depth is greater than 8.0 m^3/s.

The emerging spillway excavation will amount to a calculated 275 m^3 and the sodding sprigging would amount to 640 m^2.

It is suggested that the Gunungsari gully plug and sediment trap be installed as a dual purpose structure by installing a pipe in the bottom to release about 0.5 l/s into a small fish pond which could be constructed in the channel immediately below the structure at an elevation of about 83.5 m MSL. This would provide an ideal site for the fishpond because the gully plug would trap most of the sediment and pass relatively clean water to the fish pond. As the terracing and other conservation works began to take effect it is believed that this area will also develop a base stream flow for at least a major part of the dry season. Ultimately, there is a possibility that a small area in Hydrologic area B could be irrigated with releases from the gully plug damsite. Because of the small release rates required it is suggested that the 5 cm pipe with concrete cut off collars be installed in the bottom of the channel. Inside the reservoir provision should be made to install and support a variable length riser with a valve to permit draining the structure.

The planned gully plug and sediment trap should be constructed with a stone and sand filter placed at the toe of the plug in the same manner as for a dam, but a core wall is unecessary. Good compaction of the embankment using moist fill material is extremely important during construction. A core trench along the centerline (estimated at 31.5 m^3) is suggested as is a careful stripping of the embankment site. Assuming a crest elevation of 88.5 m MSL and a channel elevation of 84.5 the gully plug would be 4 m in height. Using a 2.5H to 1.0V upstream and 2.0H to 1.0V downstream embankment would result in a total embankment volume of 320 m^3. This fill/capacity ratio (320/1820) of 5.7 is unusually good in that many gully plugs have ratios of 1 to 2.5 [5].

The estimated construction cost of the planned gully plug and sediment trap is as follows:

Item	Rp
Core Trench Excavation 31.5 m^3 @ Rp. 500 /m^3	15,750
Embankment 320 m^3 @ Rp. 900/m^3	288,000
Pipe (5 cm) and valve to drain structure-installed with cut off collars and pipe support tower	124,000
Emergency Spillway excavation 275 m^3 @ Rp. 250/m^3	68,750
Sprigging and Fertilizing emergency spillway 640 m^2 @ Rp. 20/m^2	12,800
Special Surveys and monument locations for Grid System after construction	50,000
Total estimated Cost	559,300
Contingencies (15%)	83,895
Engineering Design (8.5%)	47,540
Administration (10%)	55,930
Total Cost	746,665

The annual cost of the surveys and analyses to determine the volume of sediment deposited are estimated at Rp. 100,000 per year. Thus, the cost of operating the soil erosion transects and the sediment trap would be Rp. 120,000 per year including the analysis of grab samples of the emergency spillway flow when it occurs.

F.10.11. <u>Gunungsari Pilot Watershed Project Cost</u>

.able F-36 summarizes the estimated 5-year project costs for the Gunungsari Pilot Watershed in terms of January 1980 values. To provide project budgeting all of these costs will have to be indexed upward to account for increased wages, transportation costs, changes in the exchange rates for foreign purchases and other factors related to inflationary trends in Indonesia and the rest of the world.

The 5 year project budget calls for spending 14.9 million Rupiah of government funds in year one, plus 1.4 million Rupiah for the farmers' cost of conservation measures for a total of 16.3 million Rupiah. This estimate may be optimistic considering the time it will take for developing an organization, hiring or assigning people to the special staff, and in letting contracts for soils or socio-economic studies. Many of these items are listed in year one to indicate their priority for accomplishment rather than a definite expectation of accomplishment.

The total project cost of 63.4 million Rupiah in January 1980 values amounts to a cost of 1.17 million Rupiah per hectare for the 54.4 ha Gunungsari Pilot Watershed. It should be remembered, however, that 8.6 million Rupiah of this, or 13.6 percent, is the estimated cost for a meteorologic station, erosion rates and sediment measurement, and surface runoff measurement. The farmers are also expected to contribute 12.3 million Rupiah, or 30.5 percent, of the total cost. Therefore, the actual government cost of applying soil and water conservation measures or in training the farmer amounts to 42.5 million Rupiah (66.9 percent), or about Rp. 781,000/ha of the 54.4 ha demonstration area.

One major factor not analyzed in estimating the cost of the Gunungsari Pilot Watershed is the need for outside consultants to aid in initiating the program and training the staff in the new approach to working with farmers. As noted in the conceptual plan for the Jratunseluna Basin, and the SMEC Soil Conservation Study for Upper Serang and Lusi River Catchment [6], there is a real need for a consultants assistance and guidence in setting up a major soil and water conservation program in any area, but it is also obvious that the project cannot afford these services for two demonstration watershed areas.

F.11. RECOMMENDED WATUAGUNG SOIL AND WATER CONSERVATION PROJECT

With the time constraints of the Consultant and the limited mapp: available for the Watuagung it was determined very early in the planning period that the work should concentrate on the Gunungsari Pilot Watershed. In some ways this is unfortunate because the Watuagung Pilot Watershed is much more accessible to the public and the problems faced by the upland farmer are just as severe.

Figure F-31 shows the limited area mapped to date and provides a few specific soil and water conservation practices for the first year' program. The diversions channels that are necessary to protect any bench terracing must be checked in the field to determine the total drainage area contributing to each segment of the channel. The limite investigation conducted to date indicates a large area could possibly be used for terracing locations if the farmer decided to divert the water in that direction. Therefore, this contributing area should be field checked before any attempt is made to estimate the necessary diversion channel capacities. The 70 percent slopes above these diver sion sites also create higher than normal peak runoff rates from these lands.

From the available topographic maps with a 1:2000 scale and 2.5 m contour intervals it appears there is a maximum of 1.7 ha of land suitable for bench terracing. This area presently has a medium stand of mostly forest type trees. The consultant recommends that a major effort be made to maintain at least the better trees while bench terracing the area.

For the Watuagung Pilot Watershed the steepness of the terrain limits the selection of the upland demonstration farm to the general area of 1.7 ha of proposed bench terracing. Completion of the topographic surveys could disclose more suitable demonstration farm sites, but this is doubtful because of accessibility problems on the high slopes of Gunung Payung with a reported crest elevation of 718 m MSL. However, the top of the mountain has a considerable area of upland cropland with traditional terraces and some other conservation measures. Topographic and soil surveys on this area should be completed as soon as pssible to enable the development of conservation plan for the entire area.

The necessary information on the socio-agro-economic situation is also lacking so it is important that these studies be initiated as soon as possible. Considering the probable large area of needed land use, change from upland crop production to agroforestry, it may be that the socio-agro-economic surveys are the most important feature to good project planning.

In consideration of the foregoing problems and constraints it was decided that the best recommendation for the consultant to make is that the project be fully funded but that no specific program suggestions be made at this time. The soil water conservation program should remain very flexible until such a time as all of the people and land resource problems of the Watuagung Pilot Demonstration area are clearly defined.

Table F-37 provides an estimated 5-year project cost for the Watuagung Pilot Watershed Demonstration area in terms of the January 1980 values. Cost estimates for tools needed for the demonstration watershed, detailed soil surveys, socio-agro-economic surveys, and the Kabupaten budget are all identical to those estimated for the the Gunungsari Pilot Watershed. The costs for precipitation, runoff and sediment production measurement were not estimated at this time because of the feeling that these types of studies often do not provide much good information when run by the project staff. They are more nearly suited to a true research program, and as such, should be run by special research groups or university departments. The costs for applying conservation measures is estimated at 90 percent of that for the Gunungsari area based on the cheaper application of the agroforestry practices as against those for large areas of bench terracing. Again the cost of maintenance for conservation measures is estimated at 5 percent of the original cost of all measures installed in previous years. This somewhat crude cost estimating process results in 5-year project cost of 51.4 million Rupiah (Table F-37) or about 81 percent of the Gunungsari area. This would amount to just over one million Rupiah per hectare for the desired 50 ha demonstration area.

It is strongly recommended that the budget for the Watuagung Pilot area remain flexible until such time as the specific program needs are determined. While the 5-year budget shown in Table F-37 would normally be accurate it would be very insufficient if a large part of the population had to be transmigrated or provided employment away from the area in order to effect any lasting improvement in watershed condition.

F.12. CONCLUSIONS

The general conclusion as to two pilot watershed demonstration areas is that they both have severe problems of erosion and long term depletion of their land resources. If the complete land and water resource development program is truly initiated in these areas a great deal of progress can be made towards accomplishing the objective of improving the well being of people in the watershed. But if conservation program is only partially funded and initiated with the traditional top down method of planning for the farmer little will be accomplished in the watersheds except to give to farmers some small subsidies for working or installing the conservation measures. Using the traditional approach the failure of the projects will be almost certain.

The factors which are responsible for the success of the Panawangan Pilot Watershed of the Citanduy Basin which is frequently quoted as a successful project are the following: 1) the soils of Panawangan are deep and relatively fertile soils developed from volcanic ash, 2) the Panawangan Pilot farm had rather constant technical assistance and guidance of qualified consultants for two years 3) the total encouragement of the Bupati's staff, particularly the direction of planning and 4) the farmers originally asked for the program, and since they understood what they were trying to do on their lands they tried very hard to make the demonstration area a success. This type of success causes many imitators, but it requires a much higher commitment of resources than most agencies or groups are able to provide. For this reason it is generally better to move slowly into a program such as the proposed pilot watershed demonstration until it is definitely known how to solve the complex "people problems" of the watershed and along with all of the technical, economic and physical problems attendent thereto.

TABLE F-23

AREA OF SLOPE CLASSES FOR INDIVIDUAL HYDROLOGIC UNITS OF GUNUNGSARI PILOT WATERSHED

Hydrologic Unit	Slope Class				Total Area
	0-2%	2-15%	15-40%	40%	
Hectares:					
A	-	6.7	4.6	1.0	12.3
B	-	2.9	2.4	2.1	7.4
C	-	0.1	-	0.8	0.9
D	-	3.1	7.6	3.3	14.0
E	-	5.0	2.6	1.5	9.1
F	-	7.4	2.4	0.9	10.7
Total	-	25.2	19.6	9.6	54.4
Percent of Area:					
A	-	54.5	37.4	8.1	100.0
B	-	39.5	32.4	28.1	100.0
C	-	11.1	-	88.9	100.0
D	-	22.0	54.2	23.8	100.0
E	-	54.9	28.6	16.5	100.0
F	-	69.2	22.4	8.4	100.0
Total	-	46.4	36.0	17.6	100.0

TABLE F-24

ESTIMATED CONSERVATION MEASURES NEEDED IN GUNUNGSARI PILOT WATERSHED

Conservation Measure	Unit	Hydrologic Unit A	B	C	D	E	F	Total
Grassed Waterways	m	1,351	538	(136)	1,165	546	550	4,150
Diversion Channels	m		100				150	250
Land Treatment Measures:								
Bench Terraces	ha	10.2	4.4	0.1	10.2	6.8	6.9	38.6
Conservation Terraces	ha	0.9	0.3			0.5		1.7
Hillside Ditches	ha		0.4	0.7		1.5	0.9	3.5
Agroforestry	ha	1.1	1.6		3.2		0.1	6.0
Critical Area Planting	ha	0.1	0.2		0.2			0.5
Other Uses	ha		0.5	0.1	0.4	0.3	2.8	4.1
Total Area	ha	12.3	7.4	0.9	14.0	9.1	10.7	54.4
Grade Stabilization Structures:								
Bamboo Wattle Checks	No	6	2					8
Small Rock Drop/Checks	No	2	6	6	5	8	4	31
Large Rock Drop Checks	No			2	3	2		7
Rubble Masonry Checks	No				1			1
Gabion Retaining Wall	No						1	1
Road Erosion Proofing	m				640			640

TABLE F-25

SPECIFICATIONS FOR REVERSE SLOPE TERRACES

S_1 (%)	VI (cm)	HI (cm)	h (cm)	b_x (cm)	W (cm)	K_1 (cm)	K_2 (cm)	b_4 (cm)	b (cm)	a (cm)	W_e (cm)	A_e (m^2/ha)	V_c (m^3/ha)
15	60	400.00	27.75	13.88	342.24	4.50	17.11	18.15	333.70	185.00	258.70	6,467.50	776.90
(8.5°)	80	533.33	37.75	18.88	465.57	4.50	23.28	24.70	453.93	251.67	378.93	7,104.98	1,077.83
	100	666.67	47.75	23.88	588.91	4.50	29.45	31.24	574.19	318.34	499.19	7,487.81	1,380.07
	120	800.00	57.75	28.88	712.24	4.50	35.61	37.78	694.44	385.00	619.44	7,743.00	1,681.60
	150	1,000.00	72.75	86.88	896.24	4.50	44.81	47.58	874.84	485.00	799.84	7,998.40	2,134.69
	180	1,200.00	87.75	43.88	1,082.24	4.50	54.11	57.40	1,055.20	585.00	980.20	8,168.33	2,588.38
20	60	300.00	27.00	13.50	243.00	6.00	12.15	16.54	236.92	135.00	161.92	5,997.33	670.13
(11.3°)	80	400.00	37.00	18.50	333.00	6.00	16.65	22.66	324.68	185.00	249.68	6,242.00	943.23
	100	500.00	47.00	23.50	423.00	6.00	21.15	28.79	412.42	235.00	337.42	6,748.40	1,217.68
	120	600.00	57.00	28.50	513.00	6.00	25.65	34.91	500.18	285.00	425.18	7,086.33	1,493.96
	150	750.00	72.00	36.00	648.00	6.00	32.40	44.10	631.80	360.00	556.80	7,424.00	1,905.18
	180	900.00	87.00	43.50	783.00	6.00	39.15	53.29	763.42	435.00	688.42	7,649.11	2,318.13
25	80	320.00	36.25	18.13	253.74	7.50	12.69	21.30	247.40	145.00	172.40	5,387.50	844.29
(14.0°)	100	400.00	46.25	23.13	323.74	7.50	16.19	27.17	315.66	185.00	240.66	6,016.50	1,100.06
	120	480.00	56.25	28.13	393.74	7.50	19.69	33.05	383.90	225.00	308.90	6,435.42	1,355.52
	150	600.00	71.25	35.63	498.74	7.50	24.94	41.85	486.30	285.00	411.30	6,855.00	1,739.96
	180	720.00	86.25	43.13	603.74	7.50	30.19	50.67	588.66	345.00	513.66	7,134.17	2,125.00
30	100	333.33	45.50	22.75	257.83	9.00	12.89	25.97	251.39	151.67	176.39	5,291.75	1,004.72
(16.7°)	120	400.00	55.50	27.75	314.50	9.00	15.73	31.68	306.64	185.00	231.64	5,791.00	1,245.68
	150	500.00	70.50	35.25	399.50	9.00	19.98	40.25	389.50	235.00	314.50	6,290.00	1,608.02
	180	600.00	85.50	42.75	484.50	9.00	24.23	48.81	472.38	285.00	397.38	6,623.00	1,970.91
35	120	342.86	54.75	27.38	258.10	10.50	12.91	30.60	251.66	156.43	176.66	5,152.54	1,152.10
(18.3°)	150	428.57	69.75	34.88	328.81	10.50	16.44	38.99	320.50	199.29	245.59	5,790.45	1,496.01
	180	514.29	84.75	42.38	399.53	10.50	19.98	47.37	389.55	242.15	314.55	6,116.20	1,840.42
40	150	375.00	69.00	34.50	276.00	12.00	13.80	37.95	269.10	172.50	194.10	5,176.00	1,396.63
(21.8°)	180	450.00	84.00	42.00	336.00	12.00	16.80	46.20	327.60	210.00	252.60	5,613.33	1,725.26

TABLE F-26

ESTIMATED RUNOFF (l/s) FOR VARIOUS CATCHMENT SIZES AND LAND USE WITH THE RATIONAL FORMULAE FOR THE 10-YEAR FREQUENCY RAINFALL

Catchment Area Less than ha	Estimated Maximum Runoff (l/s)			
	Bench Terraced	Hillside Ditch & Agro-forestry	Agroforestry Plantings	Upland Crop w/out Con-servation
0.5	63	105	160	225
1.0	100	167	250	345
2.0	175	290	440	590
3.0	250	415	625	830
4.0	325	535	810	1,080
5.0	400	660	1,000	1,320

Rainfall intensity (I) used in calculation:

1.0 ha = 240 mm/hr

5.0 ha = 190 mm/hr

TABLE F-27

EXAMPLE DESIGN CAPACITIES FOR GRASSED WATERWAYS

Design Capacity	Bed Width of Waterway	Depth of Waterway	Depth of Flow in Waterway	Area of Flow (A)	Wetted Perimeter (P)	Design Velocity of Flow (V)	Maximum Capacity (Q)	Volume of Cut Per Meter of Length
L/s	m	m	m	m^2	m	m/s	l/s	m^3
50	0.25	0.25	0.17	0.071	0.731	0.73	110	0.125
100	0.35	0.35	0.21	0.118	0.944	0.86	270	0.245
200	0.50	0.50	0.27	0.208	1.264	1.04	700	0.500
300	0.75	0.50	0.27	0.275	1.514	1.11	940	0.625
400	1.00	0.50	0.27	0.343	1.764	1.16	1,200	0.750
500	1.50	0.50	0.25	0.438	2.207	1.18	1,700	1.000
1,000	3.50	0.50	0.23	0.858	4.151	1.21	3,800	2.000

Note: Based on trapezoidal channel sections with 3% channel gradient and 1:1 side slopes, and Manning's n = 0.05 based on medium height of grass and shallow flow depths.

TABLE F-28

ESTIMATED GRASSED WATERWAY REQUIREMENTS AND COSTS

FOR GUNUNGSARI PILOT WATERSHED

Structure Number	Total Length (m)	Total Elevation Change (m)	Ground Slope %	Approximate Elevation of Drop Structures (m)	Drainage Area Served by Waterway (ha)	Maximum Design Capacity l/s	Estimated Cost Rp x 10^3
Area A							
A-GW-1	605	51	8.4	33	11.3	860	612.3
A-GW-2	200	21	10.5	15	(2.0)	175	173.6
A-GW-3	250	33	13.2	26	(2.5)	210	286.4
AC-GW-4	136	23	16.9	19	1.7	258	202.6
A-GW-5	160	24	15.0	19	(3.4)	275	209.5
Subtotal	1,351	152	(10.4)	112	13.0		1,484.4
Area B							
B-GW-1	300	53	17.7	44	3.5	285	469.7
B-GW-2	70	18	16.4	16	2.2	357 1/	163.6
B-GW-3	75	10	13.3	8	0.7	140	85.2
B-GW-4	93	23	24.7	21	0.5	115	204.3
Subtotal	583	104	(19.3)	89	6.9		922.8
Area D							
D-GW-1	320	27	8.4	18	3.1	255	236.0
D-GW-2	171	15	8.8	10	0.7	78	115.0
D-GW-3	50	11	22.0	10	(0.2)	63	97.0
D-GW-4	200	25	12.5	19	1.7	152	207.4
D-GW-5	424	44	10.4	32	4.0	322	399.6
Subtotal	1,165	122	(10.5)	89	9.5		1,055.0

TABLE F-28 (Cont.)

ESTIMATED GRASSED WATERWAY REQUIREMENTS AND COSTS FOR GUNUNGSARI PILOT WATERSHED

Structure Number	Total Length (m)	Total Elevation Change (m)	Ground Slope %	Approximate Elevation of Drop Structures (m)	Drainage Area Served by Waterway (ha)	Maximum Design Capacity 1/s	Estimated Cost Rp. x 10^3
Area E							
E-GW-1	335	45	13.4	35	4.8	480	428.6
E-GW-2	85	11	12.9	9	1.8	160	96.8
E-GW-3	126	31	24.6	28	2.2	312	284.6
Subtotal	546	87	(15.9)	72	8.8		810.0
Area F							
F-GW-1	290	19	6.6	11	3.2	320 2/	175.1
F-GW-2	223	45	20.2	39	2.2	292	406.5
G-GW-3	37	7	18.9	6	(0.5)	63	59.1
Subtotal	550	71	(12.9)	56	5.4		640.7
Total Waterways	4,150	536	(12.9)	418	42.8	(350)	4,912.9

1/ Includes 294 1/s from Diversion B-DV-1
2/ Includes 245 1/s from Diversion F-DV-1

TABLE F-29

ESTIMATED COST OF CONSERVATION MEASURES

BY HYDROLOGIC UNIT FOR GUNUNGSARI PILOT WATERSHED

(Thousand Rupiah - January 1990 Values)

Conservation Measure	Hydrologic Unit A	B	C	D	E	F	Total
Grassed Waterways	1,484.4	922.8		1,055.0	810.0	640.7	4,912.9
Diversion Channels		24.1				36.2	60.3
Bench Terraces	3,060.0	1,320.0	30.0	3,060.0	2,040.0	2,070.0	11,580.0
Conservation Terraces	25.0	8.0			14.0		47.0
Hillside Ditches		8.0	15.0		32.0	19.0	74.0
Agroforestry of Hillside Ditches		54.0	95.0		203.0	122.0	474.0
Agroforestry Planting	171.0	248.0		496.0		16.0	931.0
Critical Area Planting	62.0	124.0		124.0			310.0
Bamboo Wattle Checks	46.0	15.3					61.3
Small Rock Drop/Checks	18.0	54.0	54.0	45.0	72.0	36.0	279.0
Large Rock Drop Checks			75.0	112.5	75.0		262.5
Rubble Masonry Check Dam				124.2			124.2
Gabion Retaining Wall						130.0	130.0
Road erosion Proofing				449.7			449.7
Total Est.	4,866.4	2,778.2	269.0	5,466.4	3,246.0	3,069.9	19,695.9
Contingencies (15%)	730.0	416.7	40.4	819.9	486.9	460.5	2,954.4
Engineering Design (8.5%)	413.6	236.1	22.9	464.6	275.9	260.9	1,674.0
Administration (10%)	486.6	277.8	26.9	546.6	324.6	307.0	1,969.5
Total Cost	6,496.6	3,708.8	359.2	7,297.5	4,333.4	4,098.3	26,293.8

ESTIMATED SCHEDULE OF APPLICATION FOR CONSERVATION MEASURES ON GUNUNGSARI PILOT WATERSHED

Conservation Measures	Units	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Grassed Waterways	m	1,350	1,120	900	780		4,150
Diversion Channels	m		100	150			250
Bench Terraces	ha	2.4	5.0	7.4	10.3	13.5	38.6
Conservation Terraces	ha	0.3	0.6	0.8			1.7
Hillside Ditches	ha		0.4	0.7	1.5	0.9	3.5
Agroforestry	ha	1.0	2.5	2.5			6.0
Critical Area Planting	ha	0.2	0.2	0.1			0.5
Bamboo Wattle Checks	No	4	4				8
Small Rock Drop/Checks	No	2	6	16	7		31
Large Rock Drop/Checks	No	1	2	3	1		7
Rubble Masonry Checks	No		1				1
Gabion Retaining Wall	No				1		1
Road Erosion Proofing	m	100	400	140			640

TABLE F-31

ESTIMATED COST SHARING FOR CONSERVATION MEASURES ON GUNUNGSARI PILOT WATERSHED

Conservation Measures	Unit	Cost Per Unit 1/	Cost Sharing Percent		Total Cost 1/	Farmer Contribution 1/	Project Cost 1/
			Farmer	Project			
		Rp.	%	%	$Rp.x10^3$	$Rp.x10^3$	$Rp.x10^3$
Grassed Waterways	m	1,184	55	45	4,912.9	2,702.1	2,210.8
Diversion Channels	m	241	45	55	60.3	27.1	33.2
Bench Terraces	ha	300,000	55	45	11,580.0	6,369.0	5,211.0
Conservation Terraces	ha	28,000	55	45	47.0	25.9	21.1
Hillside Ditches		21,000	55	45	74.0	40.7	33.3
Agroforestry of Hillside Ditches	ha	135,000	30	70	474.0	142.2	331.8
Agroforestry	ha	155,000	30	70	931.0	279.3	651.7
Critical Area Planting	ha	622,200	25	75	310.0	77.5	232.5
Bamboo Wattle Checks	No	7,667	15	85	61.3	9.2	52.1
Small Rock Drop/ Checks	No	9,000	15	85	279.0	41.9	237.1
Large Rock Drop/ Checks	No	37,500	15	85	262.5	39.4	223.1
Rubble Masonry Checks	No	124,225	10	90	124.2	12.4	111.8
Gabion Retaining Wall	No	130,000	10	90	130.0	13.0	117.0
Road Erosion Proofing	m	707.7	33	67	449.7	148.4	301.3
Total Estimated Cost			50.4	49.6	19,695.9	9,928.1	9,767.8
Contingencies (15%)				100.0	2,954.4		2,954.4
Engineering Design (8.5%)				100.0	1,674.0		1,674.0
Administration (10%)				100.0	1,969.5		1,969.5
Total Cost			37.8	62.2	26,293.8	9,928.1	16,365.7

1/ January 1980 Price Base

TABLE F-32

ESTIMATED COST SCHEDULE FOR CONSERVATION MEASURES ON GUNUNGSARI PILOT WATERSHED

(Thousand Rupiah - January 1980 Values)

Conservation Measures	Year 1	2	3	4	5	Total
Grassed Waterways	1,598.2	1,325.9	1,065.4	923.4		4,912.9
Diversion Channels		24.1	36.2			60.3
Bench Terraces	720.0	1,500.0	2,220.0	3,090.0	4,050.0	11,580.0
Conservation Terraces	8.3	16.6	22.1			47.0
Hillside Ditches		8.5	14.8	31.7	19.0	74.0
Agroforestry of Hillside Ditches		54.2	94.8	203.1	121.9	474.0
Agroforestry	155.2	387.9	387.9			931.0
Critical Area Planting	124.0	124.0	62.0			310.0
Bamboo Wattle Checks	30.7	30.6				61.3
Small Rock Drop/ Checks	18.0	54.0	144.0	63.0		279.0
Large Rock Drop/ Checks	37.5	75.0	112.5	37.5		262.5
Rubble Masonry Checks		124.2				124.2
Gabion Retaining Wall				130.0		130.0
Road Erosion Proofing	70.3	281.1	98.3			449.7
Total Estimated Cost	2,762.2	4,006.1	4,258.0	4,478.7	4,190.9	19,695.9
Contingencies (15%)	414.3	600.9	638.8	671.8	628.6	2,954.4
Engineering Design (8.5%)	234.8	340.5	361.8	380.7	356.2	1,674.0
Administration (10%)	276.2	400.6	425.8	447.8	419.1	1,969.5
Total Cost	3,687.5	5,348.1	5,684.4	5,979.0	5,594.8	26,293.8
Estimated Cost Sharing 1/						
Farmers (37.8%)	1,392.3	2,019.4	2,146.3	2,257.6	2,112.5	9,928.1
Project (62.2%)	2,295.2	3,328.7	3,538.1	3,721.4	3,482.3	16,365.7
Total	3,687.5	5,348.1	5,684.4	5,979.0	5,594.8	26,293.8

1/ Based on Cost Sharing Calculations in Table F-31

TABLE F-33

ESTIMATED COSTS FOR PERSONNEL AND OPERATIONS IN KABUPATEN BOYOLALI FOR THE GUNUNGSARI PILOT WATERSHED

(Thousand Rupiah - January 1980 Values)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Personnel Costs						
Kabupaten Conservationist or Agronomist (one-half time) 50,000/m	300.0	300.0	300.0	300.0	300.0	1,500.0
Spot worker, PLP, or PPL (3) 25,000/m	450.0	900.0	900.0	900.0	900.0	4,050.0
Desa Conservation Technicians (2) 15,000/m	180.0	360.0	360.0	360.0	360.0	1,620.0
Subtotal	930.0	1,560.0	1,560.0	1,560.0	1,560.0	7,170.0
Agricultural Inputs						
Improved seeds and Plants	61.6	84.0	105.6	122.4	148.0	521.6
Fertilizer @ Rp. 70/kg	183.4	264.6	378.0	473.2	592.2	1,891.4
Insecticides and Equipment	65.0	20.0	20.0	20.0	20.0	145.0
Honeybee Hives (4 @ 17,000)	68.0	68.0				136.0
Improved Livestock		80.0	40.0			120.0
Fingerling Fish (100 kg @ Rp. 950/kg)		95.0	95.0	95.0		
Subtotal	378.0	516.6	638.6	710.6	760.2	3004.0
Training and Assistance Cost						
Watershed Development Committee	40.0	20.0	20.0	20.0	20.0	120.0
Record Keeping Costs	20.0	20.0	20.0	20.0	20.0	100.0
Farmer Tour and Education Costs	50.0	100.0	100.0	50.0	50.0	350.0
Supplies and Visual Aid Materials	150.0	200.0	100.0	100.0	50.0	600.0
Subtotal	260.0	340.0	240.0	190.0	140.0	1,170.0

TABLE F-33 (Cont.)

ESTIMATED COSTS FOR PERSONNEL AND OPERATIONS IN KABUPATEN BOYOLALI FOR THE GUNUNGSARI PILOT WATERSHED

(Thousand Rupiah - January 1980 Values)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Other Costs						
Allowances @ 25% of Personnel Costs	233.0	390.0	390.0	390.0	390.0	1,793.0
Transportation Costs	700.0	900.0	900.0	900.0	900.0	4,300.0
Miscellaneous Equipment and Tools	150.0	100.0	50.0	50.0	50.0	400.0
Subtotal	1,083.0	1,390.0	1,340.0	1,340.0	1,340.0	6,493.0
Total Estimated Cost	2,651.0	3,806.6	3,778.6	3,800.6	3,800.2	17,837.0
Administration (15%)	397.7	571.0	566.8	570.1	570.0	2,675.6
Total	3,048.7	4,377.6	4,345.4	4,370.7	4,370.2	20,512.6

TABLE F-34

ESTIMATED COST OF TOOLS FOR DEMONSTRATION WATERSHED

(Rupiah - January 1980 Values)

Description	Cost Per Unit	Units	Total Cost
Conservation Construction Tools			
Cangkul	5,000	25	125,000
Pick	5,000	5	25,000
Heavy bar for prying stones	7,000	5	35,000
Heavy hammer for breaking stones	7,500	5	37,500
Pliers for cutting wire	2,000	2	4,000
Other tools and supplies			25,000
Subtotal			251,500
Technical Instruments and Tools			
Survey Instruments (Level with tripod and survey rod) 1/	498,000	1	498,000
Abney Hand Levels	45,000	3	135,000
Supporting Pole for Hand levels	4,000	3	12,000
Special Terracing 250 cm Scaled Rod	10,000	4	40,000
Simple Water Levels	6,000	6	36,000
Measuring tapes (50 meter)	17,500	5	87,500
Hand Scales (100 kg capacity)	20,000	3	60,000
Subtotal			868,500
Supplies			
Stationary, etc.			50,000
Maps (including aerial photos)			60,000
Books and publications			100,000
Subtotal			210,000
Total Estimated Cost			1,330,000
Contingencies (25%)			332,500
Total Cost			1,662,500

1/ Survey instrument would normally be assigned to conservation specialist or engineer from the Kabupaten or Kecamatan.

TABLE F-35

ESTIMATED COST FOR ONE COMPLETE METEOROLOGICAL STATION

(Rupiah - January 1980 Values)

Item	Per Station Quantity	Rp. Cost 1/
Automatic raingage with tipping bucket (24-hour clock)	1	300,000
Standard raingages	8	124,000
Charts for raingage (Belfort)	24 boxes	62,000
Evaporation pan inducting wall, max. min. thermometer, and wind recorder	1	310,000
Sunshine duration recorder (Campbell Stokes)	1	186,000
Wind recorder with parts	1	328,600
Maximum-Minimum thermometers (Townsend Support)	6	46,500
Sling Psychometer (manual)	2	62,000
Shelter for thermometers (locally built)	1	37,200
Water Supply tank (200 liters)	1	15,000
Thermometers HM-1AC-R	6	27,900
Enclosure fence, 11 gage steel link wire me... post set in concrete (6 meters x 10 meters including foundation for each instrument)	1	375,000
		1,874,200
Contingencies 25%		468,550
Total		2,342,750

1/ Imported items based on exchange rate of U.S. $ 1.00 = Rp. 620.

TABLE F-36

ESTIMATED PROJECT COST SUMMARY FOR GUNUNGSARI PILOT WATERSHED

(Thousand Rupiah - January 1980 Values)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Government Cost:						
Tools for Demonstration Watershed	1,622.5					1,622.5
Detailed Soil Surveys	506.0					506.0
Socio-Agro-Economic Survey	500.0				500.0	1,000.0
Meteorologic Station	1,100.0	1,302.7	60.0	60.0	60.0	2,582.7
Sediment Measurement	746.7	120.0	120.0	120.0	120.0	1,226.7
Surface Runoff Measurement	4,330.0	120.0	120.0	120.0	120.0	4,810.0
Conservation Measures	2,295.2	3,328.7	3,538.1	3,721.4	3,482.3	16,365.7
Kabupaten Boyolali Costs	3,048.7	4,377.6	4,345.4	4,370.7	4,370.2	20,512.6
Project Administration (5%)	707.5	462.5	409.2	419.6	432.6	2,431.4
Subtotal Government Cost	14,856.6	9,711.5	8,592.7	8,811.7	9,085.1	51,057.6
Farmer Cost: 1/						
Conservation Measures	1,392.3	2,019.4	2,146.3	2,257.6	2,112.5	9,928.1
Maintenance of Conservation Measures		184.0	452.0	736.0	1,035.0	2,407.0
Subtotal Farmer Cost	1,392.3	2,203.4	2,598.3	2,993.6	3,147.5	12,355.1
Total Cost	16,248.9	11,914.9	11,191.0	11,805.3	12,232.6	63,392.7

1/ Other farmer costs or contributions not estimated because of time limitations.

TABLE F-37

ESTIMATED PROJECT COST SUMMARY FOR WATUAGUNG

PILOT WATERSHED DEMONSTRATION AREA

(Thousand Rupiah - January 1980 Values)

Item	Year 1	2	3	4	5	Total
Government Cost:						
Tools for Demonstration Watershed	1,622.5					1,622.5
Detailed Soil Surveys	506.0					506.0
Socio-Agro-Economic Surveys	500.0				500.0	1,000.0
Conservation Measures	2,065.7	2,995.8	3,184.3	3,349.3	3,134.1	14,729.2
Kabupaten Tuntang Costs	3,048.7	4,377.6	4,345.4	4,370.7	4,370.2	20,512.6
Project Administration (5%)	387.1	368.7	376.5	386.0	400.2	1,918.5
Subtotal Government Cots	8,130.0	7,742.1	7,906.2	8,106.0	8,404.5	40,288.8
Farmer Cost: 1/						
Conservation Measures	1,253.1	1,817.5	1,931.7	2,031.8	1,901.3	8,935.4
Maintenance of Conservation Measures		165.9	406.6	662.4	931.5	2,166.4
Subtotal Farmer Cost	1,253.1	1,983.4	2,338.3	2,694.2	2,832.8	11,101.8
Total Cost	9,383.1	9,725.5	10,244.5	10,800.2	11,237.3	51,390.6

1/ Other farmer costs or contributions not estimated because of time limitations.

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SOIL AND WATER CONSERVATION GLOSSARY [1/]

A

Accelerated erosion: See erosion

Access road: A vehicular travelway constructed to provide entry to an area.

Adequate-size farm: A farm with enough resources and productivity to generate enough income to (1) provide an acceptable level of family living, (2) pay current operating expenses, (3) pay interest on loans, and (4) allow for capital growth to keep in step with technological growth.

Aerial photograph: A photograph of the earth's surface taken from airborne equipment, sometimes called aerial photo or air photograph.

Afforestation: The artificial establishment of forest crops by planting or sowing on land that has not previously, or recently, grown trees.

Agronomic practices: Soil and crop activities employed in the production of farm crops, such as selecting seed, seedbed preparation, fertilizing, liming, manuring, seeding, cultivation, harvesting, curing, crop sequence, crop rotations, cover crops, stripcropping, pasture development, and others.

All-aged forest: A stand that contains trees of all, or almost all, age classes including those of harvestable size.

Aquifer: A geologic formation or structure that transmits water in sufficient quantity to supply the needs for a water development; usually saturated sands, gravel, fractures, and cavernous and vesicular rock. The term water-bearing is sometimes used synonymously with aquifer when a stratum furnishes water for a specific use.

Available water capacity (soils): The capacity to store water available for use by plants, usually expressed in linear depths of water per unit depth of soil; the difference between the percentage of soil water at field capacity and the percentage at wilting point. This difference multiplied by the bulk density and divided by 100 gives a value in surface cm of water per cm depth of soil. See field capacity, wilting point.

1/ Source: Resource Conservation Glossary published by the Soil Conservation Society of America, 1976.

B

Bedload: The sediment that moves by sliding, rolling, or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at velocities less than the surrounding flow.

Bedrock: The solid rock underlying soils and the regolith in depths ranging from zero (where exposed by erosion) to several hundred feet.

Benchmark: 1. In economics, data for a specific time period that is used as a base for comparative purposes with comparable data. 2. A fixed reference, usually placed on or near the ground, giving the measurement in elevation of that point in relation to mean sea level or some other reference datum.

Bench terrace: See terrace.

Brush matting: 1. A matting of branches placed on badly eroded land to conserve moisture and reduce erosion while trees or other vegetative covers are being established. 2. A matting of mesh wire and brush used to retard streambank erosion.

Bulk density: In soils the mass of dry soil per unit bulk volume. The bulk volume is determined before drying to constant weight at 105 degrees centigrade.

C

Canal: A constructed open channel for transporting water from the source of supply to the point of distribution.

Channel improvement: The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity; sometimes used to connote channel stabilization.

Channel stabilization: Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revements, vegetation, and other measures.

Channel storage: Water temporarily stored in channels while enroute to an outlet.

Check (Hydraulics, irrigation): A structure, permanent or portable, designed to raise or control the water surface in a channel or ditch.

Check dam: Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

Clearcutting: A method of cutting that removes the entire timber stand on the area cut. See selective cutting.

Compaction: 1. To unite firmly; the act or process of becoming compact. 2. In geology, the changing of loose sediment into hard, firm rock. 3. In soil engineering, the process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot. 4. In solid waste disposal, the reducing of the bulk of solid waste by rolling and tamping.

Companion crop: A crop sown with another crop. Used particularly for small grains with which forage crops are sown. Preferred to the term nurse crop.

Compost: Organic residues or a mixture of organic residues and soil that have been piled and allowed to undergo biological decomposition, until relatively stable.

Composting: A controlled process of degrading organic matter by microorganisms. Techniques include:

- **Mechanical:** A method in which the compost is continuously and mechanically mixed and aerated.
- **Ventilated cell:** the compost is mixed and aerated by being dropped through a vertical series of ventilated cells.
- **Windrow:** An open-air method in which compostable material is placed in windrows, piles, or ventilated bins or pits and is occasionally turned or mixed. The process may be anaerobic or aerobic.

Comprehensive plan: A report from a governmental planning agency that describes how its area of jurisdiction should be developed, expressing both policies and a coordinated plan for public and private land use, a transportation system, and public services, and facilities. Also called comprehensive development plan, general plan, master plan.

Comprehensive planning program: A continuing process which includes research on the conditions and trends in physical, social, and economic development; preparation and adoption of a comprehensive plan; programming of capital improvements; and initiation of the regulatory and administrative measures for implementation and maintenance of the plan.

Conservation plan for farm, ranch, or nonagricultural land unit: The properly recorded decisions of the cooperating landowner or operator on how he plans, within practical limits, to use his land in an operating unit within its capability and to treat it according to its needs for maintenance or improvement of the soil, water, and plant resources.

Conservation standards: Standards for various types of soils and land uses, including criteria, techniques, and methods for the control of erosion and sediment resulting from land disturbing activities.

Conservation tillage: Any tillage system which reduces loss of soil or water compared to unridged or clean tillage.

Contour: 1. An imaginary line on the surface of the earth connecting points of the same elevation. 2. A line drawn on a map connecting points of the same elevation.

Contour farming: Conducting field operations, such as plowing, planting, cultivating, and harvesting, on the contour.

Contour stripcropping: Layout of crops in comparatively narrow strips in which the farming operations are performed approximately on the contour. Usually strips of grass, close-growing crops, or fallow are alternated with those in cultivated crops.

Cover: 1. Vegetation or other material providing protection. 2. Fish, a variety of items including undercut banks, trees, roots, and rocks in the water where fish seek necessary protection or security. 3. In forestry, low-growing shrubs, vines, and herbaceous plants under the trees. 4. Ground and soils, any vegetation producing a protecting mat on or just above the soil surface. 5. Stream, generally trees, large shrubs, grasses, and forbs that shade and otherwise protect the stream from erosion, temperature elevation, or sloughing of banks. 6. Vegetation, all plants of all sizes and species found on an area, irrespective of whether they have forage or other value. 7. Wildlife, plants or objects used by wild animals for nesting, rearing of young, resting, escape from predators, or protection from adverse environmental conditions.

Cover crop: A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production or between trees and vines in orchards and vineyards.

Critical area: A severely eroded sediment producing area that requires special management to establish and maintain vegetation in order to stabilize soil conditions.

Crop residue: The portion of a plant or crop left in the field after harvest.

Crop residue management: Use of that portion of the plant or crop left in the field after harvest for protection or improvement of the soil.

Crop rotation: The growing of different crops in recurring succession on the same land.

Cultivar: An assemblage of cultivated plants which is clearly distinguished by its characters (morphological, physiological, cytological, chemical, or others) and which when reproduced (sexually or asexually), retains those distinguishing characters. The terms cultivar and variety are exact equivalents.

Cut: Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

Cut-and-fill: Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

Cut-over forest: A forest in which most or all of the merchantable timber has been cut.

D

Debris: The loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice, or floods.

Deep percolation: Water that percolates below the root zone and cannot be used by plants.

Degradation: To wear down by erosion, especially through stream action.

Deposition: The accumulation of material dropped because of a slackening movement of the transporting agent (water or wind).

Depth, effective soil: The depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients; the depth to a layer that differs sufficiently from the overlying material in physical or chemical properties to prevent or seriously retard the growth of roots.

Desilting area: An area of grass, shrubs, or other vegetation used for inducing deposition of silt and other debris from flowing water; located above a stock tank, pond, field, or other area needing protection from sediment accumulation. See filter strip.

Detention dam: A dam constructed for the purpose of temporary storage of streamflow or surface runoff and for releasing the stored water at controlled rates.

Diversion dam: A barrier built to divert part or all of the water from a stream into a different course.

Diversion terrace: Diversions, which differ from terraces in that they consist of individually designed channels across a hillside; may be used to protect bottomland from hillside runoff or may be needed above a terrace system for protection against runoff from an unterraced area; may also divert water out of active gullies, protect farm buildings from runoff, reduce the number of waterways, and sometimes used in connection with stripcropping to shorten the length of slope so that the strips can effectively control erosion. See terrace.

Drop spillway: Overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Drop structure: A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

E

Effective precipitation: That portion of total precipitation that becomes available for plant growth. It does not include precipitation lost to deep percolation below the root zone or to surface runoff.

Emergency spillway: A spillway used to carry runoff exceeding a given design flood.

Environment: The sum total of all the external conditions that may act upon an organism or community to influence its development or existence.

Erodible: Susceptible to erosion.

Erosion: 1. The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. 2. Detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

Accelerated erosion: Erosion much more rapid than normal, natural, or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophies that expose base surface, for example, fires.

Geological erosion: The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. Also called natural erosion.

Gully erosion: The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 0.3 to 2 m to as much as 25 to 30 m.

Natural erosion: Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. Also called geological erosion.

Normal erosion: The gradual erosion of land used by man which does not greatly exceed natural erosion.

Rill erosion: An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils. See rill.

Sheet erosion: The removal of a fairly uniform layer of soil from the land surface by runoff water.

Splash erosion: The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

Erosion classes (soil survey): A grouping of erosion conditions based on the degree of erosion or on characteristic patterns; applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion. For details see Soil Survey Staff, U.S. Department of Agriculture. 1951. Soil survey manual. USDA Handbook 18. U.S. Government Printing Office, Washington, D.C.

Evapotranspiration: The combined loss of water from a given area and during a specific period of time, by evaporation from the soil surface and by transpiration from plants.

F

Farm management: The organization and administration of farm resources, including land, labor, crops, livestock, and equipment.

Fertility (soil): The quality of a soil that enables it to provide nutrients in adequate amounts and in proper balance for the growth of specified plants when other growth factors, such as light, moisture, temperature, and the physical condition of the soil, are favorable.

Fertilizer: Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth.

Fibrous root system: A plant root system having a large number of small, finely divided, widely spreading roots but no large individual roots. Typified by grass root system. See taproot system.

Field planting (forestry): The establishment of woody plants on land essentially free of trees, including woody plantings for the protection of critical slopes, stabilization of spoil banks and sand dunes, production of wood crops, and recreation.

Flood: An overflow or inundation that comes from a river or other body of water and causes or threatens damage.

Floodway: A channel, either natural, excavated, or bounded by dikes and levees, used to carry excessive flood flows to reduce flooding. Sometimes considered to be the transitional area between the active channel and the floodplain.

Forage: All browse and herbaceous food that is available to livestock or game animals, used for grazing or harvested for feeding.

Forest: A plant association predominantly of trees and other woody vegetation.

G

Gabion: A rectangular or cylindrical wire mesh cage filled with rock and used as a protecting apron, revetment, etc., against erosion.

Gage height (hydraulics): The height of the water surface above some arbitrary datum, such as the bottom of the channel. See stage.

Gaging station: A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

Grade: 1. The slope of a road, channel, or natural ground. 2. The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction like paving or laying a conduit. 3. To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation.

Grassed waterway: A natural or constructed waterway, usually board and shallow, covered with erosion-resistant grasses, used to conduct surface water from cropland.

Ground cover: Any living or dead vegetative material producing a protacting mat on or just above the soil surface.

Gully: A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow; may be dendritic of branching or it may be linear, rather long, narrow, and of uniform width. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage. See erosion, rill.

Gully erosion: See erosion.

Gully control plantings: The planting of forage, legume, or woody plant seeds, seedlings, cuttings, or transplants in gullies to establish or re-establish a vegetative cover adequate to control runoff and erosion and incidentally produce useful products.

H

Hydraulic radius: The cross-sectional area of a stream divided by its wetted perimeter. The "r" in Manning's formula. See Manning's formula.

Hydrologic cycle: The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes, as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

I

Impervious soil: A soil through which water, air, or roots cannot penetrate. No soil is impervious to water and air all the time.

Improvement cutting, intermediate (forestry): A cutting made in an immature stand to harvest a useable product and to improve the stand's composition and character by removing undesirable species and trees of poor form and condition. See thinning; harvest cutting.

Infiltration: The gradual downward flow of water from the surface through soil to ground water and water table reservoirs.

Infiltration rate: A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions, including the presence of an excess of water.

Intensive cropping: Maximum use of the land by means of frequent succession of harvested crops.

Interplanting: 1. In cropland, the planting of several crops together on the same land, for example, the planting of beans with corn.
2. In orchards, the planting of farm crops among the trees, especially while the trees are too small to occupy the land completely.
3. In woodland, the planting of young trees among existing trees or brushy growth.

K

Key terrace: Staked terrace line that is selected as a reference in laying out other terraces.

L

Land capability: The suitability of land for use without permanent damage. Land capability, as ordinarily used in the United States, is an expression of the effect of physical land conditions, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land capability involves consideration of (1) the risks of land damage from erosion and other causes and (2) the difficulties in land use owing to physical land characteristics, including climate.

Land capability class: One of the eight classes of land in the land capability classification of the Soil Conservation Service; distinguished according to the risk of land damage or the difficulty of land use; they include:

Land suitable for cultivation and other uses.
Class I : Soils that have few limitations restricting their use.
Class II: Soils that have some limitations, reducing the choice of plants or requiring moderate conservation practices.

Class III: Soils that have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Class IV: Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Land generally not suitable for cultivation (without major treatment).

Class V: Soils that have little or no erosion hazard, but that have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI: Soils that have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII: Soils that have very severe limitations that make them unsuited to cultivation and that restricts their use largely to grazing, woodland, or wildlife.

Class VIII: Soils and landforms that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

Land capability classification: A grouping of kinds of soil into special units, subclasses, and classes according to their capability for intensive use and the treatments required for sustained use.

Land capability map: A map showing land capability units, subclasses, and classes or a soil survey map colored to show land capability classes.

Land capability subclass: Groups of capability units within classes of the land capability classification that have the same kinds of dominant limitations for agricultural use as a result of soil and climate. Some soils are subject to erosion if they are not protected, while others are naturally wet and must be drained if crops are to be grown. Some woils are shallow or droughty or have other soil deficiencies. Still other soils occur in areas where climate limits their use. The four kinds of limitations recognized at the subclass level are: risks of erosion, designated by the symbol (e); wetness, drainage, or overflow (w); other root zone limitations (s); and climatic limitations (c). The subclass provides the map user information about both the degree and kind of limitation. Capability class I has no subclasses.

Land classification: The arrangement of land units into various categories based on the properties of the land or its suitability for some particular purpose.

Land resource area: An area of land reasonably alike in its relationship to agriculture with emphasis on combinations and/or intensities of problems in soil and water conservation; ordinarily larger than a land resource unit and smaller than a land resource region.

Limestone: A sedimentary rock composed of calsium carbonate, $CaCO_3$. There are many impure varieties.

Liming: The application of lime to land, primarily to reduce soil acidity and supply calcium for plant growth. Dolomitic limestone supplies both calcium and magnesium. May also improve soil structure, organic matter content, and nitrogen content of the soil by encouraging the growth of legumes and soil microorganisms. Liming an acid soil to a pH value of about 6.5 is desirable for maintaining a high degree of availability of most of the nutrient elements required by plants.

Loose rock dam: A dam built of rock without the use of mortar; a rubble dam. See rock-fill dam.

M

Map, topographic: A representation of the physical features of a portion of the earth's surface as a plane surface, on which terrain relief is shown by a system of lines, each representing a constant elevation above a datum or reference plane.

Masonry dam: A dam built of rock and mortar.

Measuring weir: A shaped notch through which water flows are measured. common shapes are rectangular, trapezoidal, and triangular.

Mechanical practices: Soil and water conservation practices that primariily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion.

Multiple use: Harmonious use of land for more than one purpose; i.e., upland crops, grazing of livestock, wildlife production, recreation, watershed and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output.

N

Nursery: A place where plants, such as trees, shrubs, vines, and grasses, are propagated for transplanting or for use as stocks for grafting; a planting of young trees or other plants, the young plants being called nursery stock or planting stock.

O

Overfall: Abrupt change in stream channel elevation; the part of a dam or weir over which the water flows.

Overstocked (forestry): A condition in a stand or forest indicating more trees than normal or that full stocking would require.

P

Parent material (soils): The unconsolidated, more or less chemically weathered mineral or organic matter from which the solum of soils has developed by pedogenic processes. The C horizon may or may not consist of materials similar to those from which the A and B horizor developed.

Pasture planting: Establishing adapted herbacious species on land to be treated and grazed as tame pasture.

Percolation: The downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

Permeability: Capacity for transmitting a fluid. It is measured by the rate at which a fluid of standard viscosity can move through material in a given interval of time under a given hydraulic gradien

Plant residue: See crop residue, humus, litter, mor, mulch, soil organic matter.

Probable maximum precipitation: An estimate of the physical upper limi to the amount of precipitation that can fall over a specific area in a given time. Abbr. PMP.

Protection forest: An area wholly or partly covered with woody growth, managed primarily for its beneficial effects on soil and water conservation rather than for wood or forage production.

R

Rainfall excess (hydraulics): The volume of rainfall that will result in runoff.

Rainfall intensity: The rate at which rain is falling at any given instant, usually expressed in inches per hour.

Recording gage: An automatic instrument for making a graphic record of quantities or conditions, such as flow, stage, rainfall, and temperature, in relation to time.

Reforestation: Restocking an area with forest trees.

Ridge plating: A planting method in which crops are planted on ridges; usually refers to only one seed row planted on each ridge.

Rill: A small, intermittent water course with steep sides, usually only a few inches deep and, hence, no obstacle to tillage operations.

Rill erosion: See erosion.

Root zone: The part of the soil that is penetrated or can be penetrated by plant roots.

Rotation forestry: The planned number of years required to establish and grow trees to a specific maturity. The age at harvest is called the rotation age.

Runoff plots: Areas of land, usually small, arranged so the portion of rainfall or other precipitation flowing off and perhaps carrying soluble materials and soil may be measured. Usually, the flow from runoff plots includes only surface flow.

S

Saltation: Particle movement in water or wind where particles skip or bounce along the stream bed or soil surface.

Saturate: 1. To fill all the voids between soil particles with liquid. 2. To form the most concentrated solution possible under a given set of physical conditions in the presence of an excess of the substance.

Scour: To abrade and wear away; used to describe the wearing away of terrace or diversion channels or stream beds.

Sediment: Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, or gravity, and has come to rest on the earth's surface either above or below sea level.

Sediment discharge: The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

Sedimentation: The process or action of depositing sediment.

Sheet erosion: See erosion.

Slope: The degree of deviation of a surface from horizontal, measured in a numerical ratio, percent, or degrees. Expressed as a ratio or percentage, the first number is the vertical distance (rise) and the second is the horizontal distance (run), as 2:1 or 200 percent. Expressed in degrees, it is the angle of the slope from the horizontal plane with a 90° slope being vertical (maximum) and 45° being a 1:1 slope.

Soil classification: The systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics; subdivisions on the basis of more detailed differences in specific properties.

Soil conservation: Using the soil within the limits of its physical characteristics and protecting it from unalterable limitations of climate and topography.

Soil-conserving crops: Crops that prevent or retard erosion and maintain or replenish rather than deplete soil organic matter.

Soil-depleting crops: Crops that under the usual management tend to deplete nutrients and organic matter in the soil and permit deterioration of soil structure.

Soil erosion: The detachment and movement of soil from the land surface by wind or water. See erosion.

Soil fertility: The quality of a soil that enables it to provide nutrients in adequate amounts and in proper balance for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and physical condition of soil, are favorable.

Soil loss tolerance: The maximum average annual soil loss in tons per hectare per year that should be permitted on a given soil.

Soil morphology: 1. The physical constitution, particularly the structural properties, of a soil profile as exhibited by the kinds, thickness, and arrangement of the horizons in the profile, and by the texture, structure, consistency, and porosity of each horizon. 2. The structural characteristics of the soil or any of its parts.

Soil organic matter: The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil sample passed through a 2-millimeter sieve.

Stabilized grade: The slope of a channel at which neither erosion nor deposition occurs.

Stilling basin: An open structure or excavation at the foot of an overfall, chute, drop, or spillway to reduce the energy of the descending stream.

Stony: Containing sufficient stones to interfere with tillage but not to make intertilled crops impracticable. Stones may occupy 0.01 to 0.1 percent of the surface. Stoniness is not a part of the soil textural class. The terms "stony" and "very stony" may modify the soil textural class name in the soil type, but this is simply a brief way of designating stony phases.

Stream gaging: The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See gaging station.

Stubble mulch: The stubble of crops or crops residues left essentially in place on the land as a surface cover during fallow and the growing of a succeeding crop.

Subwatershed: A watershed subdivision of unspecified size that forms a convenient natural unit. See watershed.

Suspended load: Solids or sediments suspended in a fluid by the upward components of turbulent currents or by colloidal suspension.

T

Terrace: 1. An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Terraces or terrace systems may be classified by their alignment, gradient, outlet, and cross-section. Alignment may be parallel or non-parallel. Gradient may be level, uniformly graded, or variably graded. Grade is often incorporated to permit paralleling the terraces. Outlets may be soil infiltration only, vegetated waterways, tile outlets, or combinations thereof. Cross-section may be narrow base, broad base, bench, steep backslope, flat channel, or channel. 2. A level, usually narrow plain bordering a river, lake, or sea. Rivers sometimes are bordered by terraces at different levels.

Terrace outlet channel: Channel, usually having a vegetative cover, into which the flow from one or more terraces is discharged and conveyed from the field.

Terrace system: A series of terraces occupying a slope and discharging runoff into one or more outlet channels.

V

Velocity head(Hydraulics): Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity.

W

Water conservation: The physical control, protection, management, and use of water resources in such a way as to maintain crop, grazing, and forest lands; vegetal cover; wildlife; and wildlife habitat for maximum sustained benefits to people, agriculture, industry, commerce, and other segments of the national economy.

Water management: Application of practices to obtain added benefits from precipitation, water, or water flow in any of a number of areas, such as irrigation, drainage, wildlife and recreation, water supply, watershed management, and water storage in soil for crop production. See irrigation water management, watershed management.

Water resources: The supply of groundwater and surface water in a given area.

Watershed area: All land and water within the confines of a drainage divide or a water problem area consisting in whole or in part of land needing drainage or irrigation.

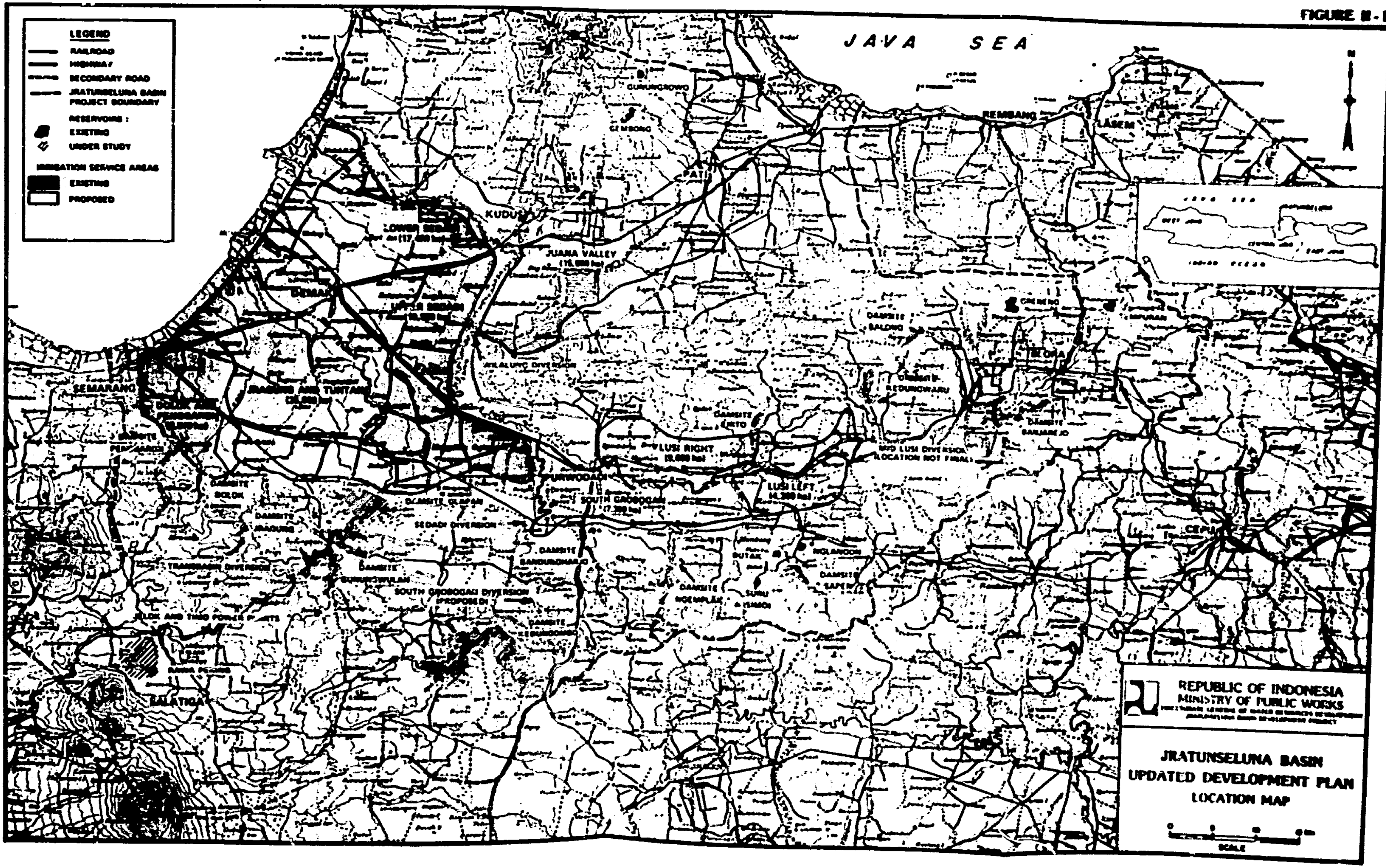
Watershed management: Use, regulation, and treatment of water and land resources of a watershed to accomplish stated objectives.

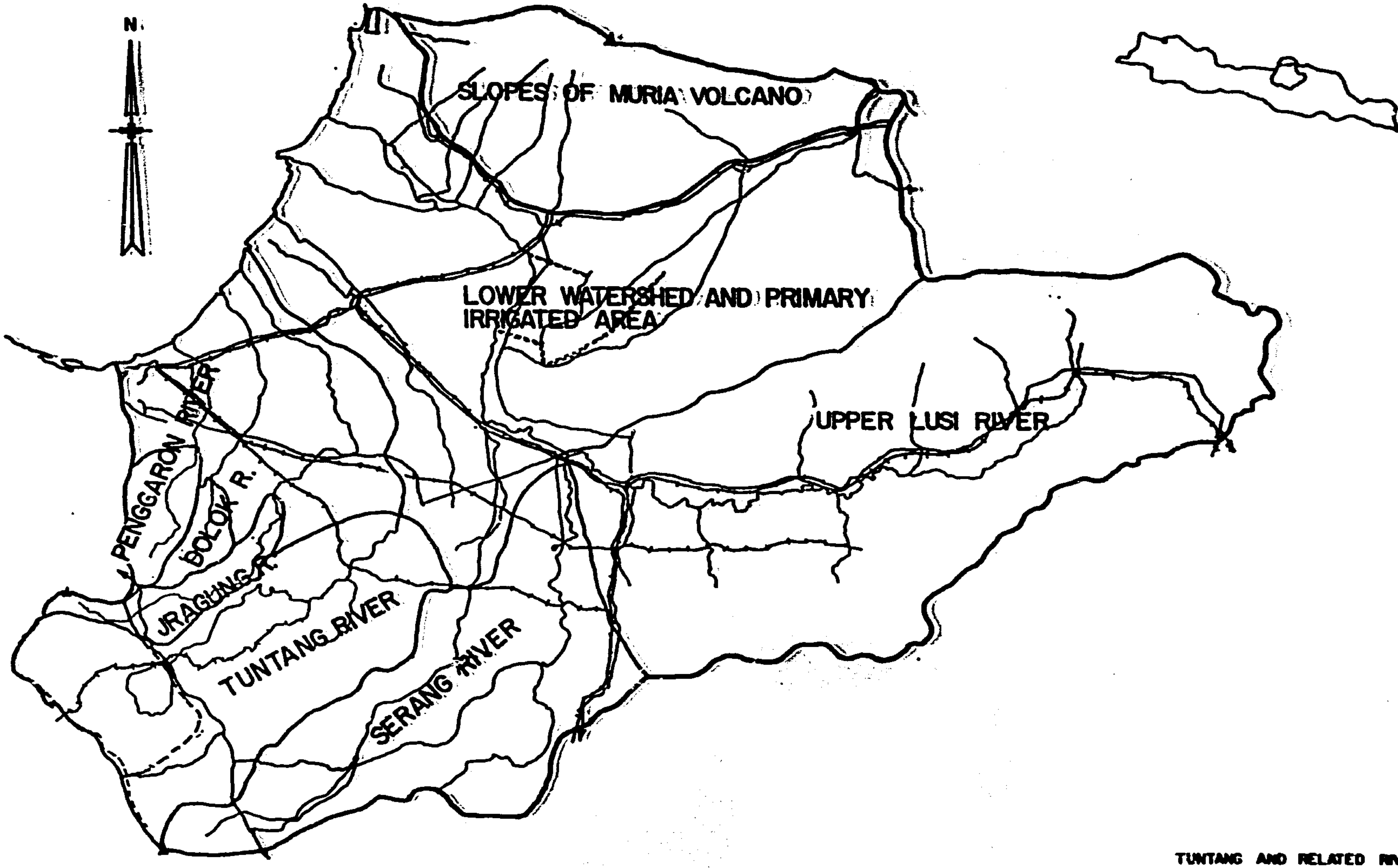
Watershed planning: Formulation of a plan to use and treat water and land resources.

Waterway: A natural course or constructed channel for the flow of water. See grassed waterway.

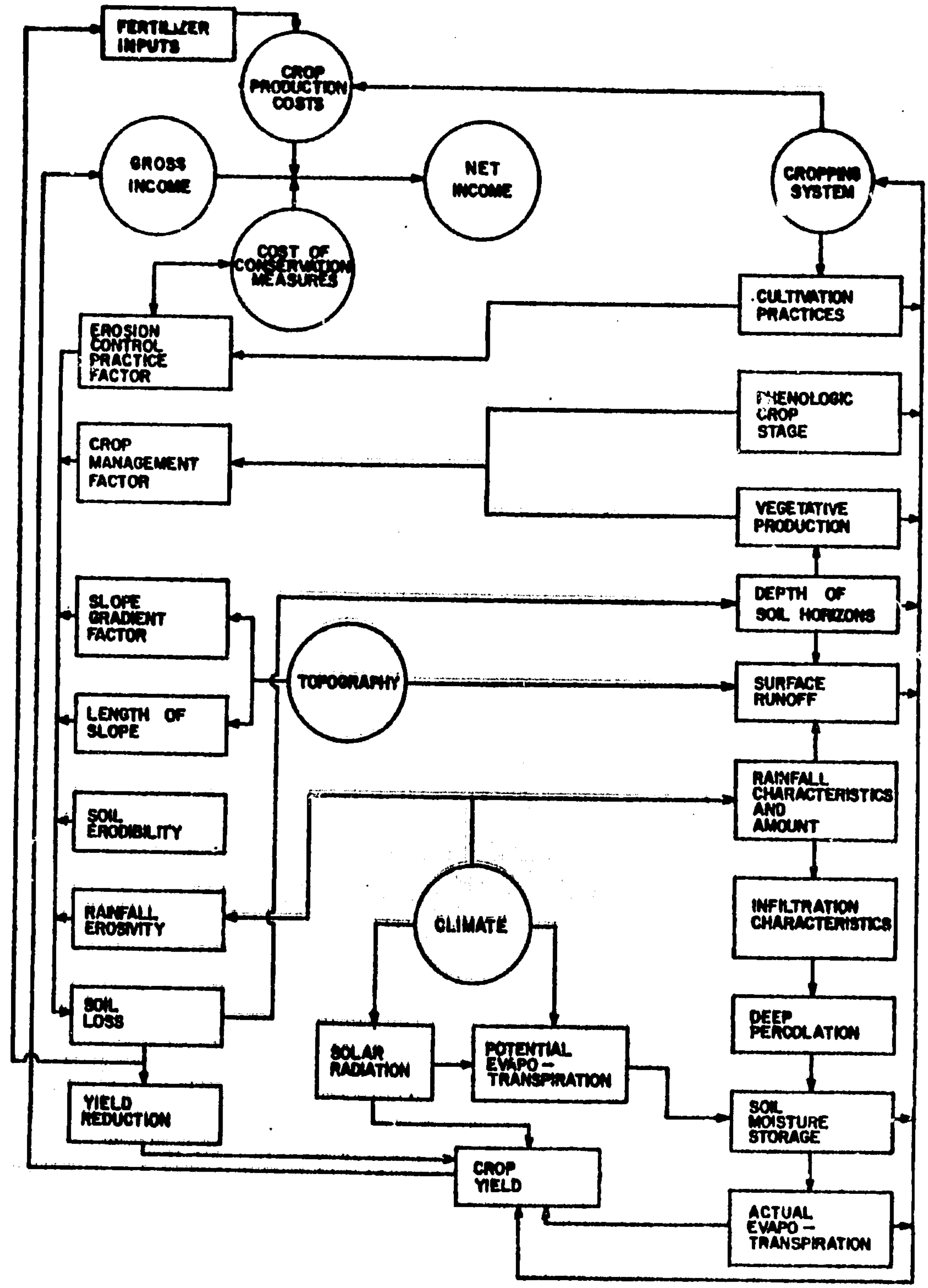
Wetted perimeter: Length of the wetted contact between a liquid and its containing conduit, measured along a plane at right angles to the direction of flow.

FIGURE II-1


LEGEND
RAILROAD
HIGHWAY
SECONDARY ROAD
JRATUNSELUNA BASIN PROJECT BOUNDARY
RESERVOIRS :
EXISTING
UNDER STUDY
IRRIGATION SERVICE AREAS
EXISTING
PROPOSED
JAVA SEA
REMBANG
LASEM
PATI
KUDUS
DEMAK
SEMARANG
JUANA VALLEY
LUSI RIGHT
LUSI LEFT
SOUTH GROBOGAN
SEDADI DIVERSION
CEPU
BLORA
SALATIGA
GEMBONG
SOUTH GROBOGAN DIVERSION (PROPOSED)
MID LUSI DIVERSION LOCATION NOT FINAL
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
LOCATION MAP
SCALE

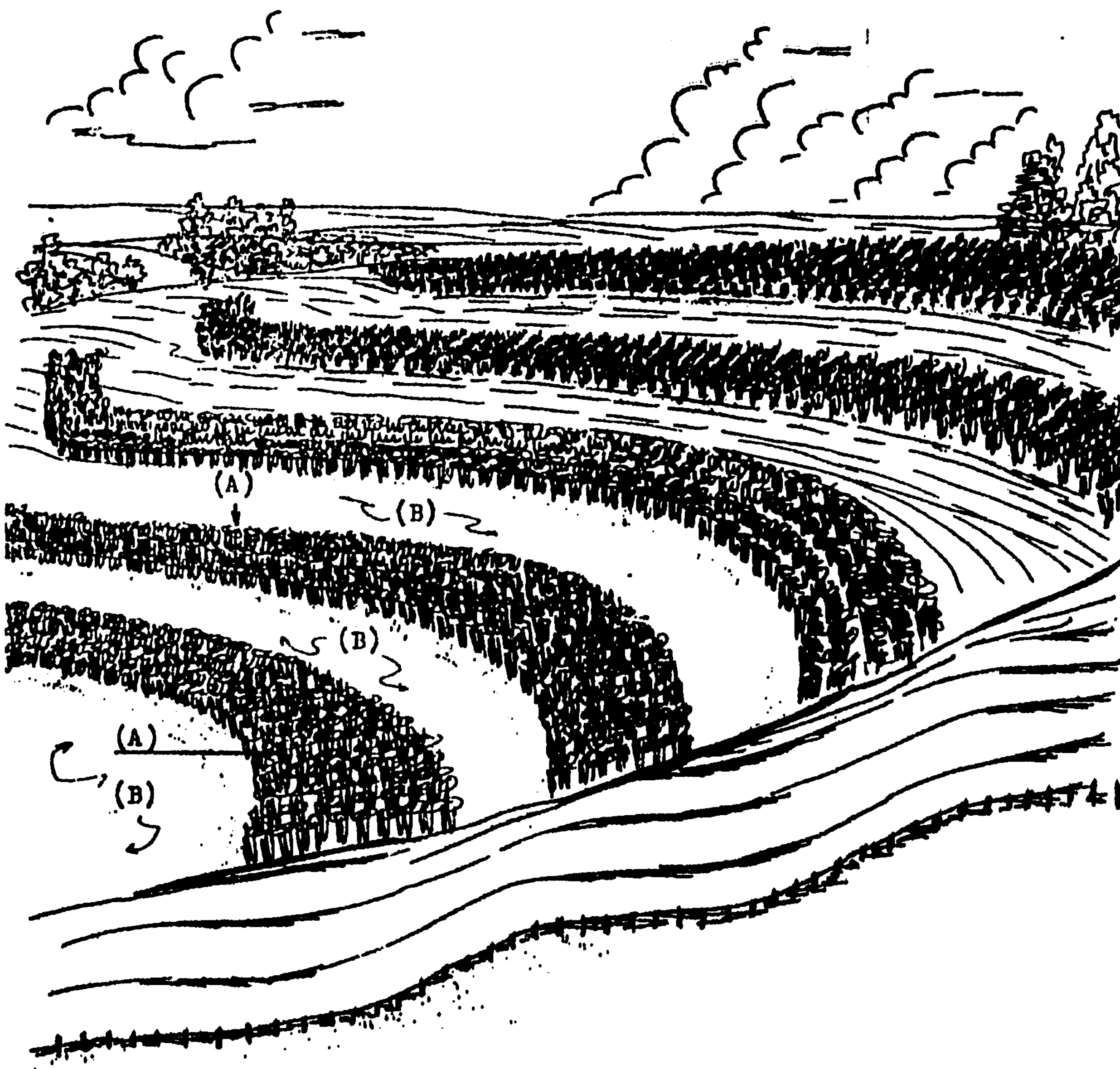


TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN
UPPER WATERSHED LOCATION MAP



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

INTERRELATIONSHIPS OF THE SOIL CONSERVATION SYSTEM



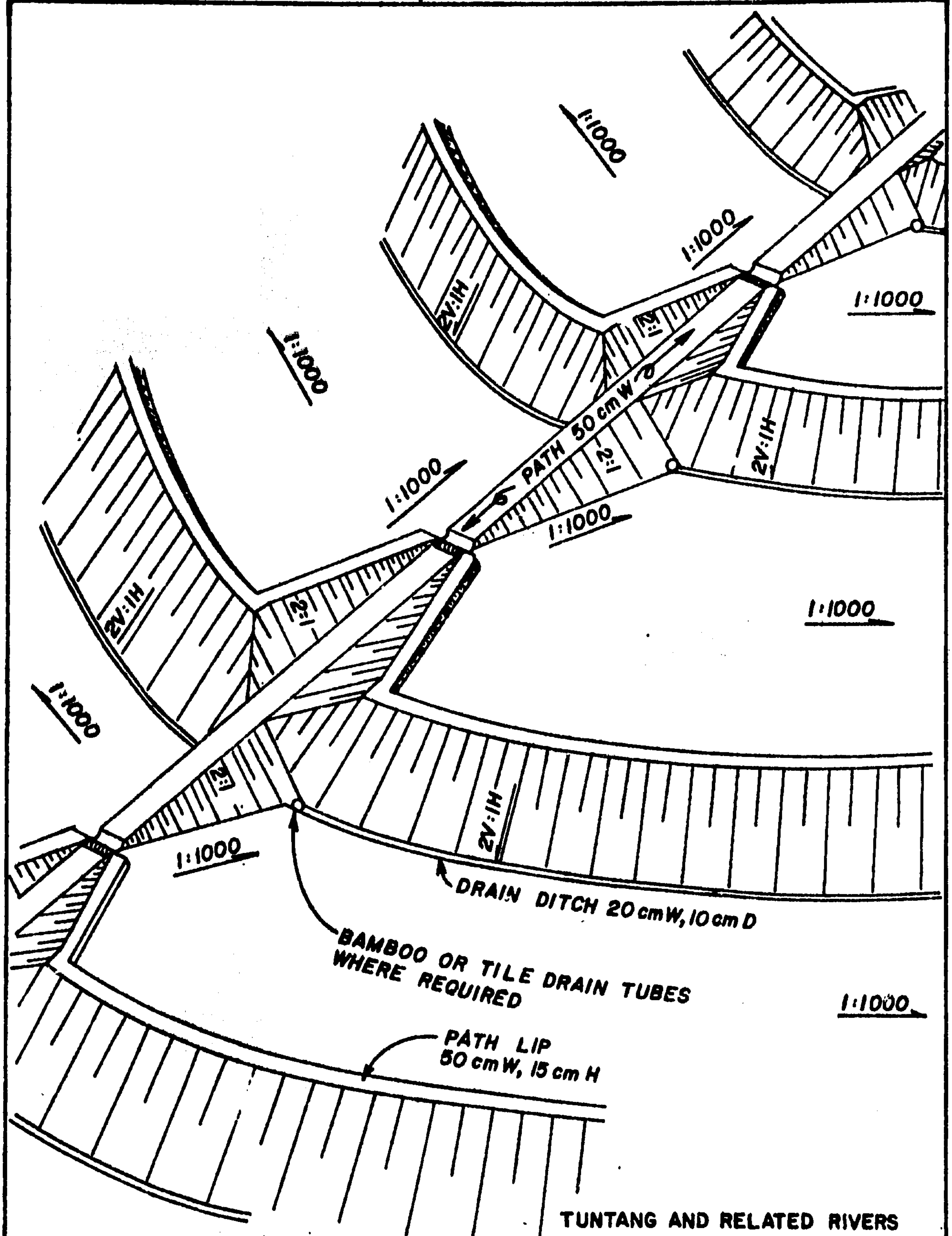
Note:

(A) - Corn or Palawija Crops
(B) - Grass

Contour strip cropping on a slope. On steep slopes the clean-tilled strips should be on the exact contour and usually not more than 15 meters wide. In this instance the corn or other palawija crop strips are protected by the intervening strips of grass, which effectively check erosion.

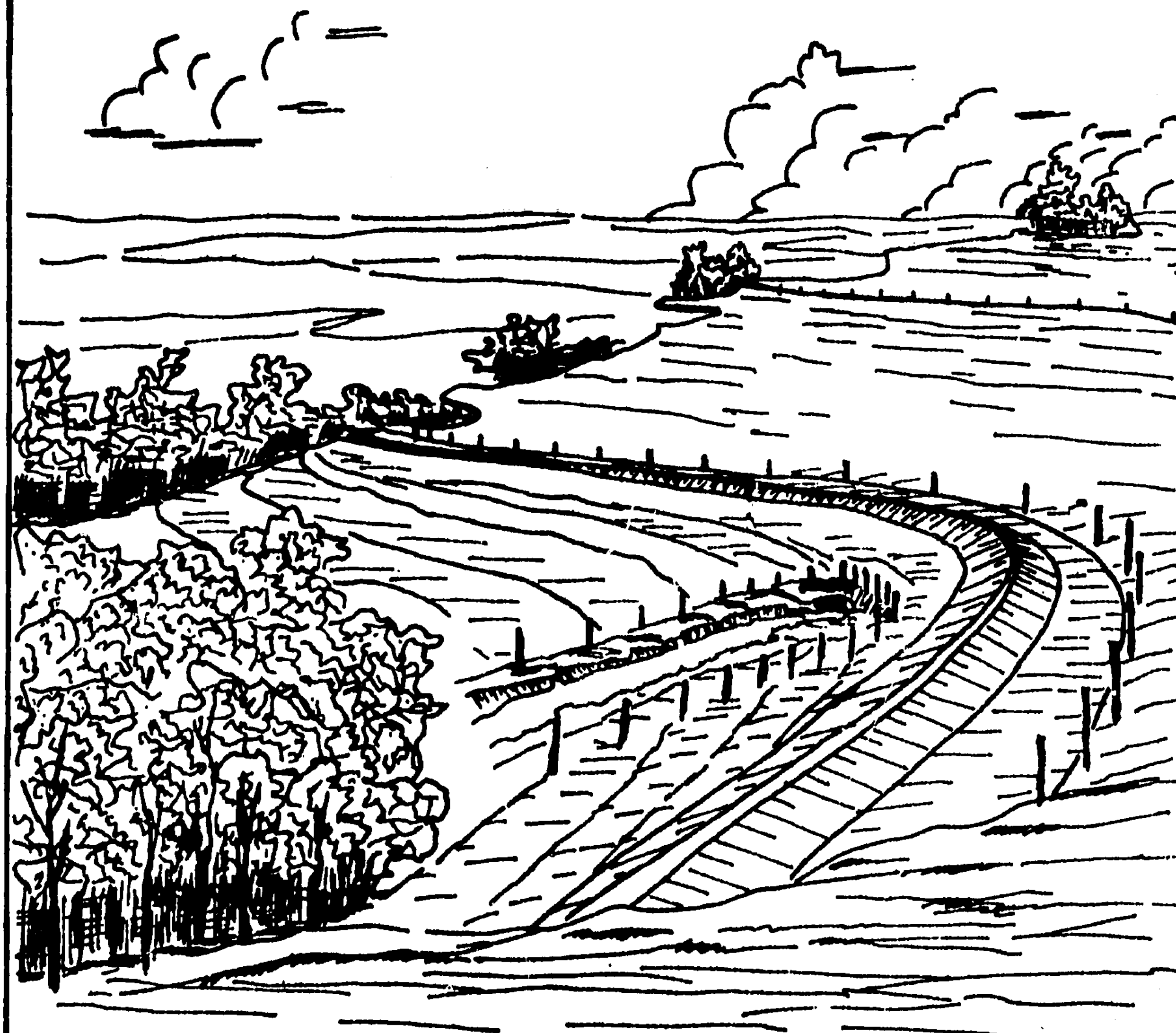
TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

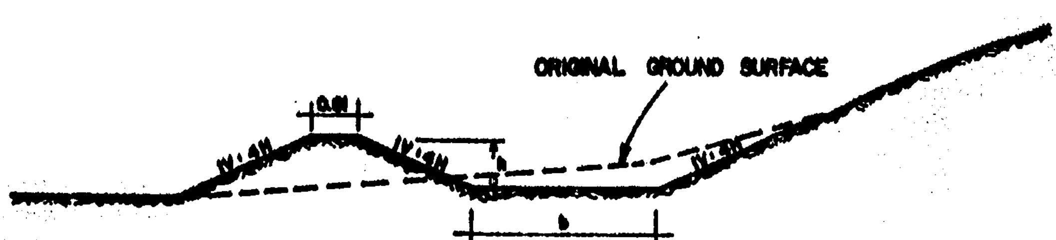
CONTOUR STRIP CROPPING



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

FARM PATH FOR ACCESS TO BENCH TERRACE SYSTEM



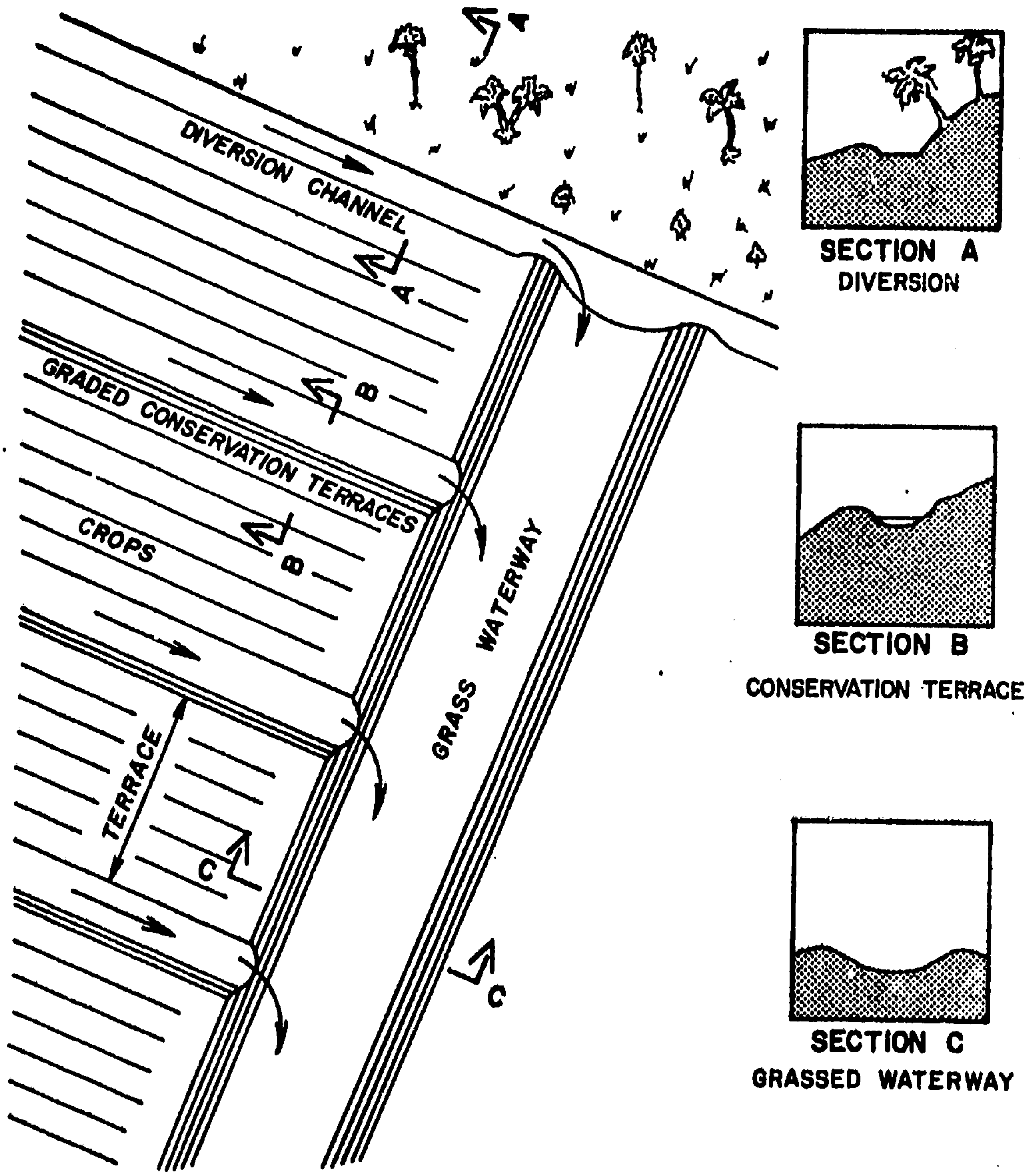


CROSS SECTION OF A DIVERSION

A diversion ditch around the head of a gully. The gully is being planted to trees and grass. The ditch drains both ways.

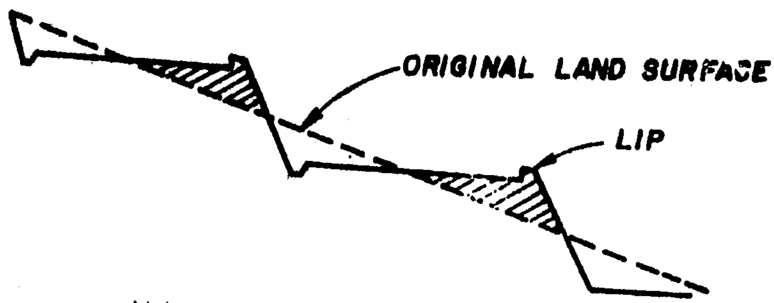
TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

DIVERSION CHANNEL

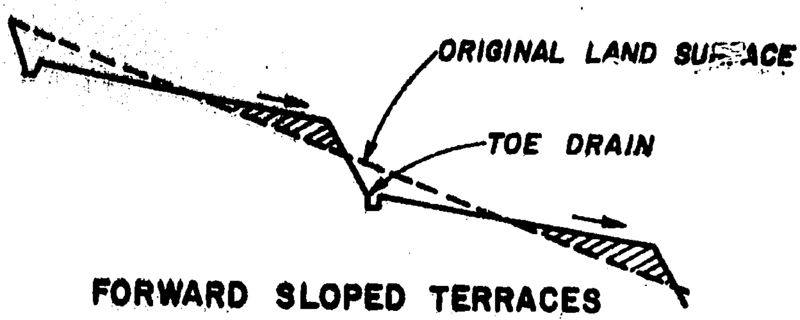


TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

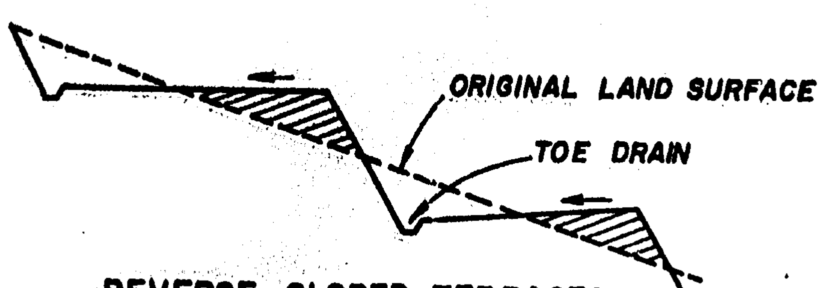
BASIC COMPONENTS OF MECHANICAL PROTECTION



HORIZONTAL TERRACES



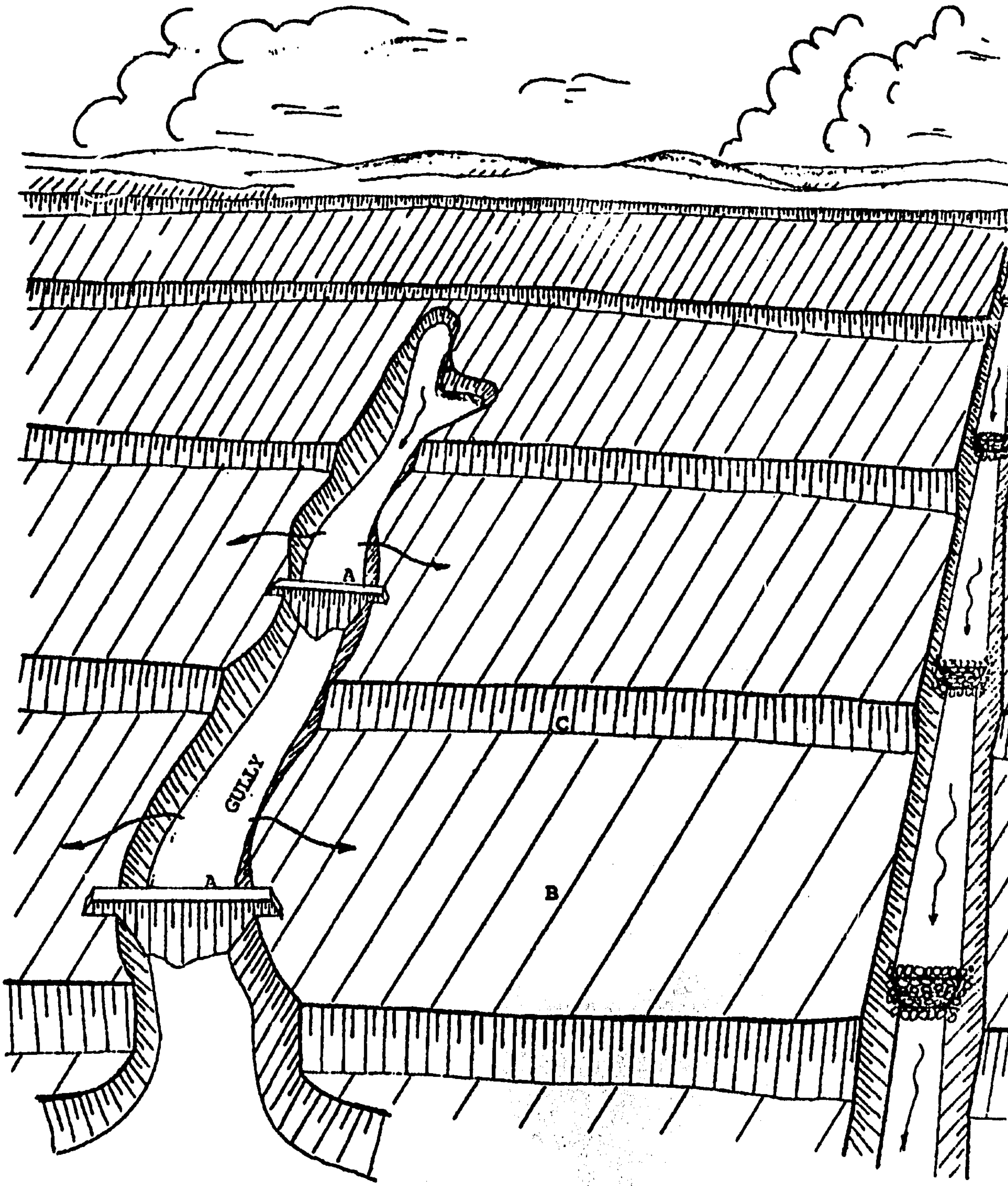
FORWARD SLOPED TERRACES



REVERSE SLOPED TERRACES

TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

TYPES OF BENCH TERRACES



NOTES :

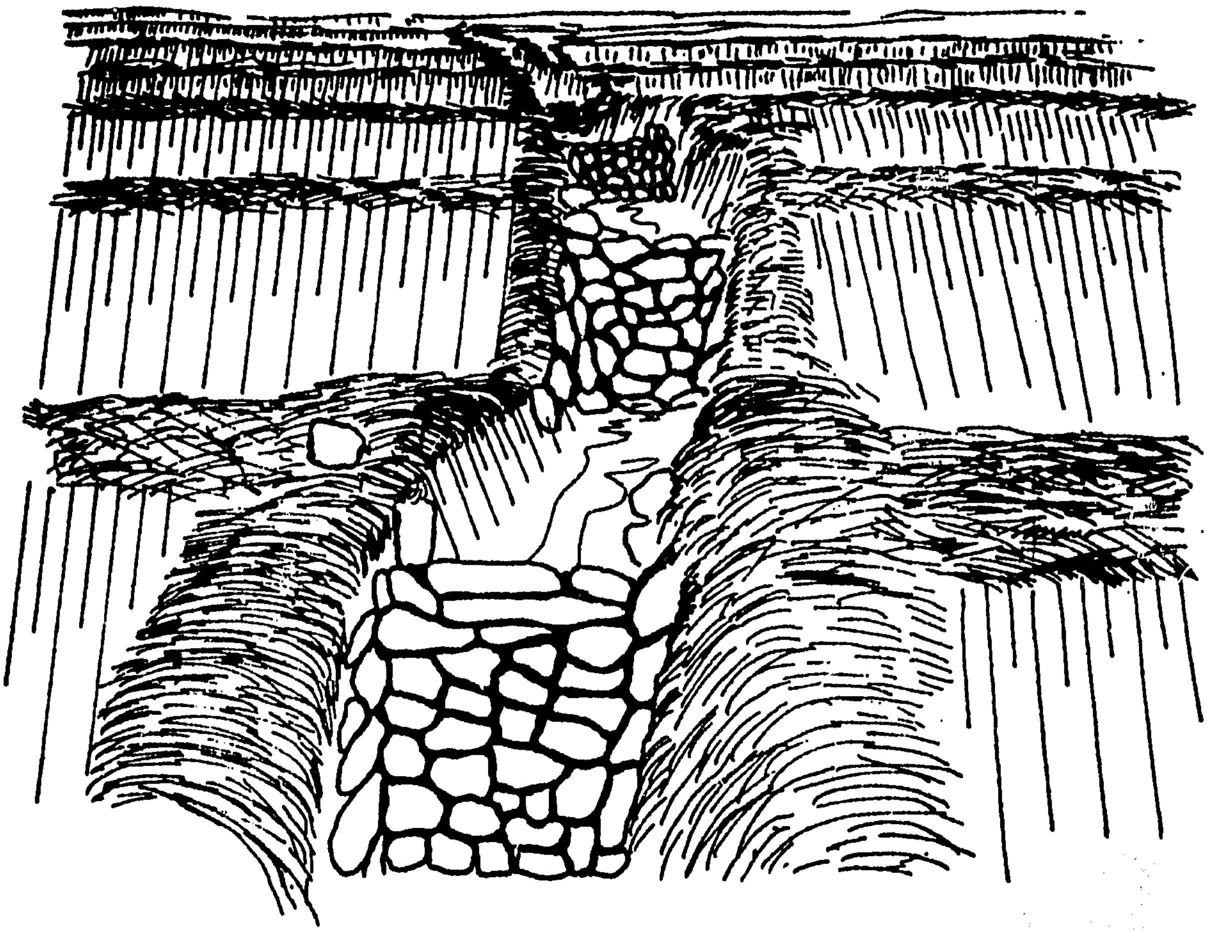
A - GULLY PLUGS

B - BENCH TERRACE

C - RISER

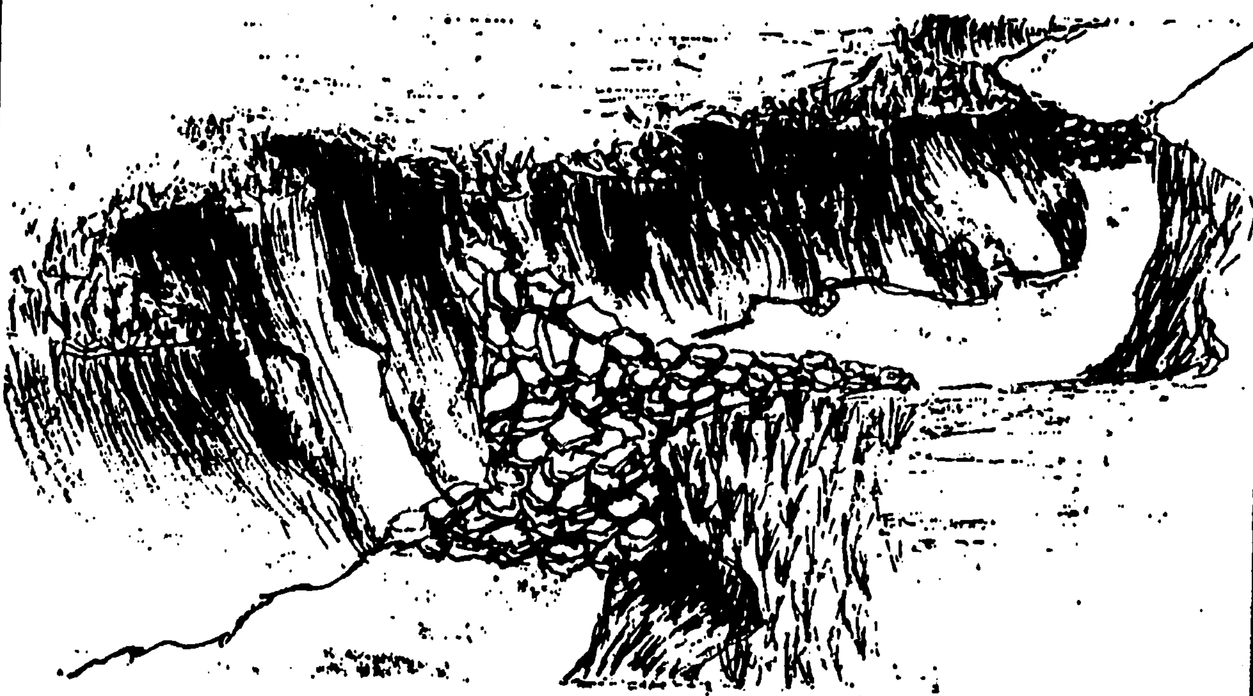
TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

DRAINING BENCH TERRACES AWAY FROM GULLIES



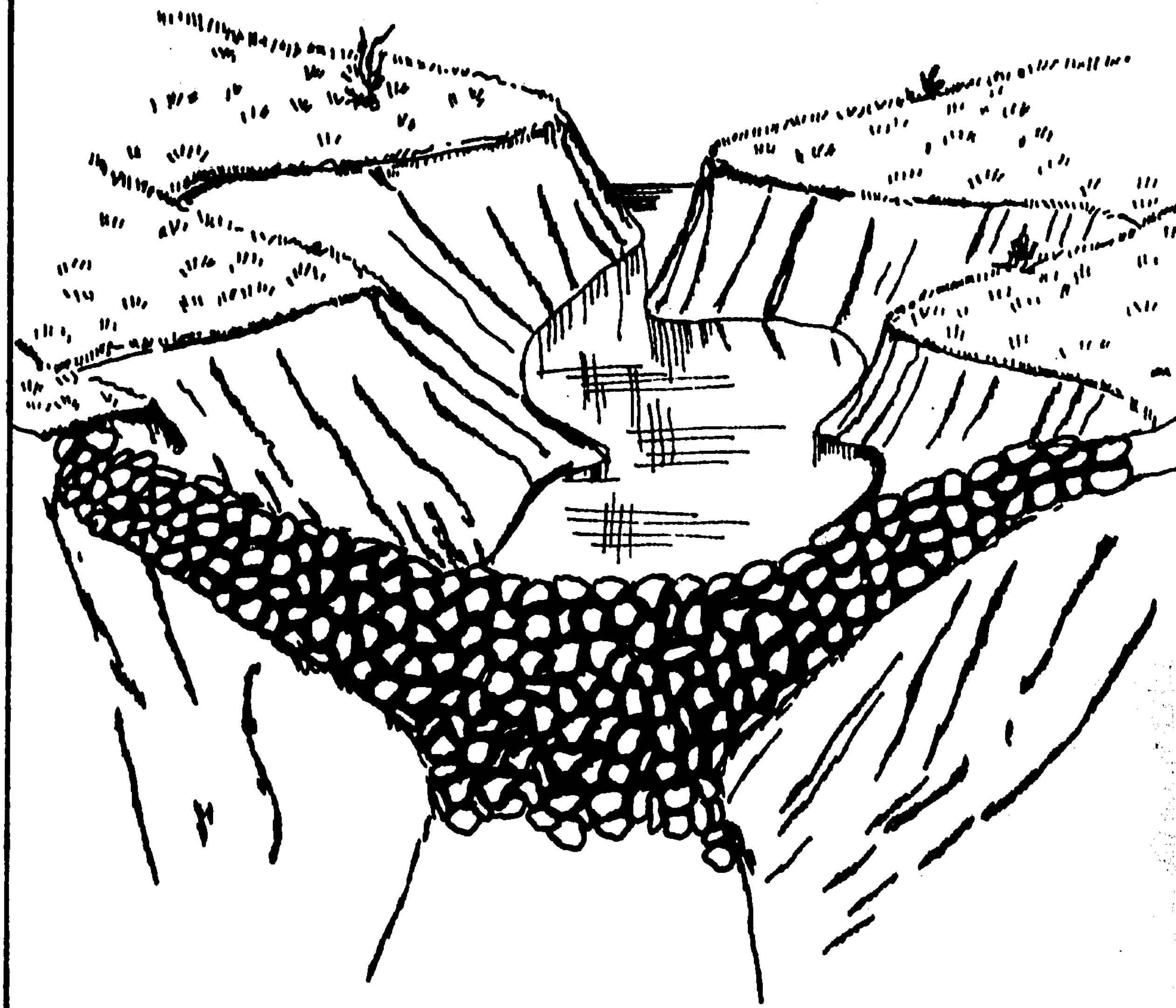
TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

SMALL ROCK CHECKS
IN A WATERWAY



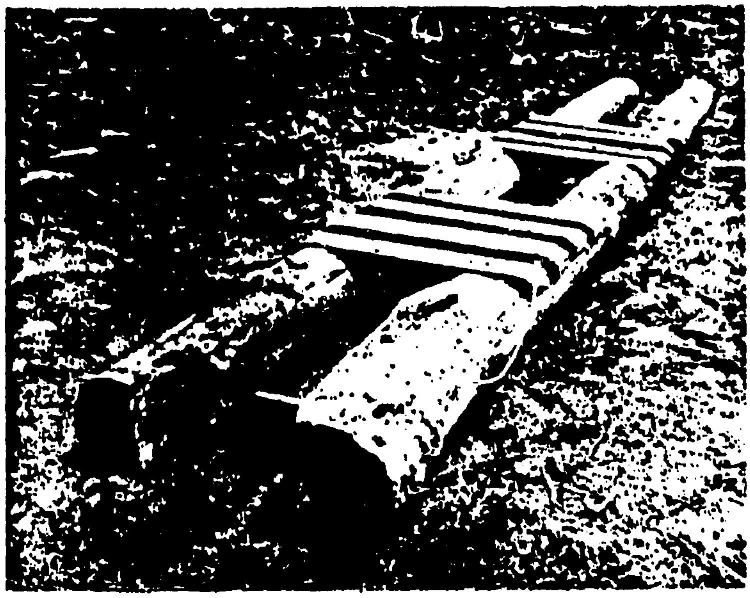
TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

USE OF SMALL ROCK CHECKS FOR GRADE STABILIZATION

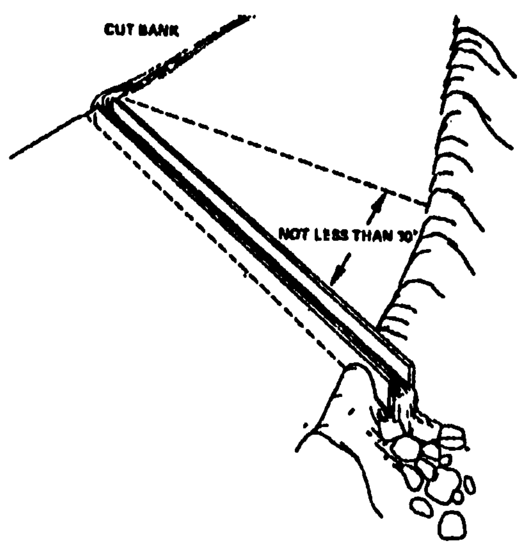


TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

LOOSE ROCK
CHECK DAM



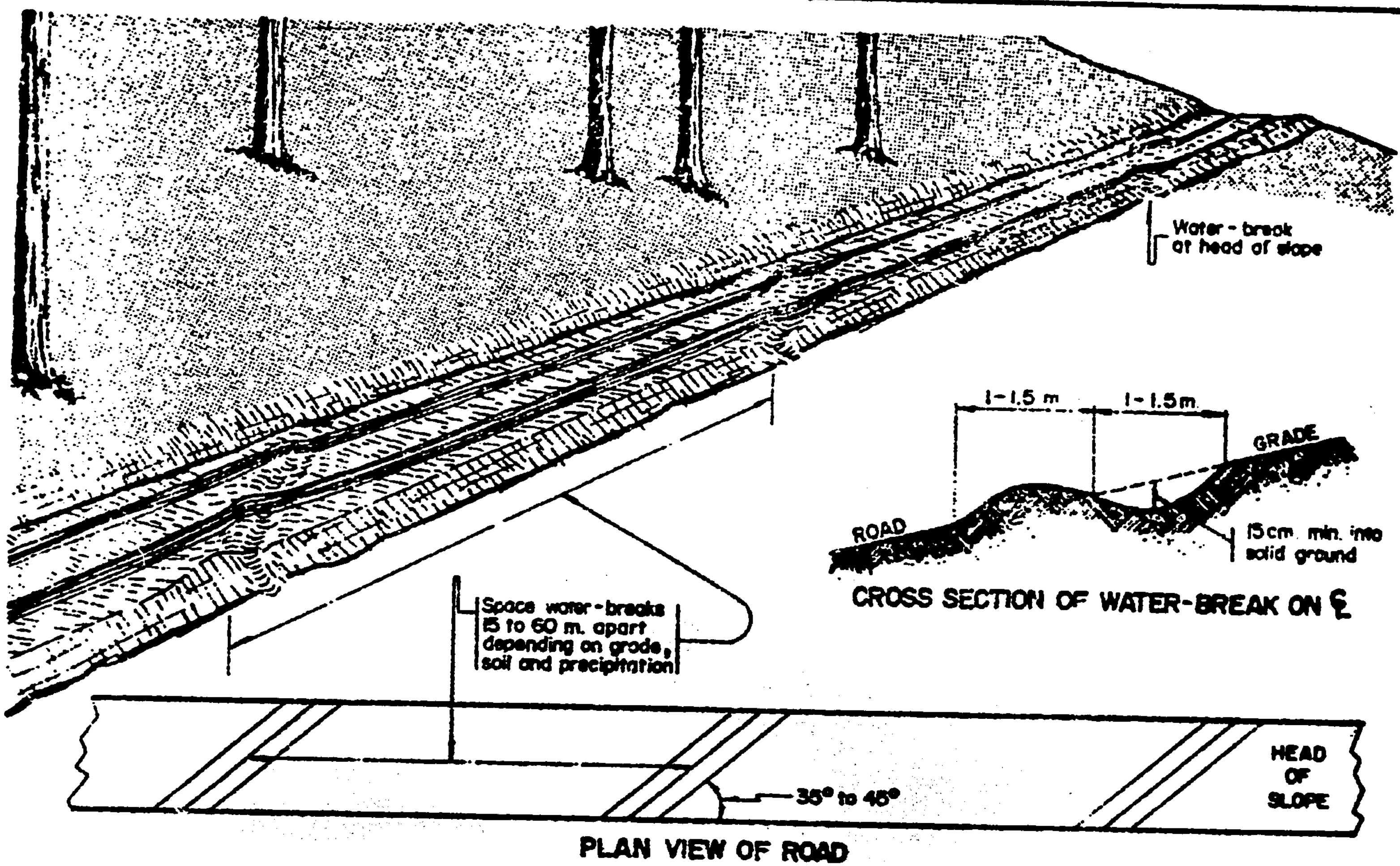
An open-top culvert constructed of wood. Spreaders on the bottom of the logs maintain culvert shape and the 5-cm spaces between the boards prevent water from running down wheel tracks and across the culvert.



Installation of an open-top culvert. Culverts should be slanted at least 30° downslope to help prevent plugging.

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

USE OF OPEN - TOP CULVERTS ON ROADS



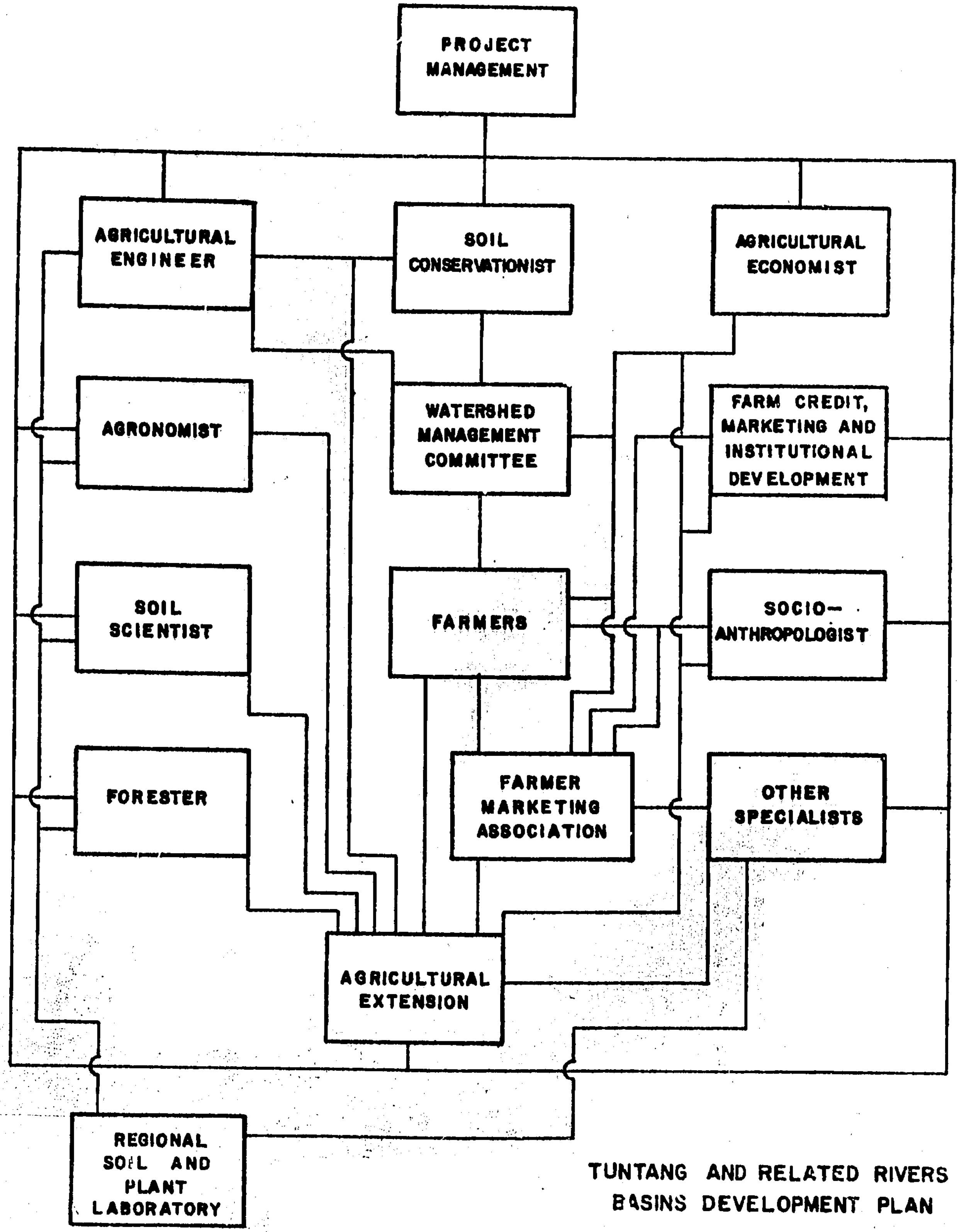
TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

DETAIL OF
WATERBREAK CONSTRUCTION

PRC ENGINEERING CONSULTANTS, INS.

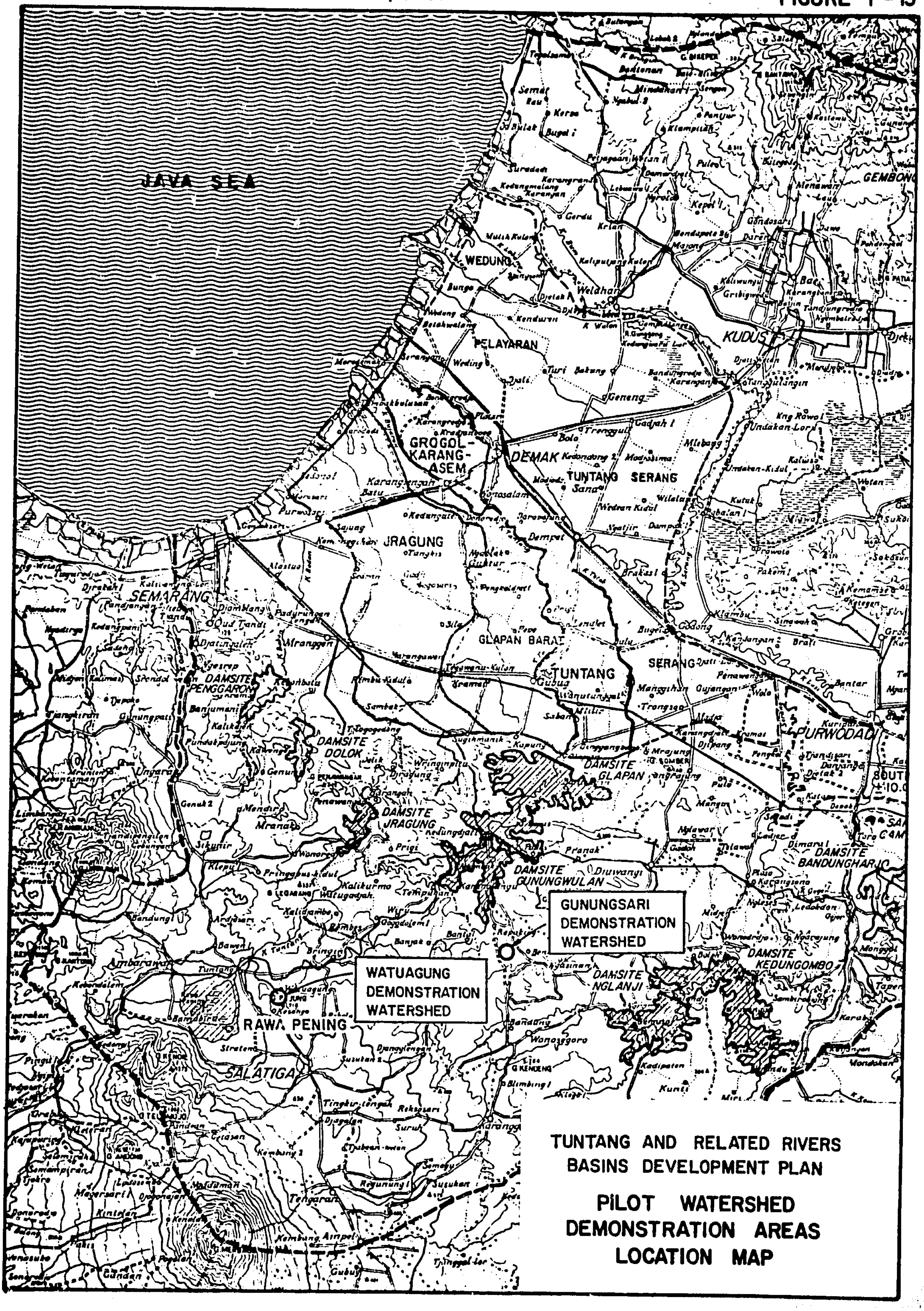
FIGURE F – 13

PRELIMINARY STAFF ORGANIZATION PLAN FOR AN INTEGRATED WATERSHED MANAGEMENT PROJECT



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

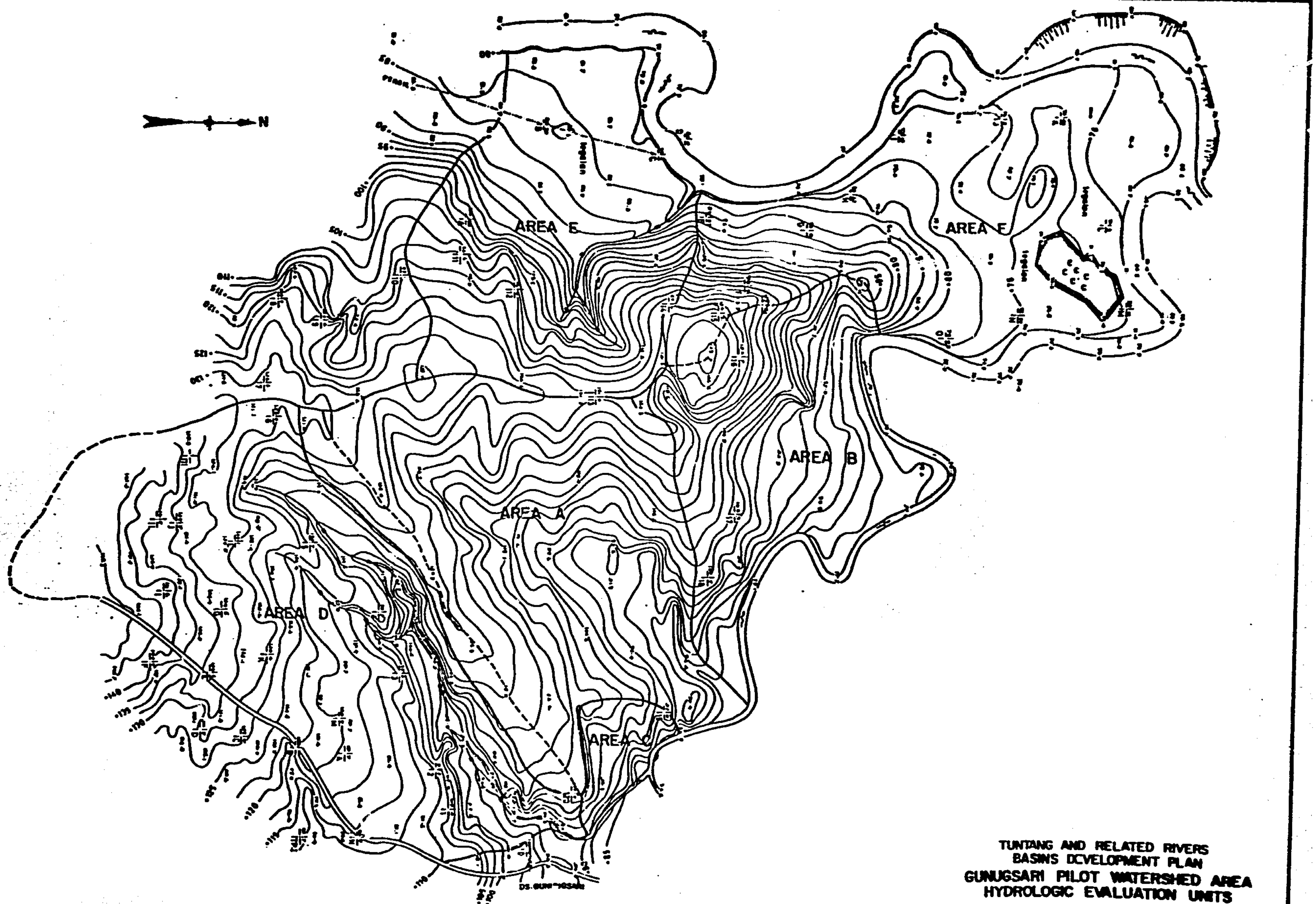
STAFF ORGANIZATION PLAN



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

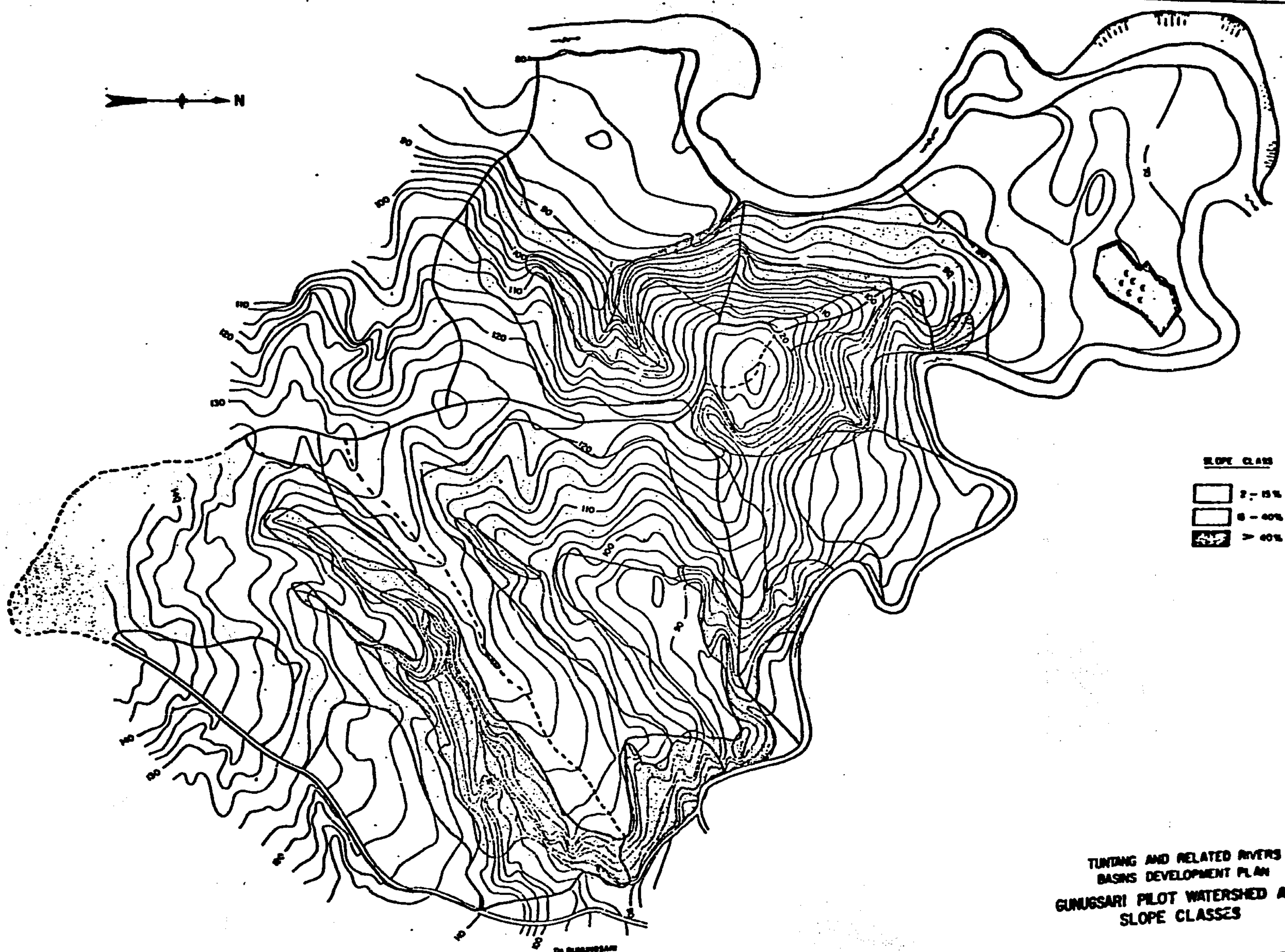
PILOT WATERSHED DEMONSTRATION AREAS LOCATION MAP

FIGURE F-16



TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN
GUNUGSARI PILOT WATERSHED AREA
HYDROLOGIC EVALUATION UNITS

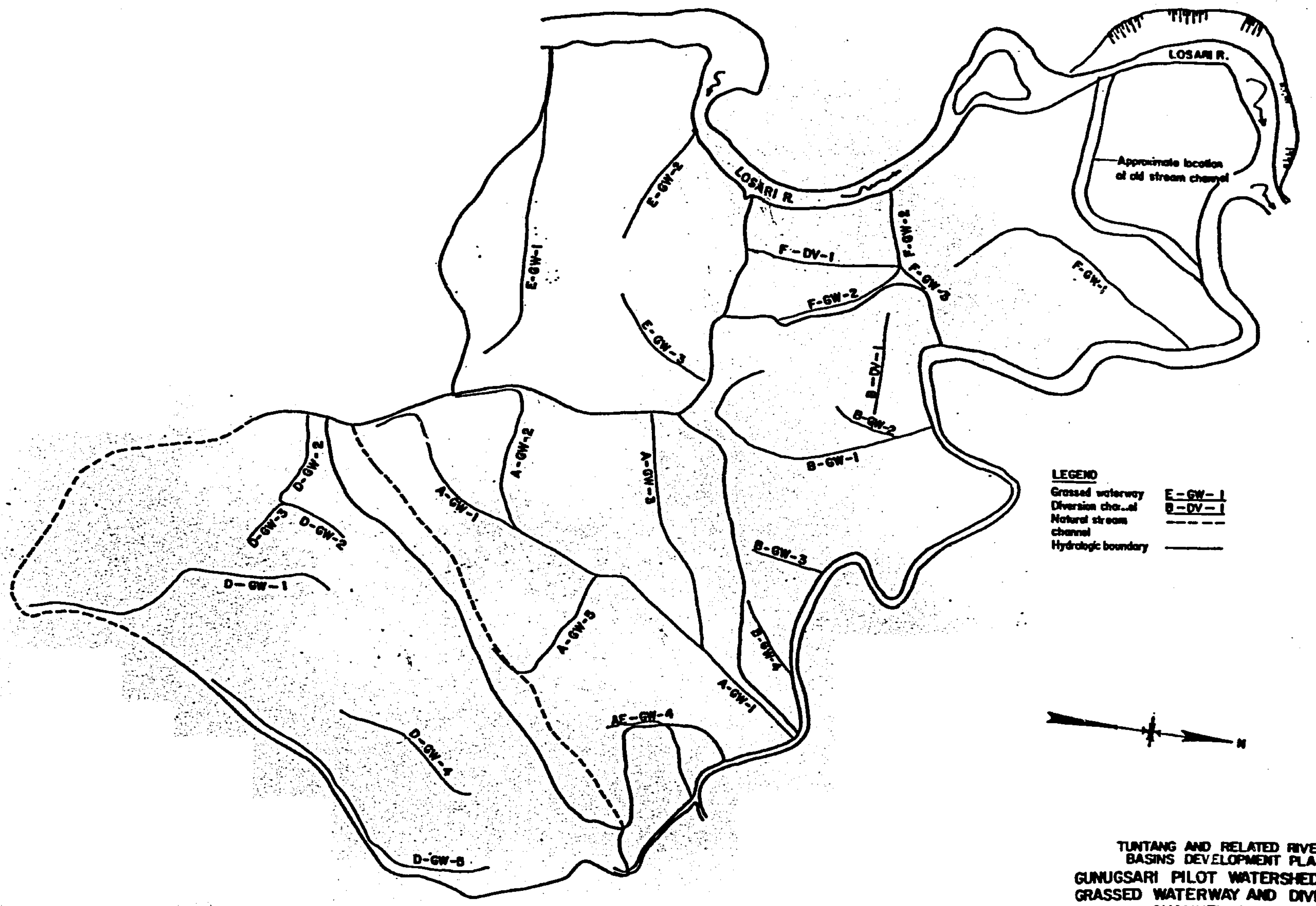
FIGURE F - 17



TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

GUNUGSARI PILOT WATERSHED AREA
SLOPE CLASSES

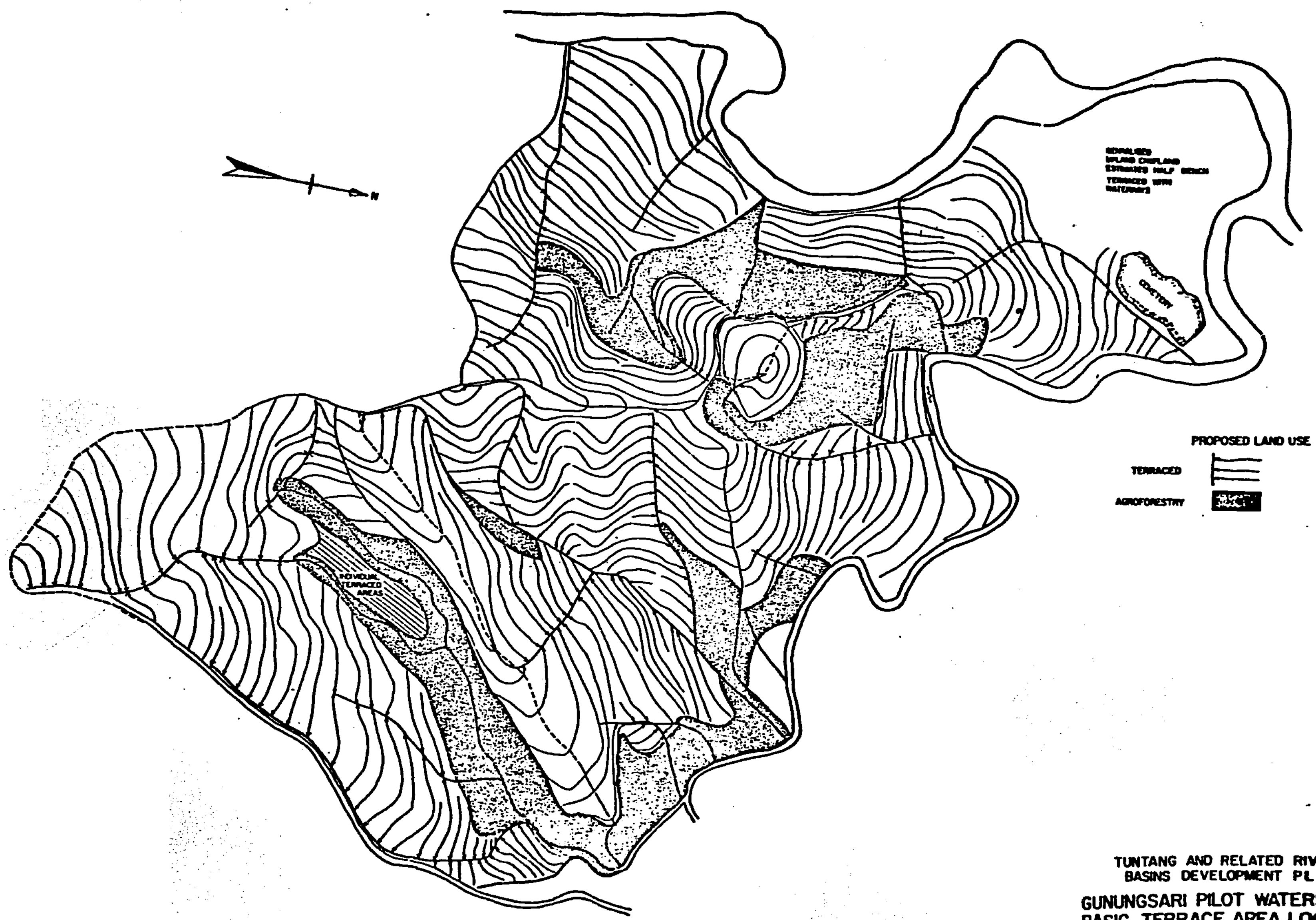
FIGURE F - 19



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

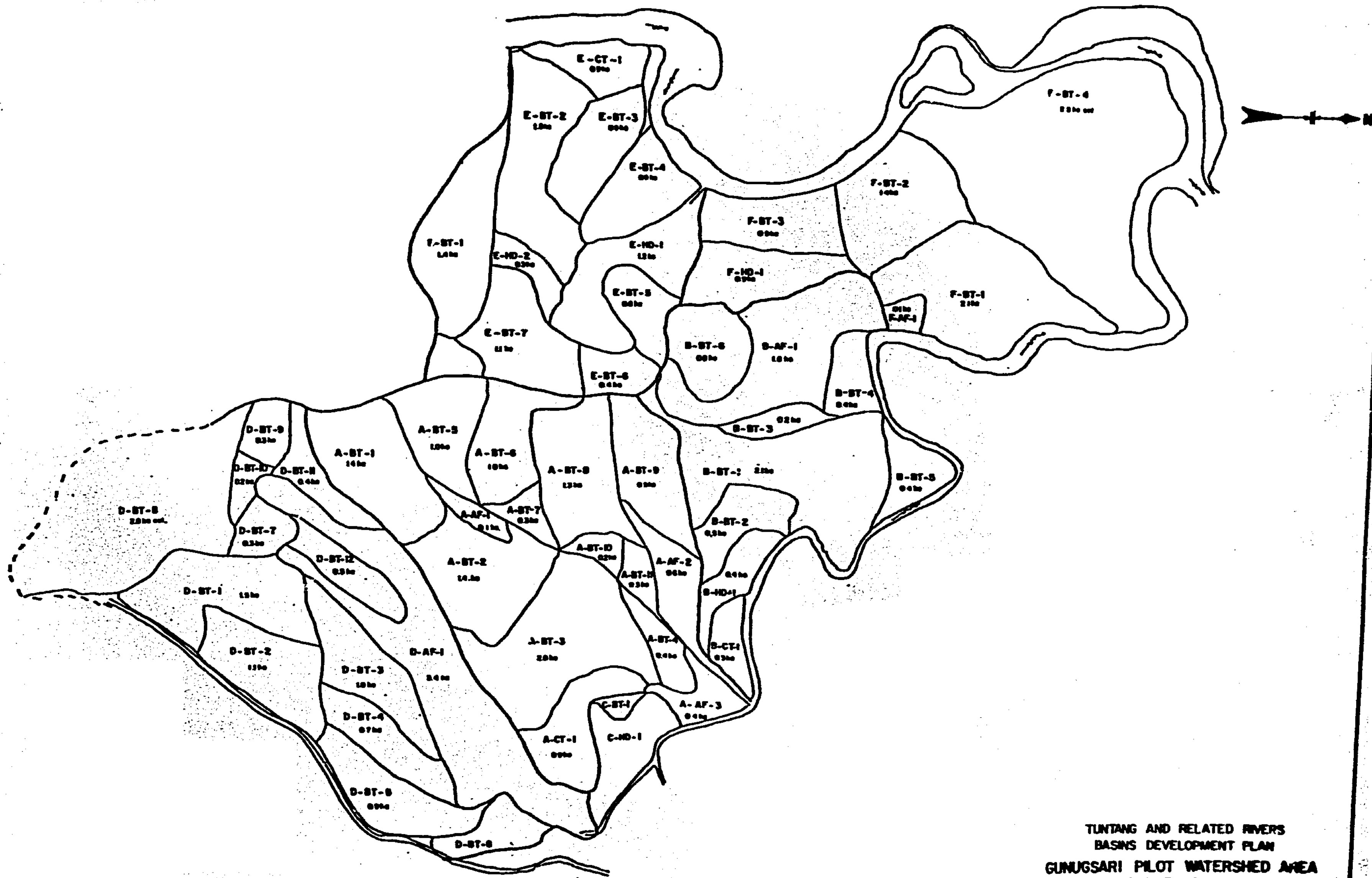
GUNUGSARI PILOT WATERSHED AREA GRASSED WATERWAY AND DIVERSION CHANNEL SYSTEM

FIGURE F-19



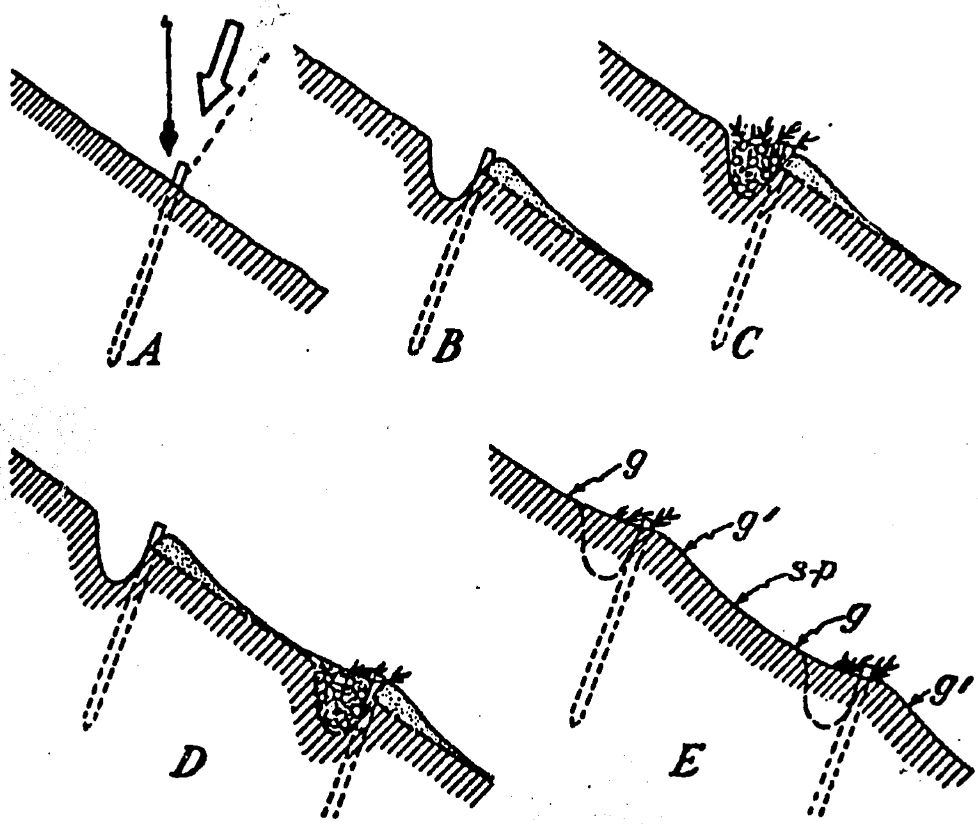
TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

GUNUNGSARI PILOT WATERSHED AREA BASIC TERRACE AREA LOCATION MAP



TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

GUNUGSARI PILOT WATERSHED AREA
PLANNED CONSERVATION PROGRAM

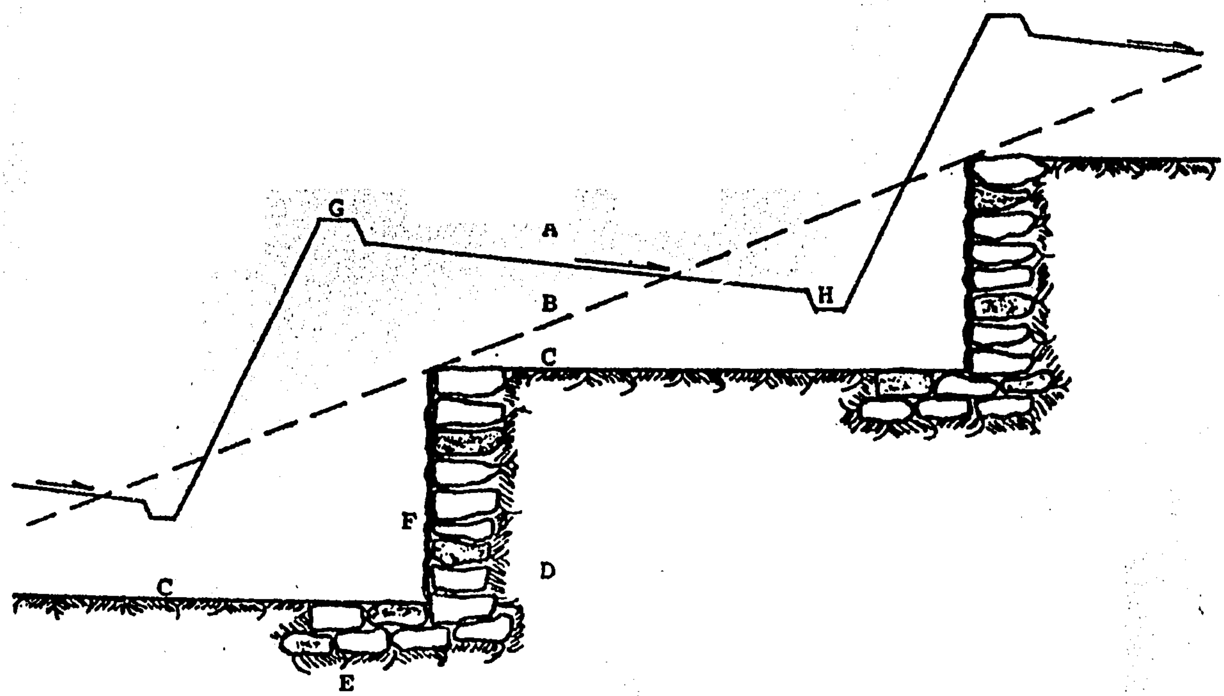


Steps in contour wattling and planting:

A = Stakes set in contour rows, showing approximate angle of the stakes which bisects the "plumb bob" line and a line at right angle to the slope.
B = Trench cut just above the stakes.
C = Brush wattles packed into trench resting against stakes.
D = Lower contour completed, with brush wattling partly buried by soil from next trench above.
E = Sowing and planting; cereal grains are sown at g (and at g' in extremely extremely loose soil or where wattles are 4 feet (1.25 m) or farther apart): native seeds or plants are set at s-p. (From U.S. Forest Service Handbook)

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

CONTOUR WATTLING AND STAKING

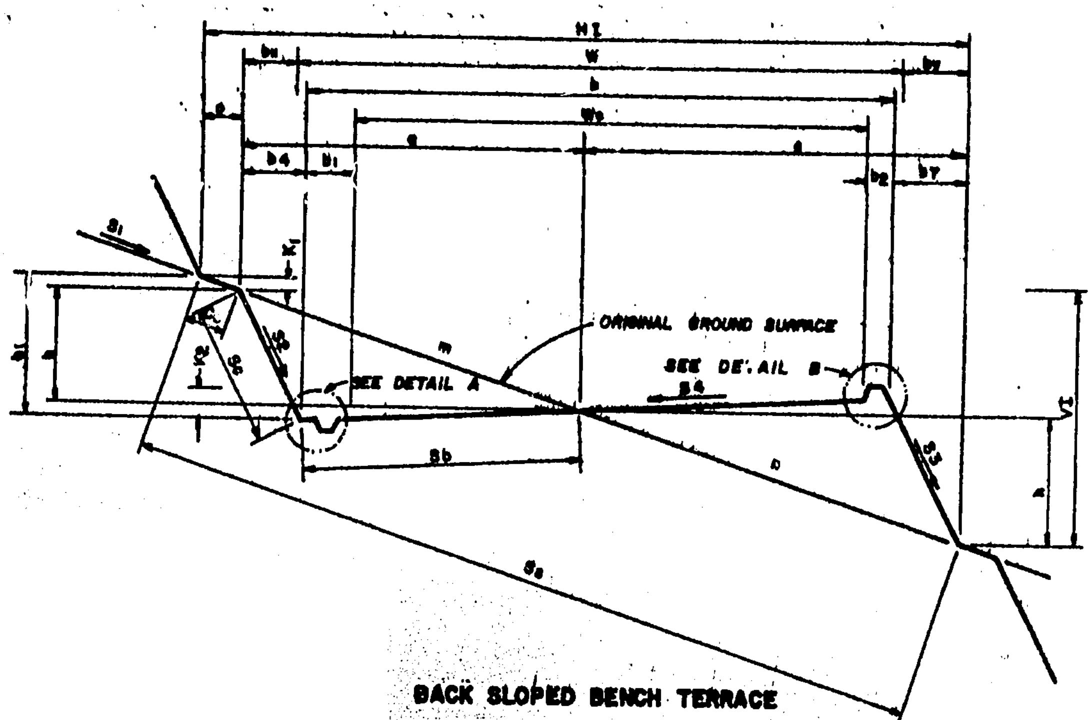


Notes:

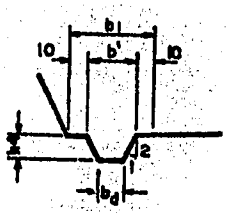
A - Profile of Bench Terrace
B - Original ground surface
C - Bed of waterway well sodded (Profile)
D - 30 cm thick with stones laid horizontally.
E - On foot at drop 0.30 cm thick (0.50 m min.)
F - Position of drop sited such that waterway is kept in cut material
G - Small dike (20 cm width and 0.20 m high)
H - Small ditch (0.20 m width and 0.20 m deep)

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

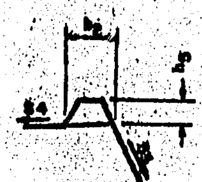
BENCH TERRACE AND WATERWAY CROSS SECTION



BACK SLOPED BENCH TERRACE



DETAIL A
TERRACE CHANNEL



DETAIL B
TERRACE LIP

TERRACE CHANNEL DIMENSION (Cm)

h_4	b_d	b'	b_1	b_2
15	15	30	50	20
20	15	55	55	20
25	15	40	60	20

DEFINITIONS

- S_1 = ORIGINAL GROUND SLOPE
- S_2 = CUT SLOPE
- S_3 = RISER SLOPE
- S_4 = TERRACE BACK SLOPE
- VI = VERTICAL INTERVAL
- HI = HORIZONTAL INTERVAL
- Wc = EFFECTIVE CROP WIDTH
- e = WIDTH OF SAFETY STRIP
- $h + \frac{1}{2} b_2$ = HEIGHT OF RISER
- Ae = AREA OF CUT

EQUATIONS

ASSUME VI GIVEN

$HI = \frac{100\ VI}{S_1}$

$h = \frac{\frac{1}{2}[S_1 (HI - e)]}{100}$

$bx = \frac{100(h)}{Sx}$

$K_1 = \frac{S_1\ e}{100}$

$K_2 = \frac{W\ S_4}{100}$

$h_1 = h + K_2/2 + K_1$

$W = HI - (bx + by) - e$

WHERE $S_2 = S_3$ $bx = by$

$b_4 = \frac{100}{S_2}(h + \frac{1}{2} K_2)$ & $b_7 = \frac{100}{S_3}(h + \frac{1}{2} K_2)$

$b = HI - e - b_4 - b_7$

WHERE $b_4 = b_7$ & $S_2 = S_3$

$b = HI - e - 2b_4$

$Wc = b - (b_1 + b_2)$

$a = b/2 + b_4 = W/2 + bx$

$a' = W/2 + by = b/2 + b_7$

$HI = a + a' + e$

$S_s = \sqrt{HI^2 + VI^2}$ OR $S_s = m + n + e_s$

$e_s = \sqrt{e^2 + K_1^2}$

$Sb = \sqrt{(a - b_4)^2 (K_2/2)^2}$

$Sc = \sqrt{b_4^2 + (h + K_2/2)^2}$

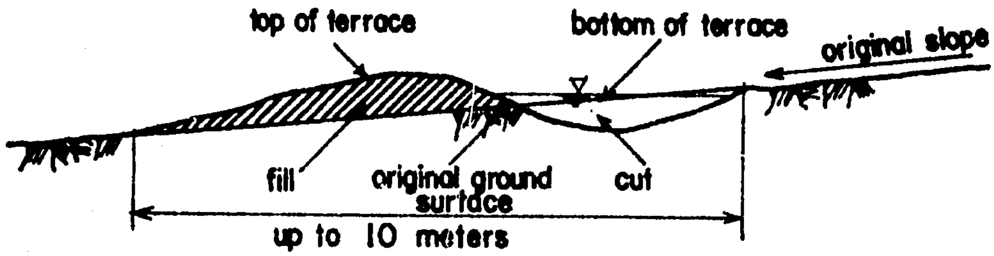
$m = \sqrt{a^2 + h^2}$

$P = \frac{1}{2}(m + Sb + Sc)$

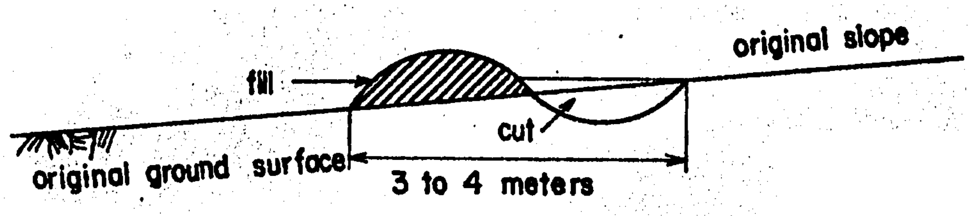
$Ae = \sqrt{P(P-m)(P-Sb)(P-Sc)}$

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

DEFINITIONS, DIMENSIONS AND PROPERTIES OF BENCH TERRACES



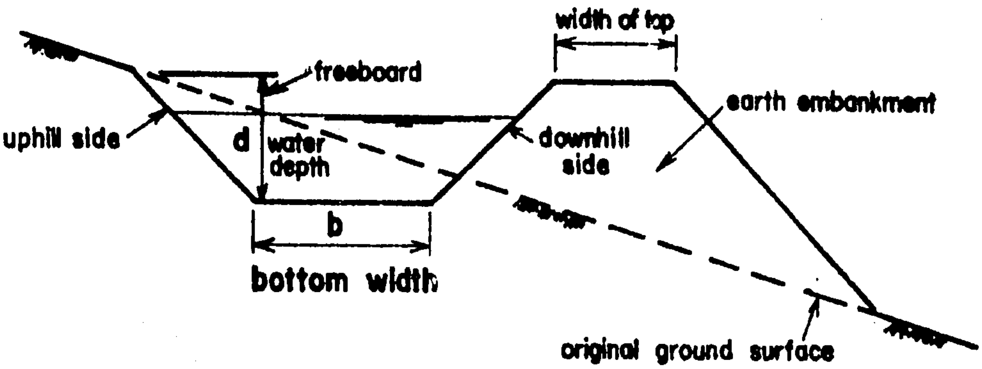
BROAD BASED TERRACE CROSS SECTION



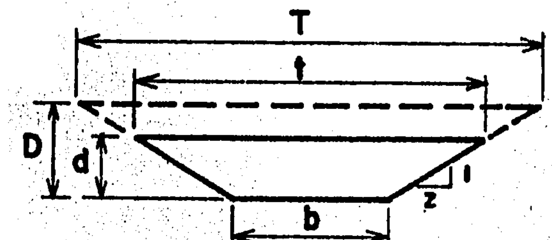
NARROW BASE TERRACE CROSS SECTION

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

CONSERVATION TERRACE CROSS SECTIONS



TRAPEZOIDAL DITCH

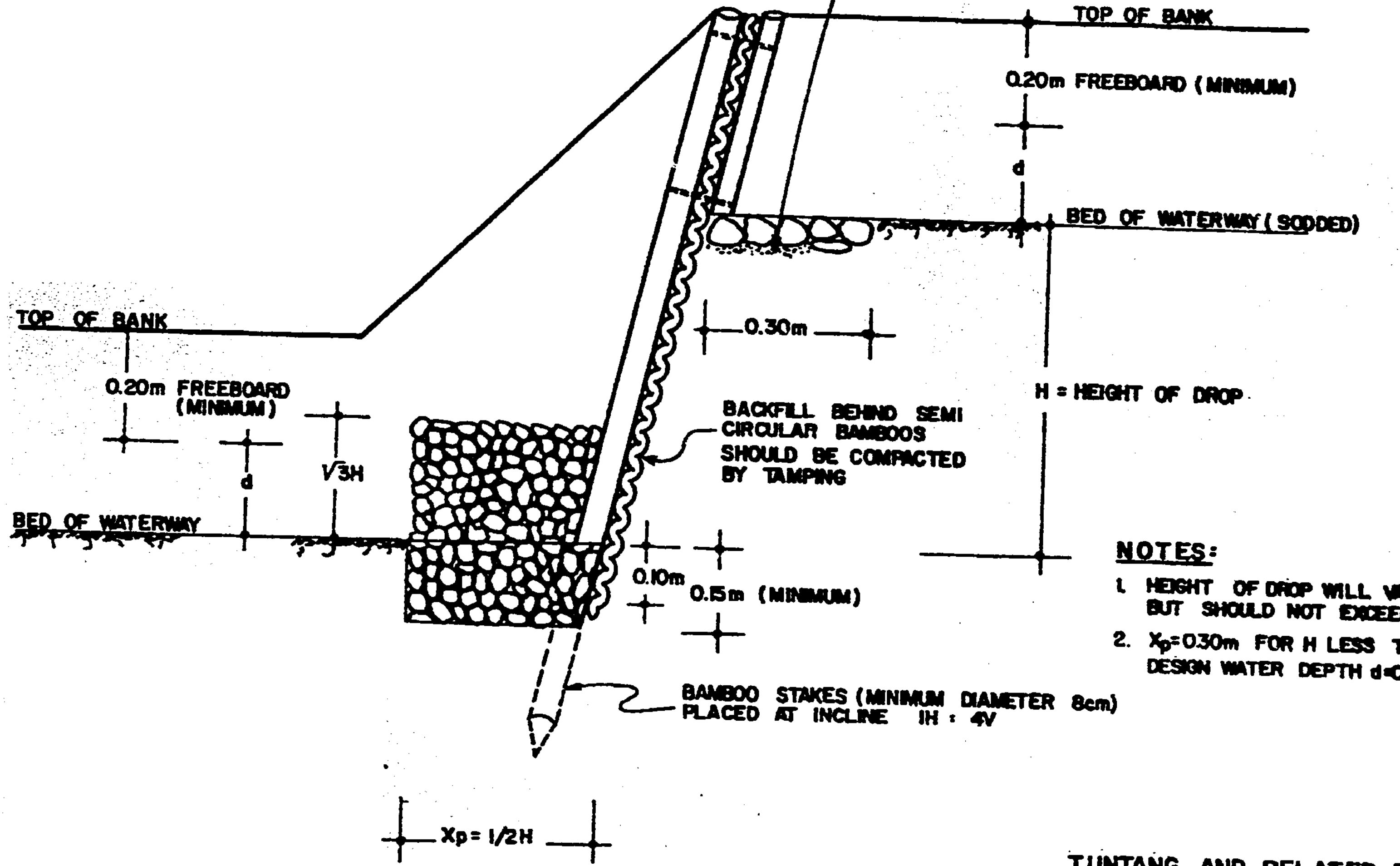


EQUATIONS

AREA (A)	$bd + zd^2$
WETTED PERIMETER (P)	$b + 2d\sqrt{1+z^2}$
HYDRAULIC RADIUS (R)	$\frac{bd + zd^2}{b + 2d\sqrt{1+z^2}}$
TOP (t) WIDTH (T)	$t = b + 2dz$ $T = b + 2Dz$
VELOCITY (V)	$V = \frac{R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$
FLOW (Q)	$Q = AV$

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

DIVERSION DITCH CROSS SECTION



NOTES:

1. HEIGHT OF DROP WILL VARY, BUT SHOULD NOT EXCEED 1.50m
2. X_p=0.30m FOR H LESS THAN 0.50m DESIGN WATER DEPTH d=0.10 TO 0.15m

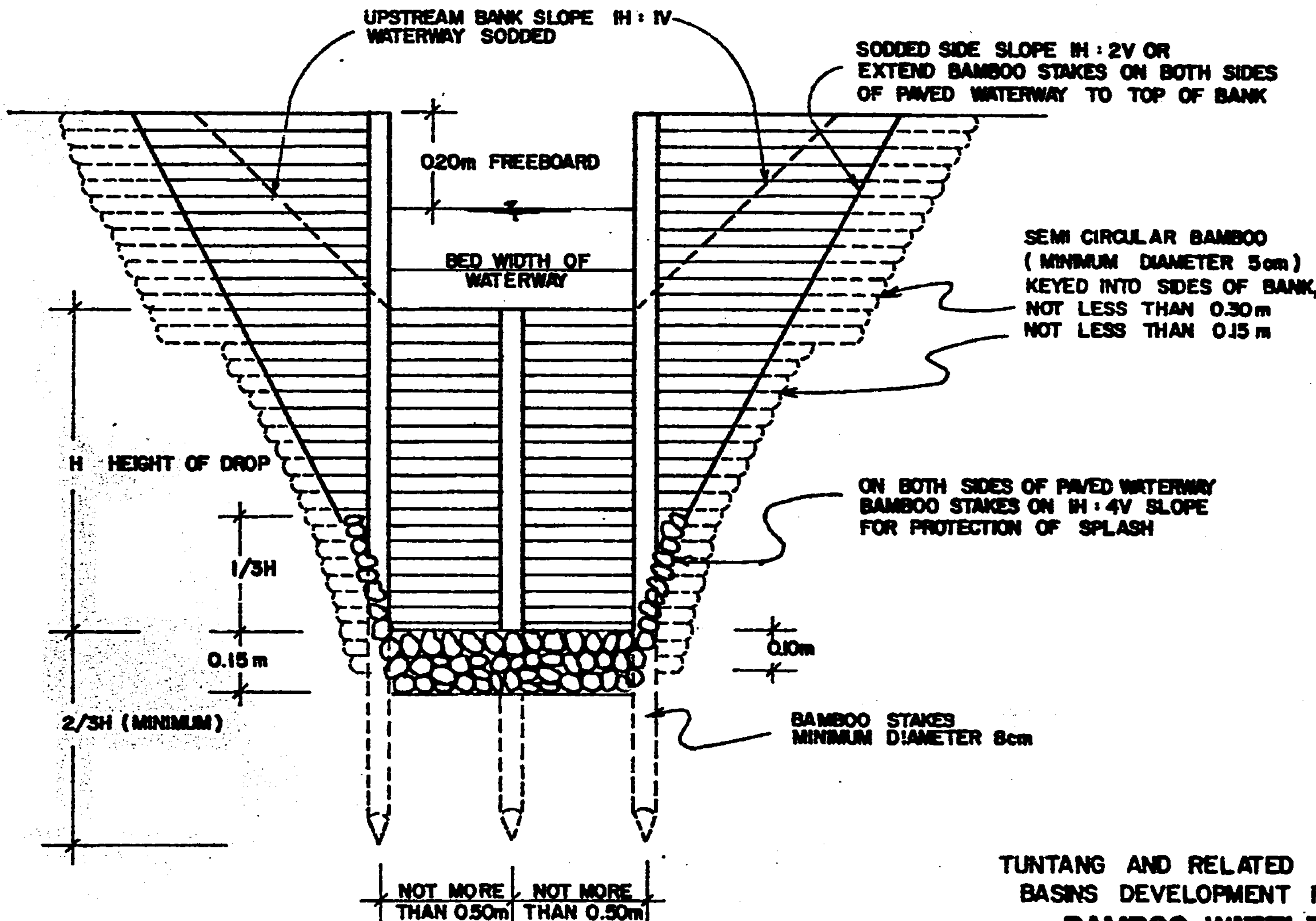
LONGITUDINAL SECTION BAMBOO DROP STRUCTURE

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

BAMBOO WATTLE CHECKS

PRC ENGINEERING CONSULTANTS, INC.

FIGURE F-26



FRONT VIEW BAMBOO DROP STRUCTURE

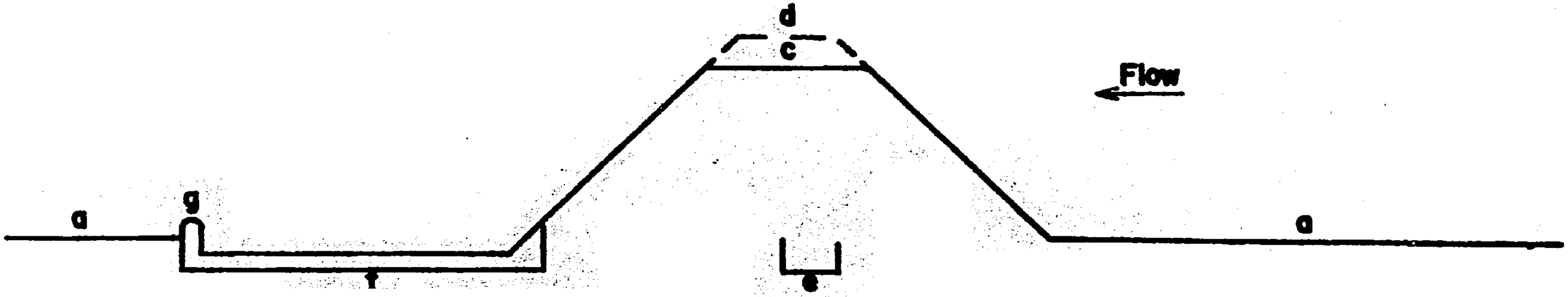
TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

BAMBOO WATTLE CHECKS

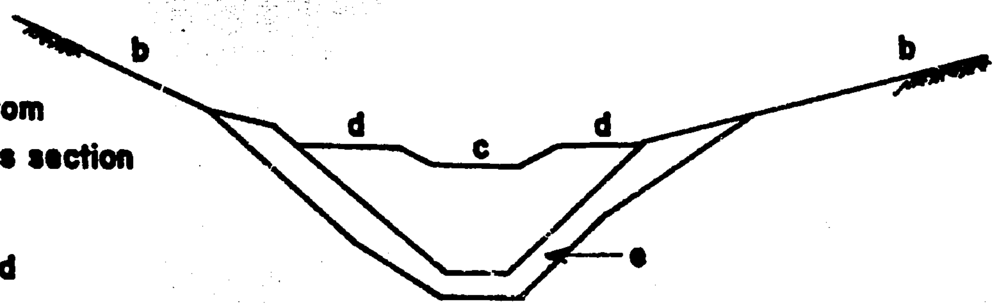
FIGURE F - 26

PRC. ENGINEERING CONSULTANTS, INC.

SECTION OF DAM THROUGH CENTERLINE OF THE GULLY



SECTION OF THE DAM AT THE CROSS SECTION OF THE GULLY



LEGEND

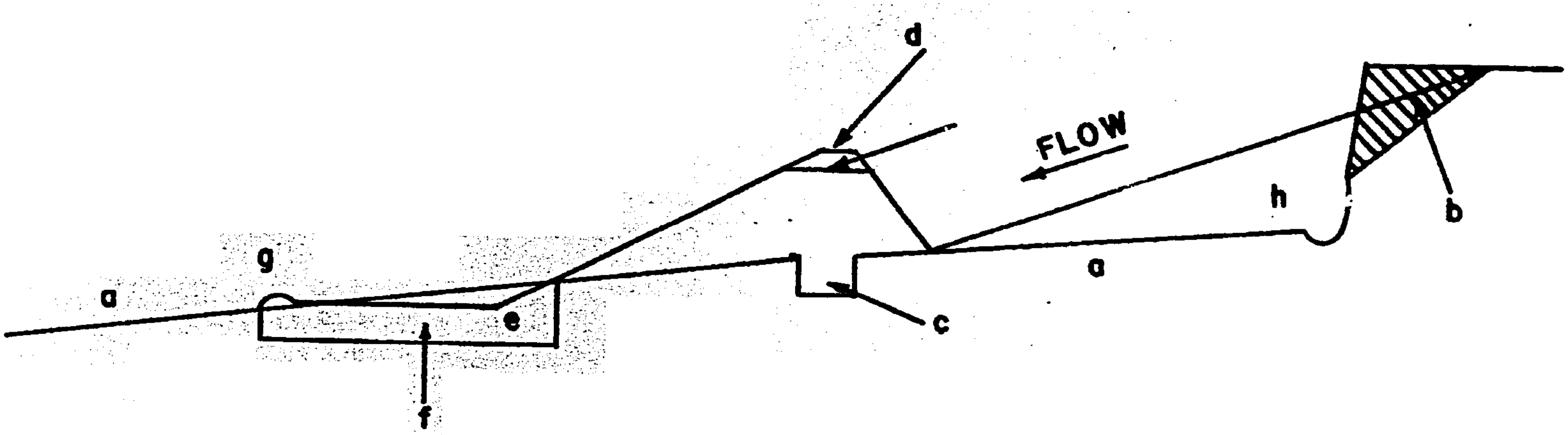
a = original gully bottom
b = original gully cross section
c = spillway
d = crest of freeboard
e = excavation for key
f = excavation for apron
g = end sill

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

LOOSE ROCK CHECK DAM

PRC ENGINEERING CONSULTANTS, INC.

FIGURE F - 27



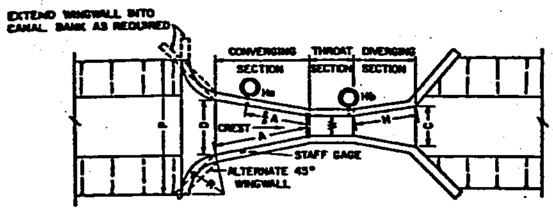
a = original gully bottom
b = excavated area of head-cut wall
c = spillway
d = crest of freeboard
e = excavation for key
f = excavation for apron
g = end sill
h = rock fill

TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

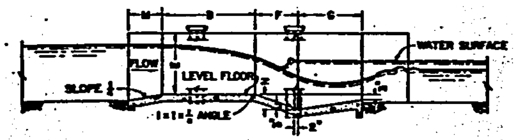
GULLY HEADCUT CONTROL WITH LOOSE ROCK CHECK DAM

PRC ENGINEERING CONSULTANTS, INC

FIGURE F - 28



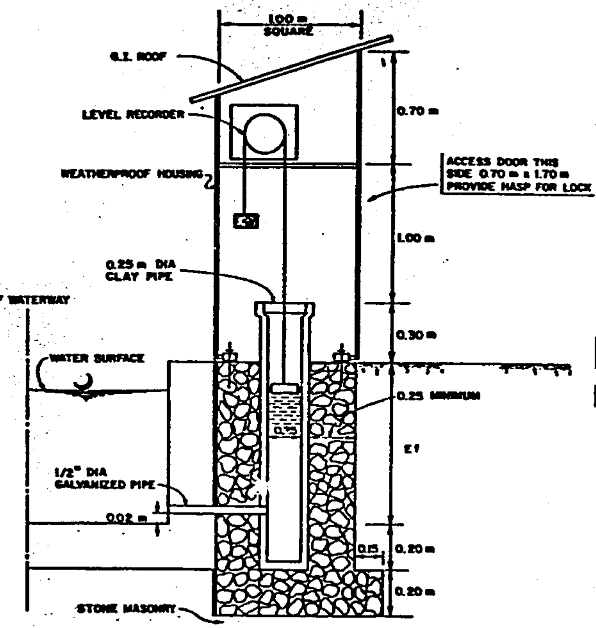
PLAN



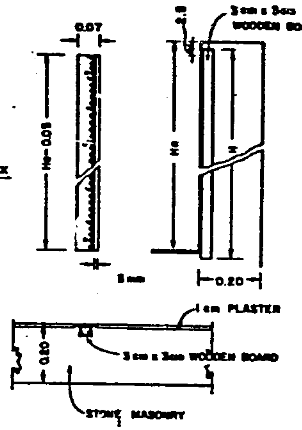
PROFILE

TABLE OF DIMENSIONS	
PLAN LETTER	m
W	1.22
A	1.83
2/3 A	1.22
B	1.79
C	1.52
D	1.94
E	0.91
F	0.61
G	0.91
M	0.46
N	0.23
P	1.07
R1	0.61

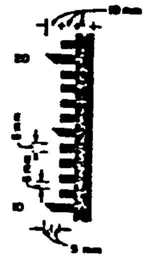
DISCHARGE RATING CURVE	
GAGE READING (m)	m^3/s
0.05	0.028
0.10	0.078
0.15	0.148
0.20	0.233
0.25	0.331
0.30	0.442
0.35	0.564
0.40	0.696
0.45	0.836
0.50	0.990
0.55	1.151
0.60	1.320
0.65	1.498
Q = 2,958 Ha	1,579



WOOD FRAME STRUCTURE
(DETAILS MEASUREMENT OF Ha)



DETAILS OF STAFF GAGE

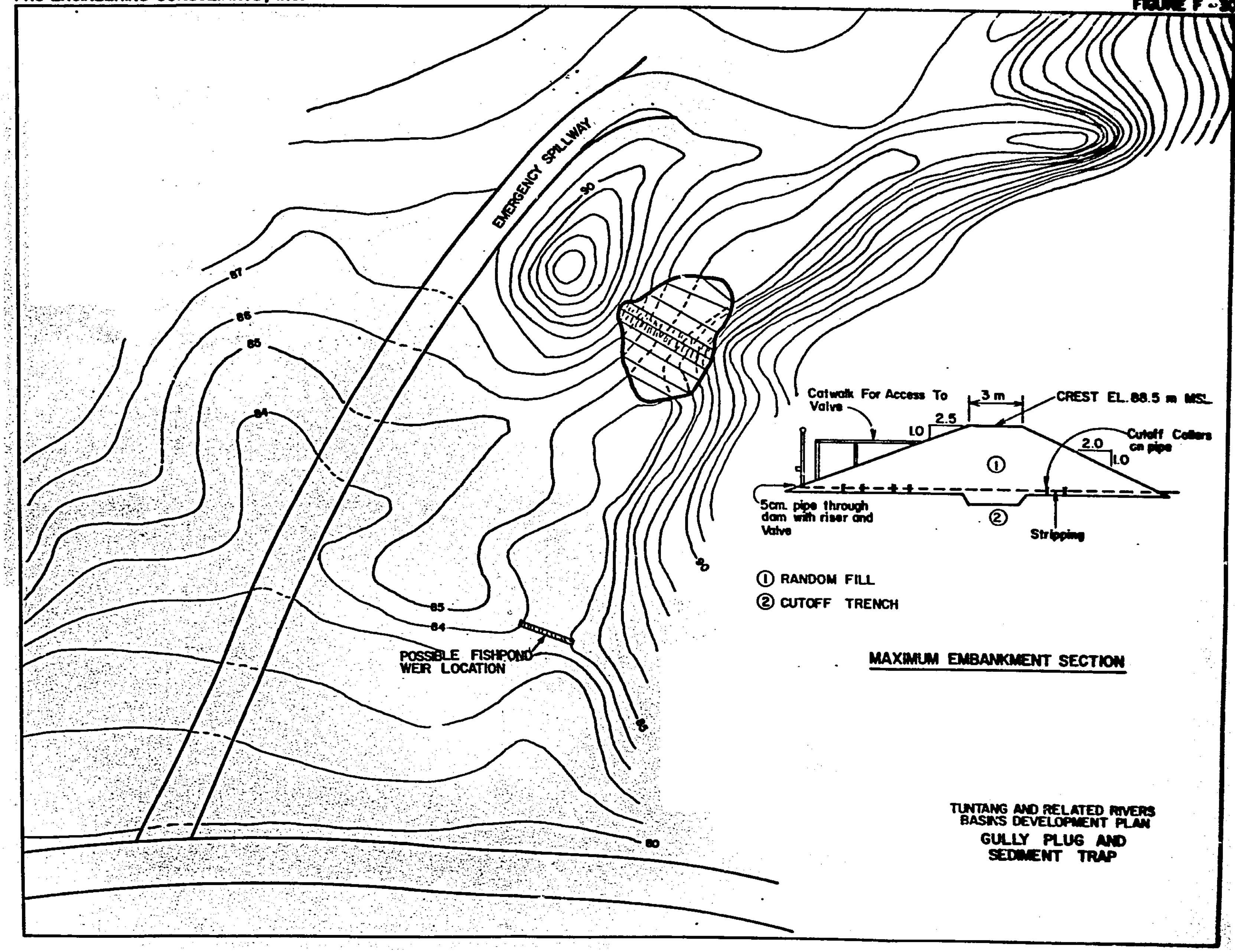


TYPICAL SUB-SECTION

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

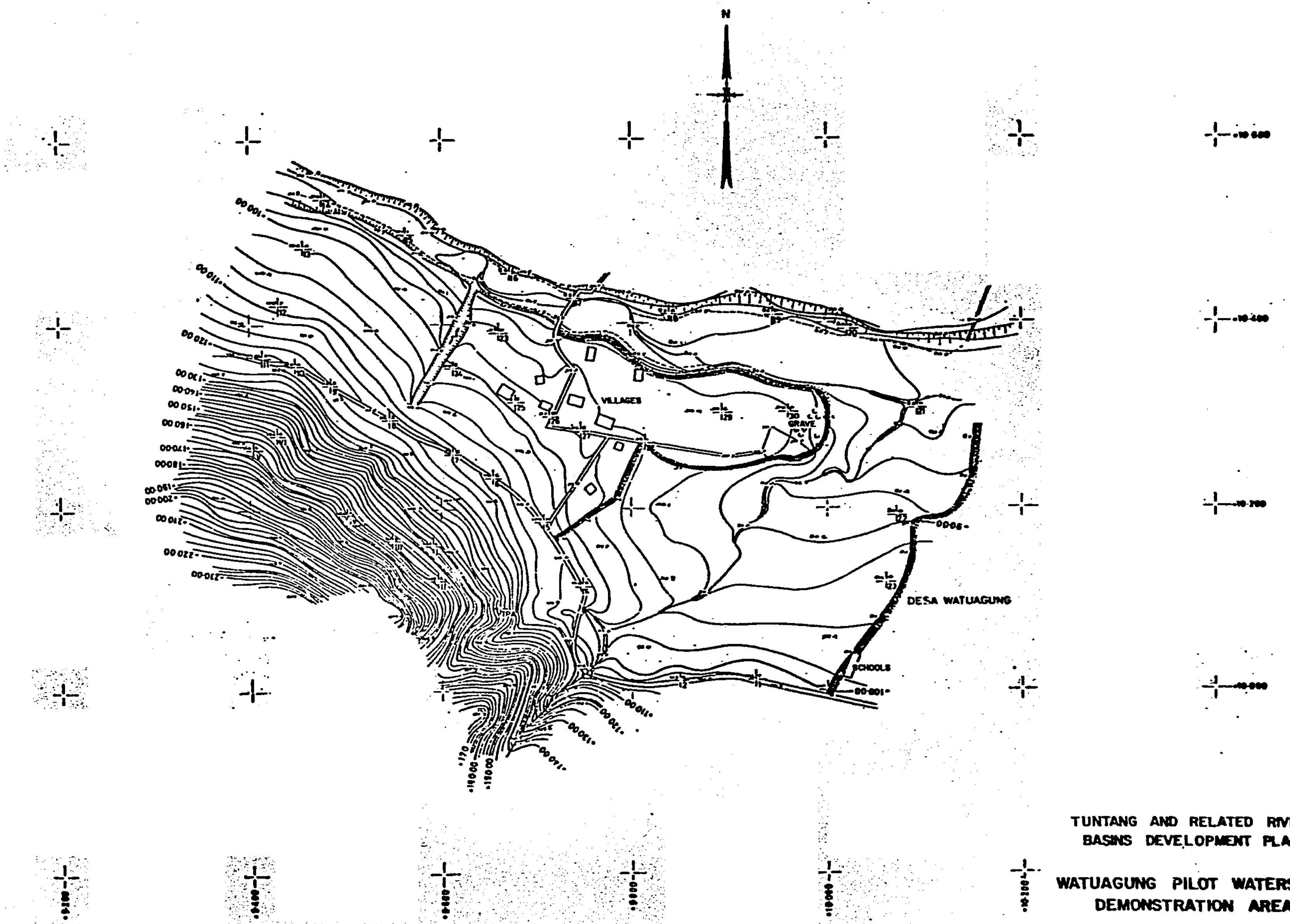
PARSHALL FLUME WITH STILLING WELL AND WATER LEVEL RECORDER

FIGURE F-30



TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

GULLY PLUG AND SEDIMENT TRAP



TUNTANG AND RELATED RIVERS
BASINS DEVELOPMENT PLAN

WATUAGUNG PILOT WATERSHED
DEMONSTRATION AREA