CHINESE - AMERICAN
JOINT COMMISSION ON RURAL RECONSTRUCTION

Forestry Series: No. 8

SOIL CONSERVATION IN TAIWAN

By
Ira K. Landon

TAIPEI, TAIWAN, CHINA
October 1963

CHINESE - AMERICAN
JOINT COMMISSION ON RURAL RECONSTRUCTION

Forestry Series: No. 8

SOIL CONSERVATION IN TAIWAN

By

Ira K. Landon

TAIPEI, TAIWAN, CHINA
October 1963

Foreword

Mr. Ira K. Landon, Soil Conservation Advisor, tirelessly served from August 1954 thru January 1962 (1) to counsel and assist in formulating and executing a soil conservation program for Taiwan; (2) to give technical assistance to commercial agricultural organizations; (3) to act as the soil conservation representative for the Joint Commission on Rural Reconstruction.

During his active tour of duty here, besides assisting in the establishment of nineteen soil conservation field offices, four soil conservation work stations, three watershed management stations and the Mountain Agricultural Resources Development Bureau, and the training of 410 technicians for the soil conservation field operations, he also wrote many papers on policy, orgnization, technique, education etc., all for the development of the soil conservation program.

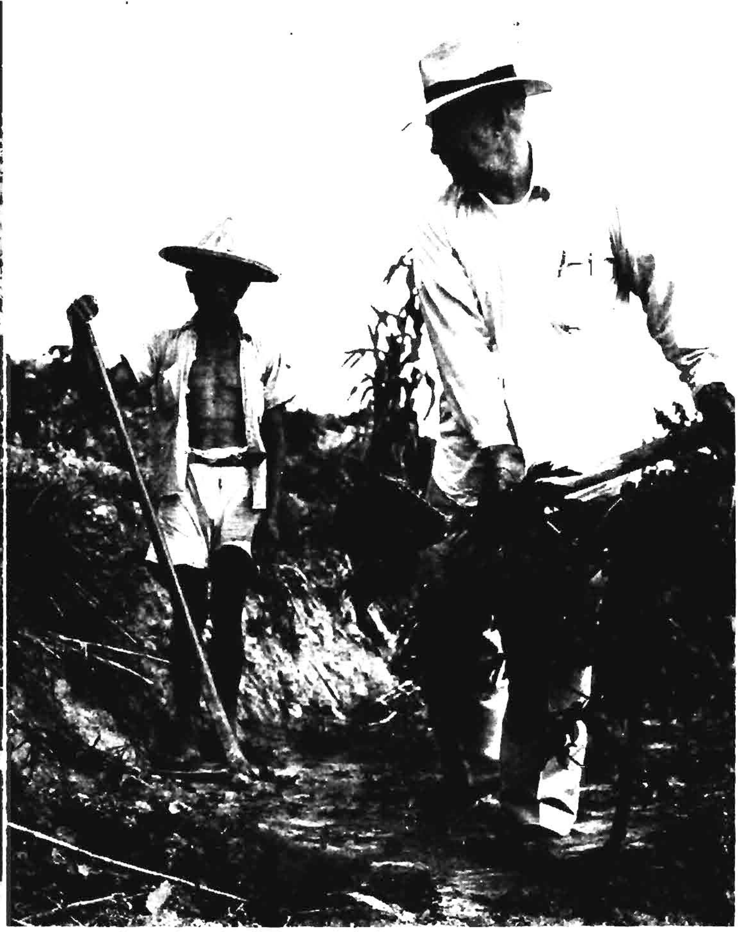
We are publishing some of these papers to show our appreciation of his valuable contributions on the one hand and for the benefit of all those interested in the soil conservation program on the other.

Ira K Landon

Briefing to Vice President Chen Cheng and Dr. Chiang Monlin at Ah-kung tien watershed

Instructing trainees in using Fresno scraper

Comments on water chute



Showing farmer the bench maintenance

Explaining to technician how

CONTENTS

POLICY

Soil conservation in Taiwan 1
Land use policy 17
Conservation of the public lands in Taiwan 20
The development of marginal lands in Taiwan for agricultural production 23
Land development for increased agricultural production 25
The development of soil resources 27
A plan for the protection and development of the natural resources of Taiwan 30
The settlement of farmers along the Cross Island Highway 34
Determination of soil conservation priorities 36
Organization, subsidy and protecting public land 39
The development of the soil conservation program in Taiwan 41
Soil conservation in the Shihmen Watershed 50
Speech at Ah-kung-tien Watershed 52
Preservation of forest litter in soil conservation demonstration areas 54
A policy needed for the planning of the Black and Muddy River Watershed development 56
Comments on whole problem of illegal cultivation of public lands 59
Farewell address at Taiwan Soil Conservation Conference 61

ORGANIZATION

Suggestions regarding an inter-agency technical committee on soil conservation 64
A permanent soil conservation organization 66
New soil conservation organization 72
For presentation to Mountain Agricultural Resources Development Bureau Planning Committee 75
Organizing the work of a soil conservation field office 78

TECHNIQUE

Land use capability classification based on the permissible intensity of use and need of protection 80
Construction and maintenance of bench terraces in Taiwan 86
Which soil conservation practices should be used? 91
Land use and soil conservation planning 93
Contour cultivation and strip cropping 98
Hillside ditches and broad based terraces 103
Runoff water 106
Waterways 117
When are surveys necessary? 122

Design for a small watershed ········· 124
Design and construction of check dams ········· 127
Stream bank erosion control ········· 131
Soil conservation by composting ········· 135
Soil and water runoff plots ········· 137
Manual for the operation of runoff plot tanks ········· 139
Soil conservation in irrigation ········· 141
Constructing a Fresnro scraper ········· 150
Using a Fresno scraper ········· 153
Procedure for constructing a V drag ········· 156
Using a V drag ········· 159

EDUCATION & OTHERS

Inaugural speech of the Soil Conservation Training Center ········· 161
Soil conservation philosophy ········· 162
Soil conservation information and education ········· 171
Interviewing people ········· 175
Soil conservation salesmanship ········· 178
Why conduct demonstrations? ········· 181
Choosing a demonstration site ········· 184
Soil conservation in the United States ········· 187
Soil conservation program and MARDB ········· 192
Briefing lecture on soil conservation for TA participants ········· 196
Soil conservation briefing for visitors to Taiwan ········· 201
Comments regarding graduate studies in soil conservation at the Catholic University ········· 203
The need for credit for soil conservation practices ········· 206

ABBREVIATIONS

Soil Conservation in Taiwan

April 1955

INTRODUCTION

Next to his ever present need for air to breathe and water to drink, man's most urgent need is for food. Food comes from the soil. It can even be said that food comes from the surface 8 or 9 inches of soil. Man cannot live without the soil or its products. Many of the world's wars can be traced to the quest for food or good soil on which to grow it. Man eats the flesh of animals but they, in turn, live upon plants grown on the surface soil. Even the fish in the sea, directly or indirectly, eat a great deal of the products of the surface soil.

Often it has been only after the soil has been destroyed or impoverished by ignorance, selfishness, or the force of circumstances and he has been forced to migrate or lower his standard of living, that man has come to realize how utterly dependent he and his animals are upon the soil. It must supply not only his food but also clothing, shelter, fuel and raw materials for many of his industries.

World Supply of Soil

In the entire world there are approximately 1,600,000,000 hectares of land immediately available for cultivation. The world's population has exceeded 2,000,000,000 for several years and is increasing steadily. This present average supply of 0.8 hectares of cultivatable land per person includes the poor marginal lands. It must produce not only food but fiber crops and many of the raw materials for industry as well.

This world supply of land is being depleted annually by neglect and misuse. At the same time, the world demand for food and fiber crops is being increased both by the increasing population and by the standard of living which is being raised in response to the popular demand. Technical advances in agriculture have done much to increase crop yields and still more increases can be expected but there is a limit to how much increase can be expected from this source.

With a limit on the amount of useable land available and an increasing demand for the products of the soil, certainly the civilized world cannot afford to waste its most essential resource, the soil. The situation is becoming more acute year by year and is particularly acute in the more densely populated areas, one of which is Taiwan.

Soil Resources of Taiwan

According to the data compiled by the Joint Commission on Rural Reconstruction, only 829,200 hectares on the island of Taiwan are now cultivated. This is but 23 percent of the total area of 3,596,121 hectares. Of this cultivated land 513,299 hectares are paddy fields and the remaining 351,901 hectares are dry farmed, mostly hilly lands.

The rest of the island is so mountainous and steep that permanent cultivation is not possible. Some of the land now being cultivated is steep and badly eroded. It is not suitable for cultivation but economic necessity and the need for more food production have forced it to remain in cultivation.

With a population of about 10,000,000 people and only 1,000,000 hectares of cultivated land, including much poor marginal land, each hectare must produce the food and raw materials for 10 people if the nation's needs are to be supplied domestically. With the population increasing at the rate of 3.4 percent annually, and constant efforts being made to improve the standard of living, the need for increased agricultural production will continue year after year. This increasing demand, and the already intense use of land, indicates the necessity for conserving the soil, protecting it from further damage, and using the most efficient methods of crop production.

Land Use Problems

The need for food and the availability of relatively cheap labor as a result of the dense population, make possible the employment of practices that would not be considered economical in western countries with more land and fewer people. It is only by producing more than one crop per year on the irrigated paddy lands that it is possible to produce the amount of food that is now produced.

The problem of maintaining the organic matter content of the soil is made more acute by the intense land use and the warm climate. Fortunately this is a problem that is generally recognized and efforts are being made to meet the needs. All animal manures are carefully utilized. Some farmers buy feed stuffs to feed hogs, barely breaking even on the returns from the sale of the pigs, merely to get the excreta for making compost for the paddy fields. Many uncultivatable areas are scraped bare of all vegetation with a hoe, to get material for making compost.

In the less intensively cultivated areas in the hills there is a more adequate supply of composting materials, some of which is not only unused but may be burned. This is an inexcusable waste. The problems on the dry lands are different from the paddy fields and on the whole are not as well met. There is but little if any water available for irrigating the hill lands. Usually where there is water, bench terraces have been constructed to grow paddy.

Many of the high terraces along the west coast are underlain with coarse gravel which permits any excess water in the soil to drain away rapidly. Therefore these soils are suitable for crop production only during or immediately after the rainy season.

Other areas along the west coast are so sandy that they are subject to severe erosion from the strong winds which are frequent there. Some of the sandiest of these areas need to be planted with trees and shrubs for a permanent wind protection cover. Other areas need the establishment of permanent windbreaks at intervals, to make possible the utilization of the intervening strips for cultivation.

The lack of fuel is so acute in most of the village areas that they burn much of the straw and cane trash and roots that are needed for making compost. The dedication of small areas for windbreaks which would supply some fuel from thinnings and trimmings would serve two needs, wind protection and fuel supply.

In the steep lands in the mountains, the practice of shifting cultivation is very common. This consists of either cutting or burning over a tract of steep forest land and cultivating it for 2 or 3 years to sweet potatoes, hill paddy, cassava or citronella grass and then reforesting it or more frequently, just abandoning it to let nature revegetate it as best it can. Most of the land with soil on it has been cultivated in this way at some time in the past. This practice has many objectionable features but due to the economic pressure, the lack of other more suitable land, the conflicting and confusing laws and regulations regarding the use of the land and the timidity of the Provincial Government in enforcing any land use regulations, nothing is being done about the matter at present. It does constitute one of the outstanding land use and soil conservation problems of the island and must eventually be faced and solved.

Broad Problem Areas of Taiwan

Without even so much as a reconnaissance conservation survey, it is possible to divide the soil resources of Taiwan into three broad groups from the standpoint of land use and soil conservation.

1. The wet paddy fields surrounded by dikes which retain the water. While these fields suffer little soil erosion they do present soil conservation problems such as soil and water management and the maintenance of soil fertility. Since the solution to these

problems is included in the Crops Production Program, a Soil Conservation Department, when organized, should undertake to protect these fields from siltation damage.

2. The forested, mountainous areas which are generally not suitable for any kind of cultivation, present many soil conservation problems such as proper land use, reforestation, forest management and fire protection. The application of the forestry practices will be a function of the Taiwan Forestry Program. The Soil Conservation Department should concern itself with land classification, selection of areas suitable for cultivation and the demonstration and promotion of appropriate cultural methods on these areas.

3. There is a wide range of conditions between the above extremes. These vary from lands with just enough slope to require a little simple protection to those so steep that only by applying every known protective practice can they be retained in cultivation without destroying them. Also included are the sandy lands of varying wind erosion hazards which, if not controlled and properly managed, become a menace to better adjacent lands because of drifting sand. The Soil Conservation Program, while concerned about land use and conservation of all lands, should first be concentrated on this great middle group. According to existing data, it includes some 315,000 hectares. These are lands suitable for cultivation but subject to some form of erosion. They require protective practices of one kind or another when they are cultivated.

The paddy fields of the first group have already been extensively developed and are quite intensively used but are producing less than formerly. The mountainous areas in the second group offer only limited possibility for agricultural expansion although there are undoubtedly some small areas suitable for crop production. It is in the third or intermediate group that most of the future increases in productivity per unit area and most of the expansion in cultivated area must take place. Therefore, the Soil Conservation Department, while concerned with the conservation of all lands, should concentrate its efforts here.

The objective of this program should be two-fold:

1. Increased production from lands not now contributing their maximum potential to the food supply of the island, and;

2. Conservation of the soil resources in order that optimum food production can be sustained.

WHAT IS SOIL CONSERVATION?

Dr. Robert M. Salter, former Chief of the Soil Conservation Service, U.S. Department of Agriculture, defined soil conservation as; "proper land use, protecting the land against all forms of soil deterioration, rebuilding eroded and depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income; all at the same time".

"Use every acre in accordance with its capabilities and treat every acre according to its needs for protection and improvement" is a slogan used often in the campaign to accomplish those laudable objectives.

Soil Conservation is not a panacea for all of the ills of agriculture. It is merely one of the planks in a sound agricultural platform or program. Therefore, a sound Soil Conservation Program must be integrated with the national programs for reforestation, for irrigation and drainage and for agricultural production.

Soil Conservation is not a substitute for soil fertility, for good seed, for timely field operations, nor for the control of weeds' insects and plant diseases. Neither will these practices, important as they are, substitute for soil consevation. Like the fuel in the tank, the oil in the crankcase and the water in the radiator of a car, each has its own function to perform and an abundance of one will not offset a lack of another.

The Soil Conservation Program is itself made up of several phases such as erosion control, proper land use, maintenance of the fertility and structure of the soil, and water management, particularly the utilization and disposal of the rain waters falling on the soil. Soil erosion control is one of the most important phases but it is by no means the entire soil conservation program.

Soil conservation is an essential part of the program for the watershed of any power or irrigation reservoir because of the erosion control phase. Unless the soil of the watershed can be held in its proper place, siltation will destroy the usefulness of the reservoir.

Soil Erosion

Like many other processes, soil erosion when broken down into its component parts, seems quite simple. Soil erosion, in its simplest terms, is merely the moving of soil particles from one place to another. There are two parts to this process.

First, the detachment of the soil particles from their present anchorage or place of attachment.

Second, after being detached, the transportation of the soil particles to another place.

To the extent that either or both of these processes can be prevented or reduced, soil erosion can be controlled.

In nature, a vegetative cover prevents the falling raindrops from striking the surface of the soil and detaching the particles with their force. Unfortunately, it is not possible for man to produce all of the food and other products that he wants and needs if all of the soil is kept covered with grass and trees all of the time. He must cultivate some of the land a part of the time.

The fact that some of the forests are cleared or some of the grass lands are plowed does not necessarily mean that all of that soil surface will be bare all of the time. By reducing the amount of time that the bare soil is exposed to the effects of the falling raindrops or by reducing the degree of the exposure, the farmer can prevent much of the detachment that would otherwise occur. This protection can be accomplished by growing those crops in the rotation which will maintain a canopy or mulch of vegetation to absorb the energy of the raindrops, thus preventing detachment.

After soil particles have been loosened or detached, they may be transported by wind or by running water. The velocity of this wind or flowing water is the factor that is most important in determining the amount of soil particles it will carry. On level paddy fields where water is confined by the surrounding dikes, water does not flow and consequently it does not transport the soil and there is no soil erosion, even though the particles may have been detached by rain drops striking the bare soil.

Where a supply of irrigation water is not availables, it may not be economically feasible to make level, bench-type terraces on all of the cultivated fields. But it is possible to plow, plant, and cultivate on the contour. In effect, this makes each row a narrow, level reservoir just like the paddy fields. Instead of running away water stands in these contour furrows where it falls. This stops transportation which means that erosion is prevented.

Sometimes the rain will fall faster than the water can be absorbed by the soil or, it will be accumulated in amounts greater than can be stored in the contour furrows. Under these circumstances it is necessary to provide for the orderly removal of the excess water. By making the furrows on a very slight slope or gradient, the excess water will flow off, but at such a slow speed that it will carry only a little of the soil materials away from where it was detached.

The entire program of land use and erosion control is based on controlling the detachment and transportation of the soil particles. Viewed from that standpoint, the soil conservation program does not look very complicated, and it is not. Nevertheless, considerable skill and ingenuity is required to apply these simple principles in an effective manner that will maintain profitable crop production and at the same time prevent erosion.

Wind erosion protection is obtained by keeping the ground surface covered with plants or a mulch which prevents the wind from striking the soil. Partial protection while the soil is being used for crop production, is afforded by placing windbreaks at intervals to reduce the velocity of the wind or to deflect it up from the soil surface. When the velocity of the wind at the ground line is reduced or eliminated, the detachment and transportation of the soil particles is likewise reduced or eliminated.

Need for Trained Soil Conservationists

Academic training in agriculture, engineering, forestry, or soils greatly facilitates the attainment of skill in the application of such a program. Since Soil Conservation is a relatively new art or science, academic training in it is not yet available in Taiwan. After completing the academic training in one or more of the supporting sciences, it will be necessary to round out the training of a soil conservationist by working at the job.

Agressiveness and ingenuity combined with experience are required to accomplish all of the desired results in the form of an effective, economically sound, conservation program on the land. In addition to these qualifications, the success of the individual as a soil conservationist will depend largely upon his enthusiasm for the work and upon his abilty to "sell" the farmers on the need for taking action and on the effectiveness of the practices recommended.

Not only the farmers, but the entire public, has an interest in the conservation of the soil resources of their nation, although some may not yet realize that fact. A Soil Conservation Program is just indispensable as a National Health Program or as is National Security. In fact, national health and at least the economic phases of national security are based on the soil and its proper utilization.

WHAT IS A SOIL CONSERVATION PROGRAM?

A Soil Conservation Program has both immediate and long time benefits. Properly applied soil conservation measures will go far toward preventing the floods which follow each rain storm. These floods wash out roads and bridges, interrupt rail and truck traffic, destroy growing crops, clog irrigation canals and drainage ditches with silt and, even more serious, lower the producing capacity of the fertile fields in the valleys. An adequate Soil Conservation Program not only reduces these damages but, at the same time, increases the yields of the various crops during the current season.

Sometimes it is necessary to choose between two desirable objectives, both of which cannot be accomplished at the sametime. For instance, a reservoir to be used for irrigation or for generating electric power should be managed to keep it as nearly full as possible throughout the year. But a reservoir used for flood control should be managed to keep it as nearly empty as possible at all times so as to provide the maximum flood control storage capacity. Policy makers, realizing that every foot of water held favors the irrigation and power possibilities and that every foot of water discharged before the storm occurs increases the flood control potential, must decide which course of procedure is most beneficial to the entire community. In such a case, favors to one concept are detriments to the other.

Soil conservation practices are not opposed to any other good objective. Soil conservation practices are compatible with both flood control and with storage since they reduce the flood hazard and reduce the sedimentation of the reservoir. While doing this they also promote maximum crop yields for the present, and increase the productivity of the land for the future.

Unwise and wasteful exploitation of the land is the only practice that is hampered when a good Soil Conservation Program is applied to the land. No one is hurt by Soil Conservation but everyone stands to benefit from it.

Farm Conservation Plans

The term Farm Conservation Plan, as used here, does not necessarily mean a plan for just the land operated by a single farmer in the same way the term is used in the United States. In Taiwan where the farms are small and the individual parcels often scattered, a farm or neighborhood conservation plan would generally mean a plan for a number of adjoining fields, frequently those contained within a small watershed or other naturally bounded area or those fields supplied by one irrigation canal.

It is the combination of practices and land use that are applied to the land that prevent erosion, improve the soil and increase the crop yields. Nevertheless, as one means of insuring that an adequate set of practices will be applied, it is important that a well conceived plan be written up in some detail. There are several reasons for this, some of which are:

1. It is not often that an entire conservation program for a farm or given area of land can be executed at one time. Usually some parts of it must be applied over a series of years. During this period the soil conservationist who made the plan may be moved because of transfer or promotion.

2. Having access to the written plan, as originally agreed to, will avoid much confusion and wasted effort, especially if some other conservationist is called upon to assist in carrying out parts of it in later years.

3. Having the farm conservation plan formally transcribed on paper gives it a certain amount of dignity and prestige in the eyes of the farmer and his neighbors. He or they then have a definite goal toward which to work, and, when it is reached, they may have a justifiable pride in their accomplishment. They will have set a worth-while goal and then reached it.

4. Having a plan for the various steps leading up to the completed job makes it possible to schedule the work to be done at that location for each season of each year. This permits more efficient management of personnel, equipment and materials.

5. The materials and labor for each increment of work can be estimated from such a plan, so much for this year, so much for next year and so much for the completed program.

6. Making a paper plan for a soil conservation program on a tract of land is much like making paper plans for a building. If you intend to simply drive four poles in the ground and add four walls and a roof, no paper plan is needed for such a simple shack and would probably add nothing to the project. But, if the building is to be permanent and of some consequence, especially if it is to be constructed by stages over a period of time and possibly by different workers for the different parts, the necessity for having written plans becomes more apparent. Without a written plan for the completed structure, what is built today may have to be torn out next month to make way for additional features which were not contemplated by the first workman.

The planning process for soil conservation operations involves three phases; (1) obtaining or preparing a base map, (2) soil conservation survey of the area on which soil conservation measures are to be applied and, (3) preparing an adequate conservation plan.

These phases will be discussed in more detail in succeeding paragraphs.

Base Maps

One of the basic parts of a farm conservation plan is a base map of the area covered by the plan. It is much easier for everyone concerned to visualize the finished product before the work starts, if the practices to be applied are shown on a map. This map will eliminate a lot of mistakes and confusion. It will probably be the most used and the most highly treasured part of the completed farm plan.

Aerial photographs have been made of all of Taiwan. If the security officials will permit the use of these photos for areas which are not of strategic military importance, this will greatly facilitate the preparation of base maps. Enlarged sections of aerial photographs show in detail the exact location of all of the identifiable landmarks such as roads, trees, houses, fences, etc. and frequently the boundaries between different soil types are visible.

If the use of existing photographs is not permitted, it will be necessary to make plane table maps or to secure copies of crop reporting or land ownership maps. Plane table mapping is a time consuming job and there is always the possibility of human error creeping in. Photos do not have these errors.

Base maps, whether photographic or plane tabled, should be made on a community basis. This is especially true where the individual fields are small and the holdings of one individual are so scattered. Flowing water pays no attention to property boundaries. It follows natural rather than man-made laws. Therefore, soil conservation plans should be made for natural subdivisions like watersheds rather than on the basis of man-made property lines. It is true that each farmer should do the work on his own land but the overall result should be a complete program for a naturally bounded unit or area.

The adoption of a uniform scale for the base maps in all areas will avoid much confusion in matching one map to another and in making measurements on the maps. Special scales might be authorized for special purposes but these should be multiples of the basic scale.

Soil Conservation Surveys

After the base map is obtained by whatever method, a soil conservation survey should be made on one copy of it. This is an inventory of the soil resources of that tract. It consists of making a graphic record of the soil characteristics that:

1. Have a bearing on the ability of that soil to sustain land use of a given intensity and that,

2. Determine the intensity of need for and the nature of, erosion control practices. This survey corresponds to a doctor taking the pulse, temperature, blood pressure, etc. of a patient, preparatory to diagnosing his illness and prescribing a treatment. Although these facts are not a part of the treatment, they must be determined before the proper treatment can be prescribed.

This is an important job which should be done by men trained especially for the work. This phase of the whole program can be performed more efficiently if an entire community is mapped at the same time by the same crew of conservation surveyors rather than attempting to survey each farm separately as it is planned.

As this survey proceeds, an inventory of the soil resources of the island will be obtained. This will be useful not only for the planning of soil conservation on the individual farms but also for land use and crops production planning, for land classification and evaluation and many other broad programs. To the extent that the Marginal Land Survey now in progress furnishes the information needed for developing conservation plans for given areas, these areas will not need to be remapped.

Planning the Individual Farm

Based upon the information gathered in the conservation survey, the soil conservationist must first determine the most intense use to which each tract can be put without permanently damaging it. If the land is used too intensively it will deteriorate, regardless of the kind or amount of conservation practices applied.

Next, the owners or operators must be consulted about what they wish to grow, for they are ones who must make a living on the farm. Then, within the limits of the capability of the land and in conformity with the owner's or operator's wishes, the conservationist plans a combination of land use and soil and moisture conservation practices that will adequately protect the soil from further damage and, if possible, provide for its improvement.

Peoples are naturally most interested in their own land and in its preservation. To that extent, the soil conservation program is effected by who owns the land. However, the need for soil conservation practices is the same whether a tract is owned by the government, by an absentee landlord, or by the farmer who operates it. In the same way, the conservation needs for a tract are the same whether it is all operated by one farmer or as separate fields by a number of different farmers.

Regardless of the ownership or management, a certain amount of water falls on a field during a given rain storm. Under a given intensity of land use, a certain proportion will be absorbed by the soil and the remainder must runoff. On a given topography, it will try to follow the natural drainage ways, regardless of who owns or cultivates the separate tracts. The application of the practices to the land must be on the basis of individual ownerships but the planning or overall strategy of controlling the erosion remains the same regardless of the man-made subdividions.

In helping the farmer to work out a plan by which he can conserve his soil and yet, at the same time, maintain his standard of living, it is necessary that the conservationist gains the farmer's confidence and respect. One of the essentials of such a relationship is that the conservationist must know about the farmer's problems. What does he have to do to make a living? How does he do this? When he can answer these questions he is in a better position to attack the problem of improving the farming methods.

In getting the farmer's cooperation on any program, one of the most successful approaches is to emphasize the self-interest angle of the undertaking. When and if the farmer realizes that he is the principal beneficiary, he will become more interested.

Benefits to society in general and the protection of the land for the future generations are important but they probably do not have the strongest appeal to the farmer. When the farmer becomes convinced that following the conservation plans means better crop yields and more profits for HIM this next harvest season and during the years immediately following, he is far more apt to carry out the complete plan.

In preparing a farm conservation plan, the various steps to be taken from the present situation to the ultimate conservation goal, must be worked out and described in a logical and a reasonable sequence. It should specify the materials, equipment and facilities that are available, TO THAT FARMER. If the plan calls for the use of tools or seeds that for any reason are not obtainable, the plan becomes not only useless but ridiculous. It might even cause the farmer to lose confidence in the conservationist and in the soil conservation program. To be usable the plan must show in detail how the farmer can accomplish the desired ends with what he has or can obtain.

This plan of conservation operations corresponds to the prescription written for a patient by a physician. However good it might be, it is up to the patient to decide whether he will follow the prescribed diet, swallow the bitter medicine or submit to the recommended surgery. Of course if the patient does not follow the treatment recommended in the prescription or if the farmer does not follow the plan of conservation operations, the writing of them will have done him no good.

These individual farm conservation plans are the backbone of the entire Soil Conservation Program. They must not only be technically correct and economically sound but they must be presented or "sold" to the farmer in such a clear and effective way that he will make very effort to put them into practice.

Voluntary Application

It is not contemplated that the Soil Conservation Program will be other than a voluntary cooperation. At the present time it would not only be impossible, but it would probably be inadvisable to attempt to apply the prescribed soil conservation practices by force of law. Since the soil conservation program was started some 20 years ago in the United States, the number of farmers who have wished to voluntarily cooperate has always exceeded the supply of technically trained men available to assist them, notwithstanding the fact that there are now some 18,000 employees in the U.S. Soil Conservation Service.

As long as trained men to assist in planning and applying the program are as scarce as they are in Taiwan, the efforts of those available can best be utilized in connection with a voluntary program. Legal limits might well be placed on the use of some of the most erosive public lands which some people may wish to exploit under cultivation.

Farmer's Contributions to the Program

Since the individual owners and operators of the land are to receive the major benefits in the form of immediate and future increased yields, it is reasonable to expect that they will make material contributions to the furtherance of the program. The financial means of many of them are limited and they cannot be expacted to make big cash outlays. However, there are some very important contributions which they, and only they, can make. The following things are the basis of a sound soil conservation program but require little if any cash expenditure:

1. The acceptance of land use capability limitations.
2. Cultivation on the contour rather than up and down the slope.
3. The establishment and maintenance of windbreaks.
4. The adoption of soil improving crop rotations and the maintenance of soil organic matter by conserving crop residues.

By devising methods which employ the tools and power that are available and by scheduling construction work over several years, the farmers will be able to do a great deal of the construction work themselves without any appreciable cash expenditures.

Public Contributions

Some of the practices needed in effectuating the program may require the use of equipment which the farmers do not ordinarily own or which is not available in their community. In order to facilitate the rapid application of the program, such equipment as animal drawn dirt scrapers, when needed, should be made available on a loan or rental basis, either by some agency of government or by private enterprise. Trees and new varieties of plants or seeds which are needed in the program but which are not common to the community should be made available when necessary. Whether these materials should be given as a public subsidy or merely made available at a reasonable cost is a matter of policy for the administrators to determine. The most important thing, so far as the program is concerned, is that these things be available to the farmers when they need to use them to carry out their farm conservation plans.

In coping with their unemployment problems, the local governments might very well supply the skilled and unskilled labor needed, in addition to the labor of the farmers and there families, to help along those practices which require a lot of labor.

The Provincial Government also has an interest in the conservation of the soil, since the land is the basis of a sound economy, solid citizenry and adequate defense. In support of these interests the Provincial, Hsien or Township Governments would be justified in paying the salaries and administrative expenses of the Soil Conservation Program and in making available such materials and equipment as might be needed to carry out the program at the various locations.

Land Classification

The laws and regulations governing the disposal of public lands have been conflicting or at least confusing on some points. With several agencies issuing leases, some mistakes were made during the rush to get the land into the hands of the tillers. Many tracts of public land that were not at all suitable for cultivation have been leased or sold to individuals since the Restoration.

A committee appointed by the PDAF Commissioner is making a study of these laws and regulations and will propose remedial revisions to prevent the disposal of any more nonarable lands. Eventually, some of the lands not suitable for cultivation should be reclaimed by the public to prevent further downstream damages resulting from erosional debris from them. Most of these lands will probably be abandoned for cultivation when experience proves that they are not suited for that purpose. Unfortunately, much damage will have been done to them and to the better lands lying below them, before they are abandoned. The repetition of this mistake on additional lands is a thing which should be avoided.

Setting up criteria by which lands suitable for cultivation can be separated from those not suitable, will not be a simple task. In addition to the slope of the land which is so evident, the depth, the texture, the parent material of the soil and the extent to which erosion has already progressed, must also be given consideration. For this reason, the Soil Conservation Survey which has been made of some marginal areas in Nantou, Taichung, Miaoli Hsiens, should be extended to cover all of the marginal lands as soon as possible. This will furnish data which can be the basis for classifying public lands for leasing for cultivation.

Eventually the entire island should be surveyed although the forested mountainous areas which are clearly beyond the possibility of cultivation could be given lowest priority. The Forest Survey recently made by JCRR and TFA will reveal the land use and some of the more prominent erosion conditions in these areas and will be in enough detail for the immediate future. From such surveys, information for determining land use capability classification and the kind and degree of protective practices required, can be compiled.

A SOIL CONSERVATION PROGRAM FOR TAIWAN

As previously pointed out, a comprehensive soil conservation program includes all of the practices that are involved in the management of all the kinds of lands for their protection, improvement and maximum protection. But since some of these practices are to be applied by the Crop Production or Forestry Programs, the Soil Conservation Department should concentrate its major efforts in the dry farming uplands and the marginal crop lands.

Although the need for widespread application of soil conservation measures on the upland and marginal farming areas is very urgent, the speed with which the soil conservation program is applied will depend upon the willingness of the farmers to adopt farm conservation measures, upon the availability of trained personnel, and upon the funds appropriated for that purpose. The reaction of the farmers to the program is not known. Funds for any new program are always a problem which must be met. But regardless of how favorable the situation might be in these respects, the soil conservation program must be inaugurated on a limited scale in the first few years because of the scarcity of trained personnel.

One man COULD start the field operations work but not much measurable progress could be expected from such a small force. It would be much better to start with a relatively small staff of six or eight men and add to them as the demand for their services grew and the budget would permit. These men, even with outside technical advice, would have to learn how to do the job by actually doing it. After they had gained skill and experience, they would be able to train others as the need arose and so effect a healthy growth rather than an inefficient mushrooming expansion.

All people, but especially farmers, are much more impressed by what they see actually happening than by what they hear or read about. Therefore, it is important to establish pilot or demonstration areas at various locations where farmers can see other farmers actually doing, with some help and supervision perhaps, the things that are applicable to the community as a whole. These areas should not be looked upon as experimental plots nor as government operated show places. To the extent that this idea is prevalent, they lose their value to the farmers. All of the facts pertinent to soil conservation in Taiwan are not known but enough are known to form the basis of a good field operations program. These demonstration areas should be the locations where a few progressive farmers can demonstrate to their neighbors that some of these basic principles of soil conservation, intelligently applied, are both effective and economically sound.

To establish this sort of a demonstration the most important item would be technical advice and "know how". Some equipment might eventually be used advantageously to speed up the program but it should first be demonstrated that the job can be done with what the average farmer has available. If bench terracing, for instance, is STARTED with a bulldozer, it may be difficult to convince other neighboring farmers that they can do the same job with their bullocks or buffalos. If the work is started with animals and after it is successfully underway, bulldozers are provided to help speed up the work, an entirely different attitude is developed. Nursery stock for windbreaks or seed for new crops may be called for but these do not require large cash expenditures. Getting the farmers in the frame of mind to try soil conservation measures and then showing them how to apply them is the basis of any successful soil conservation program.

The few technically trained men available might well be assigned to start one or two such demonstration areas. Observing the men at work actually doing the job would afford the best possible basis for selecting the leaders for succeeding projects or for supervisors when the size of the organization justified the appointment of non-producing suppervisors. Such overhead jobs should be held to the minimum and should be set up only when the need for them became apparent.

The organization chart and the discussion of it attached, are intended as a guide or plan for the ultimate organization. It is not contemplated that all of the indicated positions would be filled at once. That would be impossible because of both the lack of funds and of adequately trained personnel. Rather, the chart is submitted to serve like a farm conservation plan, a picture of the completed organization, so that the growth and progress from to time would be compatible with the desired end product.

The first few appointees should work directly under the Director's supervision in operating the first demonstration areas. Only after the job indicated the need for a Chief Agronomist or a Chief Engineer or other Chief, should some individual who had demonstrated his leadership and technical ability in that field be designated for this specialized job. These jobs as specialists are not directly productive of soil conservation and only when it can be demonstrated that filling such a position will add to the overall quality or volume of work of the entire organization, should such appointments be made.

In the beginning, many of the soil conservationists would probably have to be recruited from the agricultural specialists now employed by the hsien and township governments. Because of the differences between academic agronomy, engineering, forestry, soils, etc. and the application of these sciences in a soil conservation program, every consideration should be given to filling specialists jobs by promotion from within the organization rather than from other sources. All employees should be developed to accept the responsibilities of leadership.

After the number of demonstration areas increased, the administrative leadership might be subdivided by establishing Hsien Soil Conservationists in those Hsiens in which the volume of work justified such a position. Later on it might be desirable to establish Township Soil Conservationists where the volume of work justified such positions. These positions should be set up only when the work indicate the need and not in anticipation of this need.

When the need for a project in research or in extension is felt, such projects should be set up. The need for the work to be done as well as the availability of funds, should dictate the speed and the direction of growth. The entire soil conservation program, research, extension and field operations should develop as a natural, healthy growth rather than being born in full bloom.

A Soil Conservation Organization for Taiwan

Any program that is as important to Taiwan and is as broad in scope as the matter of soil conservation, needs a responsible administrator to organize it and guide its development and an energetic, efficient organization to carry out the program. This program to be completed, must include research, extension and field operations activities. These three functions are separate, distinct phases of the complete program. Even though some individual may be called upon to perform duties in more than one phase, the phases should be recognized as such and responsibility placed accordingly.

The General Motors Corporation, like most large business, has these three divisions. They have a research division at work on the development of new motors, new transmissions, etc. so that their future models can be based on proven facts. They also have a sales department which is responsible for publicising their new products and creating a demand for them. There is also the production department which actually builds the cars.

Each of these departments has an important job to do. If any of them fails to do its assigned part, the other departments cannot function efficiently. If research fails to continually improve the G-M line, no amount of publicity or production efficiency will keep G-M ahead in the competition for auto sales.

Likewise, however advanced the design, if the public is not informed about or "sold" on them, the sales will lag. Even with good cars and superb salesmanship, if the factory stages a sit down strike or fails to produce quality merchandise at a competitive price, the team as a whole is crippled and all divisions suffer.

There should and can be an exchange of ideas and suggestion from all sources but all such ideas must be channeled through the division or organization which is responsible for that particular phase of the overall program.

In a Soil Conservation Organization for Taiwan, all of these phases are needed and should be provided for:

1. Research to develop and to prove technical facts about proper land use or the conservation of soil and water.

2. Extension, including information and education, to present the program itself and its importance to the public in an interesting, understandable manner and to thus create an appreciation of soil conservation.

3. Field operations, to plan and assist in the application of the various practices to the land in response to the demand that grows out of appreciation of the need for soil conservation.

As in the case of a commercial organization, each of these phases must function efficiently or the program as a whole will languish. Each section should be alerted to receive suggestions from other sections or from anyone else, but each section has the responsibility for carrying out its own phase of the entire program.

In setting up a Soil Conservation Organization for Taiwan, provision should be made for carrying out all three of these functions in a coordinated manner. This does not imply that three new and separate bureaus should be created for this purpose. The setting up of a new organization for Soil Conservation Research might not be as efficient utilization of existing manpower or facilities nor as good administration, as to assign this function, with adequate budget and personnel, to some existing research organization such as the Agricultural Research Institute, provided the Institute is willing to accept and able to discharge the additional responsibility.

Definite research projects in pure science or in the techniques of applying such scientific facts to field operations should be set up in detail. Agreement should be reached between the directors of the Research Institute and the Soil Conservation Organization as to the methods to be used, equipment to be provided, space, materials and personnel required. All of these needs should be provided for in the budget by a transfer of funds from one agency to the other.

In this way the research needed for the Soil Conservation Program would be provided for and full utilization of existing facilities would be possible without danger of duplication or unwholesome rivalry by two research organizations.

A great deal of unnecessary duplication and possible rivalry could also be avoided by the assignment of the extension phases of the soil conservation program to the existing extension group. This assignment should also be made on a definite project basis by agreement between the directors of the Extension Service and the Soil Conservation Organization as to the scope, location and quantity of work to be undertaken. A budget to carry the additional personnel, supplies, and other expenses should be arranged with transfer of funds between the organizations. This would lead to a stronger Extension Service and a coordination of soil conservation publicity with that of other overall agricultural programs.

Since there exists no organization such as would be needed to plan and assist in the application of the soil conservation practices to the land, such an organization would have to be authorized and recruited.

There is no good reason why a satisfactory soil conservation program consisting of coordinated research, extension and field operations could not be carried out if set up in this manner. Coordination with Field Operation would be assured, in that the Director of Soil Conservation would participate in setting up the projects to be carried out by research and extension and in making the transfer of funds to support these projects. Coordination of the soil conservation research and extension activities with other similar projects would be assured by the administration of these projects by the directors of research and extension.

The success of such a cooperative scheme would depend largely upon the setting up of definitely outlined projects and administrative pressure, if required, from the top administrators to see that the assigned responsibilities were properly discharged. Separate agencies to do the research and extension work for the soil conservation program should be considered only if personal or agency rivalries disrupt the operations to the point where the administrator cannot cope with them.

Soil Conservation Field Operations Division

The entire soil conservation program should be administered by a Director of Soil Conservation who would be responsible to the Commissioner of Provincial Department of Agriculture and Forestry. This position should be on a par with the directors of other agencies such as Taiwan Forest Administration, Taiwan Forest Research Institute, Taiwan Agricultural Research Institute, Extension, etc. The prestige and authority of such a director would go far in getting adequate consideration for the Soil Conservation Program.

In addition to setting up and authorizing the cooperative projects in soil conservation research and extension, this director would administratively control the Field Operations Division. This division should be set up as on a line and staff type of organization. Directly responsible to this Director of Soil Conservation there should eventually be in each Hsien in which soil conservation work is to be done, a Hsien Soil Conservationist who would be in charge of all soil conservation field operations in that hsien. In each Township in which the volume of work justified it, there should eventually be a Township Soil Conservationist responsible to the Hsien Soil Conservationist and in charge of all soil conservation operations in that township. These would constitute the administrative or line of authority officers. Care should be exercised to see that the flow of authority did not by-pass the regular channels and thus cause confusion.

The Director and the Soil Conservationists at each level should have an administrative and technical staff adequate to handle the volume of business at their respective locations. In addition to the clerical and fiscal employees usually found in similar government offices, there will be need for technically trained agronomists, engineers, foresters, soil technicians and soil conservationists. All of these men would serve in a staff capacity as technical advisers to the line officers in planning and assisting in the application of the various practices that would make up the soil conservation program at that location.

These technical men are the backbone of the program and should be given adequate recognition and remuneration. However, distinction must be made between technical and administrative responsibility. There is a very natural, human tendency for technical chiefs in the headquarters office to want to direct the activities of all of the specialists in their field, calling them in for conference or directing them to come here or go there to do certain jobs. If they are permitted to do this, and so by-pass the authority of the intervening line officers, great confusion and difficulty can ensue, since the line officers are responsible for travel funds and time reports as well as making duty assignments for all of the various phases of the work under their direction.

Under the line and staff type of organization, if a technical chief in the headquarters office wants a field specialist to do something, the orders for this should flow from the Director to the Hsien Soil Conservationist to the Township Soil Conservationist to the man in the field. In this way, all administrative details would be cleared as the orders passed through the various offices. Travel funds could be allocated and substitutes arranged for any minor field assignments ordinarily performed by the men so detailed.

When the new Soil Conservation Field Operations Division is first set up, it will be in a state of rapid expension. The demand for its services and the availability of qualified men will determine its rate of growth. For that reason the organization chart should be kept quite flexible so that new positions can be added as the need for them develops and funds are available.

If the procedure for setting justifiable new positions is too cumbersome and action is too slow, it may foster the habit of requesting and attempting to justify new positions, the need for which does not exist, just in anticipation of needs. This leads to overstaffing and should be avoided. Having more men on the payroll than are required to do the work at hand is not only a waste of public funds but is bad for the morale of the organization and develops poor working habits.

After their appointment and during their training period, new employees will necessarily be watching and learning rather than actually producing much on their own. This training on the job is necessary and should be closely supervised. After their training period is completed, all soil conservationists should be assigned work loads that will tax their capacity. Working under pressure to get more work done without more than enough help tends to develop ingenuity and industry as means of reaching that goal. Overstaffing tends to develop sociability and indolence.

While the organization is new and before the pattern of work becomes established, it is especially important to see to it that this pattern of work is developed in the proper manner. It is much easier to establish and maintain good working habits than to attempt, at a later date, to alter and improve poor habits after they have once become established. It is much easier and more certain of results, to prevent overstaffing in the first place than to attempt to prune out deadwood after it has become embeded in the organization.

During periods of great unemployment, the organization may be forced to employ numbers of unneeded people. It would be much better for the organization, particularly for its future, if these extras, put on as a relief measure, could be kept entirely separate from the regular working group except as they were needed and proved able to do some useful work. Much relief labor can be used in forwarding the soil conservation program in the field work but this relief labor is not a substitute for the regular trained workers and should not be used to dilute their efforts and disrupt the pattern of working.

Most of the actual work of planning and establishing the soil conservation practices will be done by the Township and Hsien Soil Conservationists and their staffs. Because of their location in the field offices they will not be in daily contact with their administrative and technical superiors. Since they will be thrown on their own resources most of the time, without direct supervision, they should be trained to take the initiative. As rapidly as they are capable of accepting it, they should be given authority to make decisions on the spot. Along with this authority to make decisions, of course, must go the responsibility for the results.

Experience in exercising authority instead of continually deferring action awaiting advice or approval from above, will develop the initiative of the men and will train them for greater responsibilities and for posts of leadership. The future of the organization, especially when it is still in the stage of rapid expansion is dependent on developing leaders to head the new field offices and technical posts.

Nothing is quite so demoralizing to an organization as to have men who know what to do and are willing to accept the responsibility for their actions, held back by the rule book. On the other hand, being held responsible for the results, is an effective deterrent to rash exercise of authority.

SUMMARY

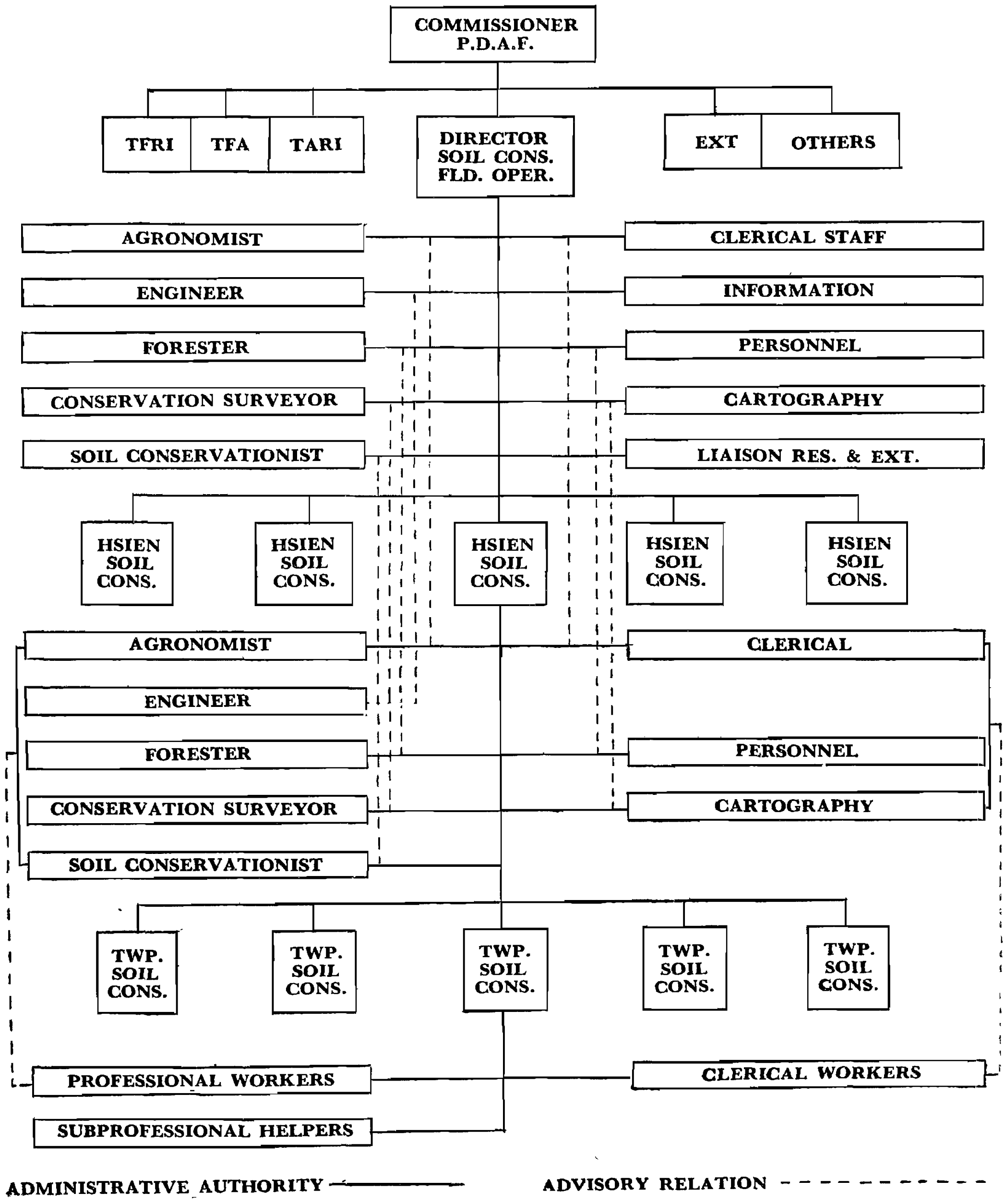
Of the 3,596,121 ha. on Taiwan, there are 513,299 ha. of paddy fields and 351,901 ha. of dry farmed uplands. This land must produce the food and raw materials for a population of about 10 million which is increasing at the rate of 3.4 percent annually. Heavy rainfalls, steep slopes and intensive use all contribute to the destruction of the available land.

Soil conservation, which includes proper land use, and all of the practices necessary for the protection, improvement and maximum production of the land, is urgently needed to meet the future needs of the people.

The control of erosion, one of the important phases of soil conservation, is accomplished by preventing the soil particles from being either detached or transported. Though the principles are simple, some skill and experience are required for their practical application.

Maps and written plans for the soil conservation program should be made on a community basis by trained conservationists. These plans must be concisely written and acceptable to the farmers who are to apply them with a minimum of assistance. An organization for carrying out such a Soil Conservation Program is suggested.

SUGGESTED ORGANIZATION CHART



Land Use Policy*

June 5, 1956

There has been considerable discussion relative to land use policies since my arrival in Taiwan. Some regulations are in effect and others have been proposed. It is one of the most serious questions from the standpoint of soil conservation and I have given it quite a bit of thought. One thing we can be relatively sure of is, that there will not be any one solution to the matter.

The prohibitory regulations now in effect and proposed will no doubt have a place in the solution but it seems to me that they alone are not adequate. Therefore I am taking this means of passing on to you some facts and philosophy which point toward yet another avenue of approach to solving this land use problem.

As I see it, my responsibility extends only to the point of presenting to you and your staff the technical aspects of the matter, leaving it to you at your discretion to take the administrative steps of presenting the matter to the Governor or other administrators and thru them to the legislative agencies of the government for their approval and action. With this in mind, the following is presented to you for your consideration.

The hectares of land in Taiwan which are suitable for continuous cultivation without danger of deterioration are definitely limited. There is not an unlimited amount of the marginal lands which can be cultivated occasionally. The steadily increasing population creates an additional demand for food and raw materials from the land but the supply of land is decreasing due to erosion losses. The result has been that more and more farmers have been forced to go out into the steep hills and, regardless of the ultimate consequences, the forest cover has been destroyed and the lands placed under cultivation.

When rains fall on bare, steep lands the physical effect is the same regardless of whether the land is privately owned, legally leased, or illegally exploited. These are only man-made classifications which have no effect on the damage done by the ensuing erosion.

It seems that economic necessity and the lack of more suitable lands have driven the farmers to cultivate these steep lands in order to make a living. Since there are no more suitable lands available to move them to and since the products of cultivation are needed in the national economy, may be a positive approach is indicated, trying to improve or protect these lands rather than depending entirely on prohibitory regulations.

The function of governmental agencies, particularly those which control or direct the use of public lands, is to conduct that portion of the public business for the benefit of the nation as a whole. There are frequently a number of aspects to the problem of land use. But the basic consideration should be to use the land in such a way that it will not be damaged or destroyed and, at the same time to produce on it as much wealth as possible to support the national economy and also the standard of living of the cultivators.

In order to accomplish these broad objectives, it is necessary to consider each tract of land separately. We must determine what is its use capability or the maximum intensity to which it can be used safely and permanently. This use capability is determined by a number of factors any one of which, if sufficiently detrimental, may make it unduly hazardous or uneconomical for continued cultivation. Some of these factors are: slope, soil texture (sand silt or clay), soil depth, climate, drainage, salinity, wind or flood

* Memorandum to Mr. K. Y. King. Commissioner. PDAF

hazard, etc., while slope is only one of several factors, it is probably one of the most important and certainly the most obvious.

To ignore or defy the laws of nature is to invite disaster which accompanies the destruction of the soil resources of a nation. Recognizing the limiting factors as they now exist and seeking to relax or relieve them may permit more intense use of the land without destroying it.

Land which can be made safe and profitable for cultivation by drainage or by protecting it from flood damage has, for the most part already received the benefits from those practices. Most of the land now being used beyond its use capability is land whose safe use is limited by slope. Therefore, we should consider ways to remove or relieve this slope limitation.

Taiwan abounds in examples of land from which the slope limitation has been eliminated by the construction of level, bench type terraces. These include not only the irrigated fields in the valley but also the up land irrigated fields which were originally quite steep. Where the depth of soil permits and the anticipated returns will justify the investment of labor, this seems to be the logical solution. It gives adequate protection against erosion and at the same time makes possible a higher yield of crops. More water is stored in the soil for use of the crop plants at a later date because the water is held on the field instead of being allowed to run off as it does in sloping fields. Since the water does not run off, it does not remove the topsoil which contains most of the compost and fertilizer that has been added. As a consequence the soil fertility of the benches can be built up to a higher level than on the sloping fields.

A very logical question would be "If this is such a good practice, why isn't it being done?". The answer is that it is being done to an increasing extent. Wherever there is a supply of water for irrigation, it has been done. Wherever there is no irrigation water and the crops are dependent on seasonal rain fall, the matter is receiving more and more attention on privately owned land. The cultivators of public lands would undoubtedly consider doing more benching and other forms of improvement if they were assured on continuity of tenure on lands which they might improve.

A great deal of public land, nominally owned by the townships, the hsiens or by various agencies of the Provincial Government, is being illegally occupied and destructively farmed at the present time despite laws and regulations to the contrary. The eviction of these illegal cultivators and the reforestation of the land would, after a period of years, provide adequate protection against soil erosion and deterioration. However, the execution of such a policy would deprive many farmers of a place to earn a living and as such would be difficult politically and undesirable socially.

Would it not be in the best interest of these farmers in particular and of the public in general, to establish a policy of permitting and encouraging these farmers to construct benches on some of these public lands? Some of the lands would and some would not be suitable for benching. Each farmer would have to decide for himself which lands he would be willing to bench. To the extent to which such a policy was executed, proper land use would be established, erosion would be reduced or controlled and the crop producing fields of the nation would be stabilized.

If such a policy were administratively determined, many details of procedure would have to be worked out but the details would not be nearly so complex as the Land to the Tiller Program. Proper procedures would have to be established for the farmer to apply for permission to bench terrace the public land that he had been "squatting" on. Provision should be made for the land to be inspected by technically trained personnel (rather than by politically appointed) since not all land would be suitable for bench terrace construction. Some technical guidance should be given to assure that the terraces, after construction, would be adequate. After construction, each bench should be inspected to see that it came up to specifications. After technical approval, some constituted authority should be charged with issuing a lease and arrange for the payment of rents or taxes to the appropriate office.

An attempt to consumate such a program in one or two years would undoubtedly result in its breakdown and abandonment but this is neither necessary nor desirable. Technical personnel is not available and could not be trained in so short a time. The farmers would not be able to invest so much labor in one or two years. It would seem to be much more satisfactory to adopt such a policy and then apply it over a number of years as the farmers were willing and able.

Such a policy was tried out in a small way in the watershed of the Ah Kung Tien reservoir in Kaohsiung Hsien. In order to reduce the siltation of the reservoir, a regulation was passed which required that all public land with a slope greater than 5° belonging to the Hsien or to TFA should be recalled from cultivation and reforested. Later at the suggestion of JCRR, authority was given for the farmers to apply for permission to construct bench terraces on as much as they wished of the land which they had been cultivating. Within 10 days after not very wide notification, applications were made at the township offices to bench 199 ha. of land. Only a part of these lands were inspected by the technical committee but to date, 57 ha. have been inspected and benched and an additional 16 ha. have been approved for benching at a later date.

The Kaohsiung Hsien Government and the two township offices concerned have cooperated wholeheartedly in this program. While the TFA Kaohsiung District Office has participated, they have done so in such a way as to cause confusion in the minds of the farmers. The results that have been achieved to date have been without the aid of any cash subsidies.* The possibility of getting a legal lease on the land (which they had been illegally farming) was sufficient incentive to get the farmers to construct these terraces.

Such a policy if adopted on a provincial level would have advantages from the standpoint of dealing with the farmers who are illegal cultivators. It would permit them to "save face" and become legal tenants. It would permit each farmer to determine which land he wished to bench, how much and how fast. There would be no resentment or feeling that they were being dictated to. Whereas they have been paying no rent or land taxes on the illegally exploited land, under a lease they would pay to the proper offices.

In addition to these political or social aspects, the policy would result in controlling soil erosion and reducing flood hazards. To the extent to which it was applied it would stabilize crop production on these lands. Reforestation could proceed on the lands no suitable for benching and the cover so established would give added protection to the benched lands. Such a policy would be beneficial to all and detrimental to none and would require no large budget for subsidization as it would no private lands. It would require training some technical personnel at the local levels for inspections and approvals.

---

* Since this memorandum was prepared in May, PDAF has arranged to subsidize the construction of these benches.

Conservation of the Public Lands in Taiwan

December 1957

Many people are greatly alarmed over the frequent and severe soil erosion losses in Taiwan. There are good reasons for this alarm. Industry is demanding more raw materials. The large and steadily increasing population will need more and more food. Airfields, highways, military establishments and urban expansion are occupying good farming lands each year. Taiwan can not afford to lose any productive land by soil erosion.

Most of the western coastal plain is used for rice production. Little soil erosion takes place here. The maintenance or reestablishment of a good forest cover will afford the best protection for the high, steep mountains of central Taiwan. It is on the sloping, non-irrigated uplands and foothills between these two extremes that severe soil erosion is most frequently found. It is here that the prevention of erosion should be emphasized and soil conservation practices applied.

Many of the worst eroding areas are found on public lands belonging to the Provincial, Hsien, or Hsiang Governments. They are frequently designated as "land for forestry use" but as a matter of fact, the trees have been cut from these steep slopes. They are being cultivated by illegal occupiers, contrary to regulations. Having no legal claim upon the lands and not being sure how long they will be allowed to use them, these farmers are much more concerned about how much profit they can make from these lands this year than they are concerned about protecting the lands for future users.

There is no better place for these illegal cultivators to go to earn their living. Consequently, the regulations limiting or forbidding the cultivation of these steep public lands have not been, and probably can not be, enforced. Since these lands are not leased, the governments receive no revenue from them and collect no rents or taxes. As a means of collecting a little revenue, some officials have urged that these lands, even in their eroding condition, be leased to the farmers who cultivate them. If such leases were granted, legal sanction would be given to the present misuse and destructive practices.

At present, the governments have the legal right to recall these lands to reforest them whenever there are facilities for doing so. It would be very difficult, if not impossible, to recall leased lands. Therefore the granting of such leases would be a very unwise procedure.

Most of the lands being discussed are classified for "forestry use". They are best suited for this purpose and should be so used. However, included within these large areas of forestry land, there are some small tracts which, because of the slope and the depth and texture of the soil, would be suitable for cultivation if adequate erosion control practices, such as the construction of bench terraces, were applied. After receiving proper treatment these small areas could, without danger of destruction, and should be leased to the farmers for permanent cultivation.

After being properly benched the threat of erosion would be removed. The crop production of the community would be stabilized. After leasing the governments would receive some needed revenue and the present illegal tenants would gain "face" by becoming rent paying tenants or leasors.

This scheme has been tried out experimentally on a small scale on the watershed of the Ah-kung-tien Reservoir in Kaohsiung Hsien. The illegal occupiers were permitted to apply to their Hsiang Public Office for permission to construct benches on specific tracts of land. A technical committee inspected each tract to determine whether or not it was a suitable place to be benched and permits were issued for the suitable sites. The soil conservationists from the local Soil Conservation Field Office advised and helped the farmers with the proper construction of benches and waterways. When the work was completed, those benches that passed inspection were leased to the farmer. They have invested their labor and are now sure of their tenure on these lands.

Not all of the farmers responded to this opportunity to possess the land they have been farming. A few did and the results have been satisfactory on these areas, indicating that such a program has merit. This experimental approach covered only a small area but the principle involved is applicable to thousands of hectares of similar lands thruout Taiwan.

A Soil Conservation Technical Committee, convened by the Commissioner of the Provincial Department of Agriculture and Forestry, studied this matter, and after much discussion, recommended that such a program should be sanctioned on a broader scale. At the time the committee was studying this matter. there were only three Soil Conservation Field Offices, located in Kaohsiung, Hsinchu and Nantou Hsiens. Therefore they recommended that the program be started first in these Hsiens where soil conservationists were available to give technical assistance and advise. These Field Offices are still available and since that date, six other Field Offices have been established in Taipei, Miaoli, Chiayi, and Taitung Hsiens, in Taichung City and at Fu Shing in the Shihmen Watershed.

The following summary of the existing Land Laws, as amended 29 April, 1946, indicates that no new legislation is required to permit the adoption of such a program on a wide scale. These citations are applicable:

Article 2. Land is hereby classified according to its use into the following types: Type II. Land used for direct production such as agricultural land, forest land, pasture, etc.

Article 3. In the absence of any provision to the contrary, the land offices shall be responsible for the execution of this law.

Article 81. The Municipal or Hsien Land Office may, in consultation with other government authorities concerned, classify the lands under its jurisdiction into different categories for specific uses with reference to national economic policies and due consideration of the local needs and the possible uses for which the nature of the lands is suitable.

Article 82. Any land which is classified for a specific use shall not be put to another use, unless such other use is approved by the competent Municipal or Hsien Land Office.

Article 84. The classification of lands into different categories for specific uses or any subsequent changes therein, shall be made by the competent Municipal or Hsien Land Office and announced by the Municipal or Hsien Government.

Article 85. After the classification of lands into different categories for specific uses has been announced, the Superior Land Administration may issue instructions to make changes therein, if, in its judgement, some more important interests are to be served thereby or some more important uses justify such changes.

These steep, public lands have been classified for forestry use. Until this classification is changed they should be used for this purpose, for to ignore or disregard one law, even though it be unrealistic or out of date, is to encourage disrespect for all laws. But as a matter of fact, many of these lands are being used for agriculture.

Articles 82 and 84 imply that the Land Offices now have the authority to classify or to change the classification of any tracts of land within their jurisdiction. Further, Article 85 states that the Superior Land Authority has authority to order changes in the classification of land when in its judgement more important uses justify such change. Article 81 recites the bases upon which lands should be classified. All three of the bases cited would justify the changes in classification here recommended.

1. National economic policies which encourage the maximum production of food and raw materials for industry would justify reclassification from forest use to agricultural use.

2. Due consideration of local needs of the farmers for a place to earn their living would justify such changes.

3. Possible uses for which the land is suited would be considered by the examining technicians before they recommended that the Land Office reclassify the tract examined.

The Municipal or Hsien Land Offices then, have authority under the existing Land Laws to change the classification of any lands under their jurisdiction after consultation with other government authorities concerned. This prerogative has seldom, if ever, been exercised by the Land Offices, not feeling sure of their authority, they are hesitant to act even in those cases in which they agree that it would be desirable. Some leadership and encouragement from the Provincial level might serve to assure them on this point and help to overcome this hesitancy.

A soil conservation survey showing the characteristics of many of the marginal lands in Taiwan has been made. This survey will be a useful tool in reclassifying the lands. The steep, illegally occupied public lands are not the only erosion problem in Taiwan but they do represent a very large one. The personnel of the nine established Soil Conservation Field Offices are gaining experience and many conservation practices are being applied, mostly on private lands. However, the present program is scarcely more than a token approach to the soil conservation program needed in Taiwan.

In preparation for the larger program which is needed, technicians are being trained at the PDAF Soil Conservation Training Schools and at the Soil Conservation Field Offices. Additional Field Offices are being established in the various communities which indicate the need for them. With sufficient publicity and official encouragement to the reclassification of land use, very little budget would be required to get many hectares of bench terraces constructed. The opportunity to gain legal possession of land should be sufficient inducement without paying cash subsidies.

This would be a permissive, democratic type of program in which no farmer would be forced to build benches. He would be given the choice of either protecting the land or ultimately having it reforested. It would not be possible to accomplish this entire program in one or two years. It would be much sounder economically and politically to promote a long time policy of permitting suitable lands to be benched, providing technical guidance to assure that the work was well done and then leasing the benched lands to the farmers.

To the extent that it was carried out, such a program would

1. Prevent or retard soil erosion.

2. Make it possible for the farmers concerned to earn their living in a legitimate way and thus "save face".

3. Reduce flood damages to fields, towns, irrigation works, highways and railroads.

4. Increase agricultural production, because the level benches produce higher yields than sloping, eroding lands.

5. Bring some revenue to the government.

6. Permit the reforestation program to proceed on the lands not suitable for cultivation.

All of the people would be benefited by such a program. No one would be handicapped. The necessary laws are on the statute books. Technicians are being trained to do the technical work. This part of the long time soil conservation program in Taiwan awaits only administrative approval.

The Development of Marginal Lands in Taiwan for Agricultural Production

April 1960

Most of the land on Taiwan that is suitable for cultivation has already been developed and is being cultivated. The rapidly increasing population and the desire for a higher standard of living requires that every possible hectare be used, but the future of the Nation also demands that all of the land be used in such a way that it will not be destroyed. These two considerations call for a balancing between the need for present production and the conservation of the soil for future production.

Within the mountainous and hilly areas which are generally unsuited for safe cultivation, there are some small areas which can safely be cultivated if proper precautions are observed. These are the areas which should be developed. The criteria which separate them from the surrounding unsuitable areas are the slope of the land, the depth and texture of the soil, and accessability.

In addition to these undeveloped lands which can and should be developed for cultivation, there are many hectares of sloping land which is already being cultivated but which, because it is public land which is illegally occupied, is not being given the protection against erosion that most farmers give their privately owned land.

Because all protective vegetation has been removed from them, these illegally cultivated lands are suffering acutely from soil erosion and are not approaching their potential in crop production. It is imperative that some action be taken at once to protect them from further destruction.

Stationed in Soil Conservation Field Offices in each Hsien, there are technically trained conservationists who are available to direct and assist in the protection of these lands by the construction of level, bench type terraces and other soil conservation practices. A lease which would assure them of continued tenure is all the incentive that would be required by many of these illegal occupants to induce them to construct the needed benches and protected waterways without expense to the government.

Formerly all such benches were made entirely by hand labor but recently the Soil Conservation Field Offices have demonstrated methods by which they can be built with animal drawn tools made in Taiwan. A limited supply of these tools are available in each hsien for loaning to farmers who request them. More such tools can be made in the local workshops. By using their own labor and these tools, drawn by their own cattle, the farmers can accomplish much of this important job without the need for spending much cash.

Before they can embark on such a program of protecting these lands, a procedure must be approved by the government which will permit them to do so. Such a procedure has been drawn up and submitted to the Provincial Government for approval. This phase of the land development should receive priority because of the damage being done by each rainstorm to the unprotected sloping lands.

When it is determined that the untouched lands should be developed, a logical and orderly procedure will save much wasted effort and will avoid many mistakes. Only those areas which are capable of safe exploitation should be developed. These lands can be selected only by examination in the field by technically trained soils men. Too much emphasis cannot be placed on the selection of the lands to be developed. Unsuitable areas are bound to result in uneconomic development of unproductive fields.

In addition to the actual development of the cultivated fields, consideration must be given to the availability or the cost of developing supporting facilities such as roads, villages, schools, etc. The per hectare expense of developing lands where these supporting facilities are already available will be much less than if one or all of them must be created along with the development of the fields.

For this reason, search for lands to be developed should be made nearest to usable roads, near existing villages and within reasonable distance of established schools. The areas suitable for development, when found, will usually be small individually but the aggregate total may be surprisingly large.

In some types of development it is necessary to make a survey and plan the complete development before any construction work is initiated. This is not the case in the development of marginal lands. Each separate tract can be completely developed independent of action taken on surrounding tracts. For this reason it is not necessary, or desirable, to delay the implementation of the program pending the completion of an overall survey and the analysis of the data obtained.

Efficiency in operation of such a project, requires that the field operations should be more or less concentrated to permit more economic travel and transportation of equipment, to facilitate the information and education program that should accompany development, and to facilitate the administration of the developed lands. Such a development project should be started and put into active operation in one community while surveying, inspection, and planning are in progress in the next area.

Such a program does not lend itself to explosive expansion. A staff of competent technicians, when once developed, should be kept steadily at work. If this policy is followed the program will experience a healthy, normal growth. If it is expanded faster than personnel can be trained, efficiency will be sacrificed, more costly mistakes will be made and the development of marginal lands will gain an unsavory reputation.

This is a good program. One which is badly needed to provide food and raw materials for the expanding population of Taiwan. The cost to the government, of such a program need not be excessive if it is executed wisely. If the organization which is responsible for the operation of this program is encouraged to grow rather than to expand unreasonably fast, there need be no misgivings about the ultimate results.

Land Development for Increased Agricultural Production

May 1960

There are at least two ways in which this can be done. One way is to open the national forests and reservation lands for exploitation by farmers from the plains. A second way is to increase the per hectare yields on the sloping lands which are now being cultivated. At the same time they can be protected from soil erosion.

With a huge budget and plenty of trained personnel, both methods could be used at the same time. Since this is not possible, priority should be given to the second approach. The national forests and reservation lands will not be damaged if their development is delayed for a few years. Each year that the present wasteful methods of cultivation are continued on the sloping lands, will permanently damage them as a national resource.

There are also other reasons why the sloping cultivated lands should be given priority. Social facilities such as roads, villages, schools police stations, etc. are already built here but would have to be built in the newly developed mountain areas. This requires the investment of money, time, and labor.

A greater investment is required to cut off the trees and prepare a hectare of forest land for cultivation than to bench terrace and otherwise improve and protect a hectare of sloping land which is already being cultivated. These lands are more or less accessible but roads would have to be built and maintained in the mountains.

The production per hectare can be increased when steep cultivated lands are bench terraced. There is a temporary disturbance but soon the accumulation of moisture and fertility which now runs off in each rainstorm, more than overcomes this condition.

This is not just theoretical conjecture. Measured yields from the same land before and after bench construction support that statement.

When and if the Provincial Government promulgates the Land Use Policy that was recommended by the Soil Conservation Technical Committee on October 10, 1956, facilities are already available for making "a big leap forward" in this respect.

Soil Conservation Field Offices in most of the hsien have personnel with some experience and they have the equipment necessary to start a big scale program.

The possibility of getting a legal lease on the public lands which he has been illegally cultivating should be enough incentive to get the farmers to do the work over a period of several years. It should not be necessary to pay cash subsidies.

With good organization and proper publicity such a program would grow rapidly, Bureaucratic obstruction is the principal hindrance.

On some lands the soils are shallow or there are so many stones that it is not feasible to try to build bench terraces. Such lands can be developed as grass lands where there is need for forage for cattle. They could also be planted to some fruits which did not require bare cultivation or they can be reforested. Unless they are benches they should not be continued in cultivation for to do so not only ruins these lands but causes harmful siltation below.

The results of benching these lands are: 1) Increased production for the individual farmer, the community and the nation; 2) Soil erosion and siltation will be controlled; 3) Farmers would gain "face" by becoming legal tenants rather than illegal squatters; 4) The government would receive lease rental from land not now producing any revenues.

Everyone would gain from such a program and no one would lose. Man has arbitrarily and artificially classified land as private or public. public lands are further classified as hsien, hsiang, national forest or reservation lands.

Natural laws which determine land use capability, soil erosion and its control, and productivity are based on the physical attributes of the land and entirely ignore man made or legal classifications.

There is a permissable intensity of use for each tract of land. If this intensity is exceeded the land deteriorates and is ultimately destroyed. Less than optimum intensity of use will not hurt the land but may be an economic waste. When there is the need for agricultural production that now exists in Taiwan, land that is suitable for agriculture should be so used, provided it is given needed protection.

The time will come when Taiwan will develop those tracts of land now classified as national forest or reservation lands, which are suitable for agriculture. When this time arrive, the development should be undertaken in a logical, scientific manner rather than as a political hullabaloo. Since people are human, some mistakes will be made but they will be fewer if some control is exercised in the method of developing these lands.

Since it would require less investment and would return more to the nation in a shorter time, it would be wise to develop the best lands first. This would require that technically trained men select the areas to be developed.

Since accessibility is an important factor, first priority should be given to areas close to usable roads. Areas within reasonable distance of roads should be examined and the tracts with agricultural potentialities selected and marked out both on maps and on the land *before* the farmers are permitted to rush in and settle on them. Then settlement must be confined to the designated tracts.

While from a humanitarian or political stand point it is impossible to evict the farmers who are already settled on lands not suited for cultivation, they can be prevented from settling on them in the first place. This will require organization of the program and firmness as well as integrity on the part of the administrators to avoid "land grabbing" such as has been reported in connection with the tidal lands reclamation projects.

It is not necessary to delay starting such a project until *all* of the national forests and reservation lands have been surveyed. A program of this sort can be planned and carried out by blocks, each a self contained project. While one block was being settled and developed, the next could be examined and made ready. Work handled as a steady flow causes less confusion and congestion than big pushes. Any mistakes in administration of the first sub projects could be corrected in the latter ones.

It is what is done to the land and how it is done that determines the economic results. Whether the land is developed by aborigines or Chinese is purely a political question. How well the job is done will determine its success.

The Development of Soil Resources

May 16, 1960

All soil resources should eventually be developed, to their highest potential productivity compatible with safe and permanent use and with side effects on other resources and facilities.

There are several objectives in developing marginal lands, among which are;

1. Production of more food or wealth for the national economy.
2. Prevention or soil erosion due to misuse.
3. Control of the siltation of reservoirs.
4. Providing homes and farms for more people.

Because of the inherent, or natural, characteristics of different soils, some of them can be developed to a higher state of productivity than others. More food and more wealth will be provided for the national economy if those soils with the highest potential are developed first, leaving those with less potential to be develped at a later time if facilities are available.

Soils which are covered by forests or by grass are protected against rapid deterioration. Sloping lands which are under cultivation are subject to soil erosion. This is especially true in Taiwan where the slopes are so steep and the rainstorms are so intense. If the development of these sloping cultivated lands is delayed, soil erosion may destroy them or at least so deplete them that their development at a later date will be much more difficult and expensive. If the development of forest or grass lands is delayed, their condition at that time will not have changed much.

Each tract of land has a certain intensity of use under which it can be safely maintained. The application of soil conservation practices may change this capability so that a more intense use will be appropriate. In considering the application of such soil conservation practices, their cost of application and the estimated increase in income must be compared.

In some cases the uses and benefits of use of a watershed area must be taken into consideration, as well as the direct production values. If a reservoir is located in the watershed or immediately below it, the value of the domestic or irrigation water supply or of the hydroelectric power prcduced from that reservoir may far outweigh the value of the eash crops If the conversion from forest or grass cover to cultivated crops shortens the useful life of the reservoir, the increased crop production may, in the overall picture, be accomplished only at an exhorbitantly high price.

Therefore, all side effects of a proposed development should be carefully weighed before it is undertaken.

Whenever non-cultivated lands are developed for cultivation, this will necessitate the parallel development of transportation, communication, and other social facilities such as schools, villages, hospitals, police stations, etc. Such developments should be added to the cost of the land development unless they are already available within reasonable distance.

For a number of reasons, the development of illegally cultivated sloping Public lands should be given high priority in the land development of Taiwan. These lands are being cultivated with inadequate protective measures. When these illegal occupiers are not sure that they will be allowed to remain on the land, they do not feel justified in expending the time, labor, or money to protect it from erosion that he would use to protect land that belonged to them or for which he had secure tenure. As a consequence these lands suffer from severe erosion. Each year their hazardous condition becomes more acute.

Some of these public lands are not fit for cultivation under any reasonable scheme of development. Many of them can be developed economically for safe and permanent agricultural production. When the usable steep lands are benched and properly managed, more production will result each year than is now being obtained from them. In addition, this higher production can be maintained indefinitely. Without development the production will decrease steadily and ultimately they will be destroyed.

Most of such lands are located close enough to existing public facilities so that no new community development will be required. This holds down the overall development expenses. While the development of these lands which are already being cultivated will not provide homes or farms for more people, it will provide more food and other forms of wealth which can provide more jobs in processing the products. Communication and transportation facilities are much better or are much easier to establish in these locations that in the more distant undeveloped lands.

There is little doubt but that a thoro search will reveal many areas in the more remote districts that are physically capable of being developed for more intensive uses such as agricultural cultivation. When these are located and the development work is completed the production of food and other wealth will be increased. More people can be setteld on the land.

However, it is not to be expected that lands suitable for development will be found in large blocks. It is more probable that they will be found in small units of a few hectares or less and these will be scattered.

The effect on present or potential reservoir watersheds must be considered when development plans are being prepared. Watersheds above the Wusheh Shihmen or Ta-Chien dams should be carefully safe guarded and should be developed primarily for watershed protection rather than for settlement or for food production. The overall development plan for such areas should include efforts to reduce the cultivated areas as much as possible and for stabilizing the areas that must remain in cultivation because of aboriginie or other prior rights. Technical and financial assistance should be provided for these purposes.

The newspaper stories that have been printed recently tend to raise hopes too high for the settlement of great numbers of people in the mountainous areas. The number that can be settled there without doing irreparable damage to the land, is bound to be rather small.

In addition, such lands as are suitable for development will require the establishment and maintenance of numerous soil conservation practices. These practices should be established before the farmers are allowed to settle on the lands and along with the lease or permit for occupancy of the land, should be stipulated as to the maintenance of certain practices or the prohibition of certain farming practices such as burning.

Unless the required practices are established before the leases are given or the land occupied, the farmers can, and many will, refuse to do anything to protect the land or will do so in a very desultory way. If they once gain possesion of the land and plant a crop, Chinese custom and law being such as it is, the bureau responsible for the development of the land will have lost its most potent bargaining power and will be futile in its efforts to protect the nations resources.

In making plans and in applying soil conservatiom practices the land use must first be determined and this goal must not be changed unless the practices are also changed accordingly. The value of the combined returns to the individual operator and community from more intensive land use must always be considered in relation to the cost of applying the required treatments and also to the hazard presented by the intensified land use.

The farmers have already developed the

best and the most accessible sites. It is to be expected that future development of virgin lands will have to contend with difficulties in communication and transportation or with difficult technical problems in developing sites with lower potentials. In choosing sited for developmant projects, priority should be given to those where the greatest development can be accomplished in the shortest time and with the least expenditure of men and money.

Public enthusiasm for land development is running high at present. If a creditable amount of satisfactory work can be accomplished the first few years, public support can be expected to uphold and continue the program. If some of the least productive jobs are undertaken at first the results will be accordingly meager and public support will probably lag. For these reasons the most likely projects should be undertaken first to set a good example.

A Plan for the Protection and Development of The Natural Resources of Taiwan

June 29, 1960

In order to get the continued maximum of agricultural production and forest products, and to achieve the optimum economic development of its soil resources, the Taiwan Provincial Department of Agriculture and Forestry should undertake a coordinated program which would include the work of many agencies.

The present programs of crop production in the lowlands should be continued and even strengthened. At the same time, the work of developing and protecting the soil resources in the marginal lands and mountainous areas should be started in a more vigorous manner. The most effective use of available resources will be made if each agency continues to handle the type of work for which it is set up and for which its personnel are equipped by training and experience.

In the development of marginal lands, each tract, however small, should be used within the limits of its land use capability and should be treated according to its individual needs. This will require an "on site" inspection of each tract to determine its most intensive permissible land use and at the same time the soil conservation and crop management practices that are required for its safe and continued use. Each tract need not be utilized to its maximum at the present time but the maximum allowable intensity of use should not be exceeded.

An organization, tentatively called the Mountain Resources Development Bureau, is to be organized within the Provincial Department of Agriculture and Forestry. This Bureau will be responsible for the development of both marginal and mountain lands and will make use of the facilities of existing agencies to do their appropriate parts of the overall program. In so far as they are able and willing to do so the forestry, crops, special crops, and livestock divisions of the Provincial Government will be expected to participate in their respective phases of the overall program.

Some of the marginal lands are still in virgin condition with a vegetative cover of forest or grass. These lands present little if any erosion hazard. Other areas are not in cultivation but have been cut over or burned so that they have only a little volunteer vegetative cover. While more erosive than the virgin lands, they do not present too difficult a problem of erosion control due to the less intense land use.

Some of the cultivated marginal lands are in private ownership and are being given some form of protection by the owners. Much work needs to be done to make their protection more effective. The Soil Conservation Field Office are now working with these owners to demonstrate better control methods. The most hazardous of the marginal lands are those being illegally cultivated. The cultivators have no legal tenure on the land and so hesitate to spend as much time and money in protecting them as would be spent on lands for which they had secure tenure.

As a class, these lands are steeper or thinner soils than those in private ownership. With a more hazardous condition and less incentive for protection, the erosion condition here is the most acute of any of the marginal lands. These illegally cultivated marginal lands should be given first priority when the development program is finally undertaken.

Although the occupants have no legal rights on the land, necessity has forced them to invade the public domain and appropriate them to their own use. Not having a lease, they pay no rent and cultivate them on a year to year basis. Having, by custom at least, a vested right of occupancy, these squatters can not be evicted. Since they can not be put off the land, a means of helping them to use the land with the least damage must be worked out. Even under the management which they have had, these lands do produce a living for these people and also produce food and other wealth for the national economy. Unfortunately, because of the manner in which most of these lands are cultivated, erosion is rapidly depleting their fertility, gullies are being formed which interfere with their efficient cultivation, and flooding and siltation conditions below them are being made worse each year.

A big improvement, if not an absolute cure, is possible. Not every tract can be salvaged for continued cultivation, but many can be. Each tract must be examined separately and its capability and needs determined. Some of these lands can be bench terraced so that, in effect, they become flat lands and can be used for the production of any crops the cultivator wishes to produce. Other tracts are suitable for limited use only, because the depth of the soil precludes the construction of level benches. Some of the lands now being cultivated can not be continued in cultivation with any economically feasible method of treatment without destroying them and causing much downstream damages. This type of land must be withdrawn from cultivation and converted to some permanent cover of grass or trees. If the slope and location are such that pasturing is feasible, they might be used for livestock production. Otherwise they should be afforested.

While the construction of bench terraces, which should be the most widely used practice, does require an investment of some labor, the increased production from the tract as the result of the benching, will eventually repay the investment. The percentage of the area that can be benched for increased production and the percentage that must be retired from cultivation will vary from tract to tract. No advance promises, or even estimates, of these figures can be made. Each tract must be treated as its characteristics demand.

The existing land laws permit the reclassification of forest land to other more intense uses whenever it is determined that such change is in the public interest and in keeping with the character of the land. After the land has been converted from sloping to level land, this change of classification is justified. After it is reclassified it can be leased to the former occupant who will then gain face in the community as a legal resident and can continue to earn his livelihood there, produce wealth for the national economy and start paying some rent or taxes to the local government which owns the land. By this operation the loss of soil from this field and the dangers of flooding and siltation below will be greatly reduced.

When it is established, the Mountain Resources Development Bureau should devote its resources first to the development of these illegally cultivated marginal lands since their problem is the most acute. Facilities are already available, through the Soil Conservation Field Offices which are operating in each Hsien, to assist the cultivators of private lands with their erosion control problems.

When the illegally cultivated lands have been cared for or, when additional technical men are trained and available, the development of presently uncultivated lands which are suitable for development can be undertaken. Unless some care is exercised in this development, farmers are apt to rush in and exploit these lands just as they have the lands now suffering from their operations. Before settlement is permitted, the entire area should be examined and those tracts suitable for development definitely marked out on the map and in the field. Development should take place ONLY in the permitted areas and that only according to the methods specified for each tract. It is preferrable that this development should be done before the farmers are permitted to even enter the area. Past experience indicates that if they once gain entrance, they will plant some sweet potatoes or other crops at once, and then refuse to permit benching or other improvements unless they are compensated for the loss of their crops. This causes extra expense and requires added time to complete the program.

For new development or for the development of illegally cultivated lands the same kind of organization is required. This organization would differ from the Soil Conservation Field Offices whose function is mainly to *SHOW the farmers HOW* they should protect their own lands. For the development work, an Operating Station is required, whose job is to *GET the work DONE.* This will require a large labor force in the Operating Station whereas the farmers themselves constitute the labor force of the Soil Conservation Field Office.

Where there is an abundance of farmers on the illegally cultivate land, they might be given jobs as laborers to support their families while the program of land development was being executed on lands they had been cultivating. In the development of new lands where there was no available labor supply, Work Battalions of Retired Servicemen might be organized and used. Whether the labor was supplied by the farmers or by Work Battalions, the project budget should include a generous item for labor.

While labor is an important item in the budget and in the program, other steps must precede it. The ownership of the land and the vested mights of occupiers must be determined and accurately mapped, if cadastral maps are not already available. The land must be examined and determinations made as to it most intense permissible use and appropriate conservation practices specified. These practices must also be staked out or otherwise prepared for the laborers to start their work. Grasses and trees must be planted, under technical direction. Benches and masonry structures must be constructed. Fertilizers and compost must be provided and applied in the right manner. This will require a technical and administrative staff at each Operation Station.

Where new lands are being developed, locations will be sought where it is feasible to establish large areas of forage crops and supplies of water. There, livestock demonstration farms should be developed, not as show places but as places where the practical and economical production of livestock can be demonstrated. Since large scale livestock production, especially of cattle, is not widespread in Taiwan, the presence of a practical, workable demonstration should greatly expand this industry.

In the development of lands at higher elevations, the economical production of temperate climate deciduous fruits should be demonstrated and encouraged. The production of other special crops and medicinal herbs, all under suitable conditions, should also be included in the demonstrations.

In all of these developments, the welfare of the citizens must considered. This does not mean that everything they ask for must be granted or agreed to. All the facts and factors in a problem must be considered before a decision is made. There will undoubtedly be a few cases where a farmer is cultivating land that is entirely unsuited to remain in cultivation, even with extensive treatments. He will understandably, insist that he be allowed to continue to misuse this tract, since it is his source of livelihood. If it is evident that by doing so he is not only destroying that tract of land but is at the same time contributing materially to highway damages, or the siltation of fields, canals or reservoirs below, it may be that the damage being done exceeds the small benefits he receives.

In such cases, the welfare of the community and the nation demands that this damage, with the small benefits, be stopped as soon as possible. This may require resettling the farmer is another suitable site can be found. This is a difficult undertaking since all good sites are already occupied. It may require that this man be given a more or less steady job helping to establish the program in the community. In any event, after a sound decision has been made, the personnel on the project should be encouraged to stand firm and not give in to personal or political pressures to sabotage the community program to favor an individual.

In estimating a budget for such a program it is known that there will have to be a supervisory technical and administrative staff to guide and direct the technical program, to train personnel, and to insure that the programs of the various Operating Stations follow the bureau policies and standards. It is known that a technical and administrative staff will be required to conduct the program in each Operating Station. The budget for these staffs and their facilitation services and equipment can be calculated with reasonable accuracy.

It is known in advance that laborers, construction materials, seeds, fertilizers, trees, etc. will be required to carry out such a development program. Until each tract is examined and the plan for it made, even a rough estimate can not be made of the hectares, or other units, of each practice to be applied. The proportion of the budget needed for each of these categories will vary from tract to tract and from Operating Station to Operation Station due to the differences in the conditions encountered. Great flexibility must be permitted until, as the result of experience, a more accurate estimate can be made.

The Settlement of Farmers Along the Cross Island Highway

June 8, 1960

The settlement of more farmers in the area made accessible by the new East-West Highway is a laudable objective, whether these farmers be Retired Servicemen or other farmers who are without land on which to practice their trade. However, there are certain hazards and limitations that should be considered before such a project is undertaken. These are the natural, physical limitations rather than legal or political considerations.

In order for any such settlement project to achieve success, the conditions must be such that by good management and industrious application, most of the settlers can achieve at least a modest living. Other factors which should be considered are the effect of the new project upon other, already established undertakings. In the enthusiasm for the new project, these side effects are often overlooked or disregarded. As a result, a small gain in the new project may result in a large loss on other projects and hence, cause a net loss to the nation. This should not be overlooked.

Most of the soils in the high mountain area traversed by the East-West Highway are very shallow and infertile. Few of them would support cultivated crops and will carry only a very scant cover of native vegetation. To settle loyal citizens here with a promise of becoming farm owners would be to condemn them to failure and disappointment. This would be a disservice to them and to the agency which encouraged them to make such a hopeless attempt.

If the present vegetative cover is destroyed by opening the land for cultivation, the land would soon be abandoned and it would have no protection at all. Soil erosion would then become severe and not only further damage these thin lands but would cause erosion and siltation of highways and severe siltation of the Wusheh or Tachien dam reservoirs.

Thus, large scale settlement of the high mountain areas would not be a favor to the settlers but would cause them to waste their time and energy. As a result of opening up these unsuitable lands, the existing or planned reservoirs would be seriously damaged by increased siltation. No thinking person would want to be responsible for such a double tragedy.

On the other hand, there are a few areas here and there, which are suitable for cultivation or for grazing land use. Most of these have already been found and settled on by the aborigines. If other such lands are located, they will be marked out and plans will be made for their proper utilization.

There are more and better opportunities for settlement of more farmers at and below 1,000 meters elevation than in the high mountain areas. Even here land suitable for settlement is limited and most of it already occupied. Most of the suitable lands in public ownership have already been preempted by squatters whose farms were taken from them to make way for military camps, airfields, highways, factories or urban expansions. In spite of the public ownership and that they are classified for forestry use, these desperate people have moved in on them, cleared the forests, and are growing sweet potatoes, cassava, peanuts, sugar cane or other upland crops.

The physical characteristics of some of these lands are such that if they were protected by terraces and waterways, they would be suitable for continued cultivation. Mixed in with these lands which are suitable for cultivation there are other areas which are not suitable under any economically feasible treatment. These squatters realize that they have no legal tenure on the land and for this reason they are not willing to spend the time, money, or effort that they would be willing to spend to protect lands which they owned. Consequently these lands are suffering severly from soil erosion with the passage of each year. Along with the areas in these lands which could be developed and protected there are other areas which are suitable for only forestry and these should be reforested at once to prevent further damage and to reduce flood damages below.

Some public and a few private lands which have not been classified for agricultural or grazing use or which have not been opened, would be suitable for cultivation or for grazing if properly protected. These few potentially productive lands are intermixed with lands which are NOT suitable for agricultural uses and they usually occur in small separated tracts. Technically trained men should be used to search out and designate these lands and specify their use and the treatments needed to protect them. If such areas are opened to public settelment, promiscuous development will usually result in the clearing of lands suitable only for forestry. These lands will have to be reforested in a few years. In the meantime, the little fertile topsoil there will have been washed off of the hillsides and into the stream channels and reservoirs. Once farmers get settled on even the suitable lands, it is much more difficult to establish the benching, waterways and other practices that are required, as the farmers will claim damages to their crops.

There is a limited supply of men whose technical training and experience qualifies them to select the lands suitable for clearing and to prescribe the treatments that are needed to protect then under cultivation. The same men are also needed to direct the stabilization and protection of the already opened illegally occupied lands. If the ability of this small group is utilized first to develop new lands, the older, unprotected lands will continue to be damaged, some of them beyond repair. If the ability of this trained group is utilized first to protect the already opened lands, the now forested lands will not have been damaged appreciably because of the delay.

Therefore, for the sake of the total soil resources of the nation, it is desirable that first priority be given to the protection and stabilization of the lands which have already been opened and which are exposed to the hazard of soil erosion. The development of new lands could then be undertaken as rapidly as personnel is trained for that purpose.

In the fall of 1956, the Provincial Soil Conservation Technical Committee recommended a policy of permitting the present illegal occupiers to bench and otherwise protect suitable public lands which they were then cultivating. This recommendation was lost before being received by the Provincial Government. After being sent to the Governor thru other channels it has been studied and delayed by being referred to various committees. To date the result has been more conversation than conservation.

It is imperative that a start should be made at once to stabilize those public, as well as private lands, which, because of neglect and misuse are suffering severly from soil erosion. Experience in the Ah-kung-tien watershed indicates that many of the illegal occupiers would cooperate voluntarily in such a conservation program if they were given permission to do so and were given some technical guidance and a little encouragement.

Some, of course would do nothing until compelled to do so. Certainly those who would voluntarily protect the land should not be held back while ways and means are being devised to compel the recalcitrance to comply.

Determination of Soil Conservation Priorities

(Doing First Things First)

There are many things to be done in the wide field of soil conservation in Taiwan. Without calling them soil conservation, many of these things are being done by various agencies. Drainage and irrigation which have to do with the wise use and maximum production of land and the prevention of soil deterioration are, in the broadest use of the term, soil conservation. These activities are being carried on by the Provincial Water Conservancy Bureau and by the various Irrigation Associations.

Reforestation, forest management, and fire suppression are also forms of soil conservation since they prevent soil erosion and are concerned with the wise use of the land. The Taiwan Forestry Administration and the Forestry Sections of the various Hsien Governments are responsible for carrying out these practices.

The wise use and the greatest continued production from the rice paddies involves the maintenance of soil fertility, pest control, increase or at least maintenance of organic matter, and similar programs which are the responsibility of still other organizations.

It would be a futile duplication of effort leading to unwholesome rivalries, if the Soil Conservation Field Offices should try to take over these activities. The same is true regarding extension or educational activities. Wherever there is an extension organization that can and will handle the soil conservation educational work, it should be employed and assisted rather than ignored.

There is so much soil conservation work which no other organization is doing, that the Soil Conservation Field Offices had better concern themselves with these aspects of the total program rather than to compete with other agencies which are doing a good job in their respective spheres.

Even within the scope of the work which is to be done by the Soil Conservation Field Offices, all of it cannot be done at once. Consideration must be given to the priorities of the various jobs. In the field of soil conservation operations, many things are possible. However, many of the things which it is possible to do are not economically feasible. Of those things which are feasible and even desirable, some deserve only a low priority. This matter of priority deserve some careful study.

If a man's house catches fire, he would like to save all of his belongings. If there is time, he will carry them all to safety. But, if there is time for him to carry out only one or two armloads, what should he save first? This is a problem in priority. Among all of his possesions having intrinsic or sentimental values, which should he take in that single trip to safety? Sometimes he will be faced with the unhappy choice between the protrait of his ancestors and items such as money, jewelry, valuable papers which have high intrinsic value with little weight or bulk. In any event, I am sure that it would be an indication of a very excited and thoughtless state of mind if he used the only trip possible before the roof fell in, to bring out an old kitchen table with a broken leg. Maybe such a table would be worth saving if all of the items of greater value had been saved ahead of it. This ridiculous example serves to illustrate the problem of doing first things first.

Personnel, travel and per diem funds, equipment, and other facilities for conducting the soil conservation program are limited. Only so many man days or other units of work can be done each year. One of the problems which project management must decide is, "On what jobs should these available facilities be employed first?" There are a great number of permissible and even meritorious activities, but which should have the highest priority?

In the event of some great catastrophe such as a fire, train wreck, flood or tornado, a doctor has to set up priorities on his service. In order to save human lives he must delay taeatment of several who are only slightly injured in order to treat one badly injured patient who will die unless given elaborate treatment immediately. This choice is justified because, to reverse the order would mean that it would be too late to do the badly injured one any good at all.

This illustration is not applicable to priorities in dealing with soil erosion damages. In our dealing with soil conservation we install practices not for the benefit of the soil itself, but for the benefit of the people who are dependent on the soil for their livelihood and continued existence. It is the productivity of the soil in the entire community that must be considered ahead of the soil on any one tract. That changes the emphasis or order of priority.

The benefits to be derived should always equal or exceed the cost of any operation or investment. Otherwise the project is not feasible. Secondary or indirect values, either damages or benefits, must be considered along with the primary values, in determining the priority of a proposal. In some cases it is justifiable and even necessary, to spend more for the conservation of a certain tract than that tract ltself is, or ever can be, worth for production. This is justified, for instance, when a gully is encroaching on a home, a factory, or some other valuable installation whose value must be considered along with that of the land actually being treated. Likewise, gully control or sabo work is economically justifiable on apparently worthless land if it is in the watershed of an important reservoir. This is justified as a "stop-loss" operation to prevent siltation of the reservoir.

This protection of reservoirs from siltation is an important consideration in determining soil conservation priorit. Consideration must be given to not only the cost of construction of the present reservoir dam and the power plant or outlet wooks but to the cost of replacement on a less favorable site. Ordinarily the most favorable, most efficient sites are utilized first so that subsequent installations will be more expensive or less efficient. Another aspect that should be evaluated is the economic effect on the community if the reservoir should become inoperative as the result of siltation.

All soil conservation operations should not be confined to the watersheds of reservoirs but, because of the heavy investment in the reservoir and of the economic dependence of the commuinty on its continued operation, such watershed activities should certainly be given high priority.

There is an old saying in America that "The wheel that squeaks loudest gets the grease" and I wouldnt be suppised if you had a similar addage in the Chinese classics.

This idea probably accounts for the tendency for the first soil conservation operations by a newly established Soil Conservation Field Office to be undertaken on some of the steepest, most badly eroded and least valuable land in the community. The owners or neighbors of this land will naturally be most active in seeking help to reclaim it. The plea is usually made that, by demonstrating that this almost hopeless site can be reclaimed, all others will be assured that their better lands can be helped. Such an argument will not stand the scrutiny of serious study and thought. Is not the following philosophy productive of better returns on the investment?

The problem is that there are available for investment, a limited number of man days of technical help and a limited amount of equipment. How can this be best employed to protect or increase the productive capacity of the lands of the community There will always be more work than can be done with the available facilities. Someone must choose which should be done first—set up priorities.

One of the most important considerations in undertaking any cooperative soil conservation program, is the interest of the farmers and their willingness to cooperate by doing what is within their power and ability to do. Without this priceless ingredient, the program degenerates into a futile argument between the technician who sees what is happening and what is needed to correct the situation and the farmers who fail to see the entire picture but who resist taking any part in the overall operation which is for their benefit. This results in a frustrating situation in which little is accomplished.

Without in any way discouraging the owners of the severely eroded areas from requesting help where a great deal of effort on their part and on the part of the technicians will be required to produce only mediocre results, some effort should be made to encourage the owners of better lands to make application for assistance where a little effort will produce maximum results for them and for the community as a whole.

This may smack of "politics" or "stage setting" but by whatever name it is designated, it will result in more return from the investment. Sometimes a choice is possible between utilizing the time and efforts of the Soil Conservation Field Office to provide adequate conservation protection to 100 hectares of good land which is not yet severely eroded or to use that same effort to reclaim 5 hectares of land which is practically destroyed. Even after stabilization, this land will be of only moderate productivity. Which of these two extreme choices will be of the most benefit to the community? Which is the best justification for the continuance of the soil conservation program?

The owner of the badly depleted land will almost always be the most insistent on starting on his land first. He may offer, and actually provide, all of the help that he possibly can. But after he has done this and an acceptable job has been completed, how does this benefit compare with what could have been accomplished by the application of the same facilities to the protection of many more hectares of better land?

Someone, either the present or previous users of this land had employed too intensive a land use without adequate conservation measures. This resulted in the present state of destruction. While the destruction of the good lands may not have proceeded as fast due to less natural hazards or the use of better conservation measures, the end result will probably be the same. As long as both types of farmers are willing to cooperate with the technicians in applying the needed practices, which type of effort will result in the most benefit to the entire community?

The extension or educational phase of the soil conservation program should not be confined to describing the damages and losses due to erosion and to illustrating the different practices that are applicable in the community. It should also develop the farmer's thinking on doing first things first.

The soil cosnervation program is dependent upon voluntary cooperation on the part of the farm owners and operators. Therefore, if the operators of the best lands, which require only a minimum of soil conservation practices to protect them from erosion, should choose to not participate in the program, there is no alternative but to work with the operators of the next best lands. Priority should be set up in order of the results that can be accomplished with the facilities available, not upon the basis of which wheel squeaks the loudest.

Organization, Subsidy and Protecting Public Land*

1. Eleven SCFO have been established in Taiwan. They are located in Hsinchu, Hualien, Kaohsiung, Miaoli, Nantou, Taipei, Taitung and Taoyuan Hsiens, Shihmen watershed, Taichung City District and Min-hsiung Hsiang of Chaiyi Hsien. PWCB acted as administering agency in the establishment of those at Kaohsiung, Hsinchu and Taipei Hsiens and PDAF established the one in Nantou Hsien. After one year of operation, the Kaohsiung, SCFO was handed over to the Hsien Gov't for local administration. The one at Hsinchu is now ready to be handed over and those at Taipei and Nantou Hsiens will be put under local administration as soon as Hsien personnel are ready to assume the responsibility.

Thus far the establishment of SCFOs has not followed any definite proceedure. This matter is being called to your attention at this time so that this committee can recommend a policy to guide the further expansion of the soil conservation in Taiwan. As a basis for discussion, it is proposed that when any community (Hsien, Hsiang, or City) wishes to start soil conservation work, they be requested to first set up a Soil Conservation Advisory Committee consisting of representatives from the Hsien and Hsiang Public Offices, PPA, FA, PDAF, TFA, PWCB, Irrigation Associations, Agricultural Improvement Stations and any other agencies or commercial groups which are primarily agricultural in function. If such a committee agrees that there is need for soil conservation work to be done and that the farmers are sufficiently interested, they may request PDAF to establish a SCFO. In deciding upon such action, consideration should be given to the available personnel, quarters, equipment and budgetary support.

Within the watershed of any reservoir that is threatened with rapid siltation, any agency such as PWCB, TPC or TSC that is especially interested in the protection of that reservoir, should be encouraged to establish and maintain a watershed SCFO to intensify the application of soil conservation and siltation retarding practices in that watershed. It is contemplated that such Watershed SCFOs will work within their watersheds and that the Hsien SCFO will continue to be responsible for the application of the Soil Conservation Program in all other parts of the Hsien, altho they may also work in the watershed if the need arises. The closest technical cooperation and consultation will be maintained between the Hsien SCFO and the Watershed SCFO. Each will arrange for its own personnel and equipment and will disburse its own budget.

2. The PDAF soil conservation budget for each year contains an item for subsidizing the construction of bench terraces. Prior to 1958 the funds for this item were sufficient to pay a subsidy of NT$1,000 per hectare for all of the benches which were built up to specifications. It now appears that the number of hectares of acceptable benches which will be constructed in 1958 will exceed the funds available for paying the subsidy at this rate. With the increasing interest and growth of the soil conservation program, in future years the funds available will certainly not be adequate. Therefore, we need to consider recommendations of a policy for the disbursement of the funds that are made available for this purpose. In such a way that the greatest good will accrue to the nation. Some possible solutions are:—

a. Request that more funds be made available. With the strained condition of the Provincial Budget, this is unlikely to be done.

b. Reduce the amount of subsidy per hectare to spread the funds available over all of the acceptable benches. Carried to its logical conclusion, this would require that

* Suggestive memo to members of Provincial soil Conservation Technical Committee

all benches be completed, inspected and approved before the rate of payment could be calculated and announced. This uncertainty of the rate of payment would make the administration of such a program difficult and confusing.

c. Another equally unsatisfactory solution would be to set up goals or quotas for each Hsien or subdivision at an announced rate of subsidy, dependent on funds available. Payment would then be made at this rate to the first benches completed and accepted each fiscal year. Whether deserved or not, criticism would be heaped on the inspecting technicians for giving priority to certain individuals.

d. Payments of benching subsidies could be confined to the watersheds of reservoirs. This would cause some complaint by those outside the watersheds but such a policy could be defended on the basis that these public funds should be used first to encourage benching that would protect the life of the reservoirs in which the public has already made a substantial investment and upon which many other farmers are dependent for irrigation water.

Other suggestions for solving this problem will be welcomed.

3. After the promulgation by the Provincial Government of the Land Use Policy which this committee has recommended to the Governor, many farmers can be expected to cooperate voluntarily but there will be some who will not. In anticipation of this condition, consideration should be given to means of putting pressure on these nonconformists. Publicity, education, persuasion and assistance should be used to get as much voluntary cooperation as possible. But there are usually some selfish, obstinate people who will not willingly do their share.

After the program has been promulgated and publicized, and after the facilities for encouraging and assisting the voluntary cooperators have been set up, policy might be announced under which all illegally occupied, sloping cultivated lands which had not been given adequate protection within a period of possibly one year after the date of the announcement of the policy, woild be recalled by the government for protection practices.

RETSER has been anxious to find worthwhile employment for their men. Both benching and reforestation are types of work which these men could do with a minimum of supervision. Land which is suitable for benching could be benched and leased or given to the RTESER to farm. Land not suitable for benching could be protected by vegetation, either trees or grass, depending on the local needs for forage or for fuel and upon the characteristics of those soils.

This taking away of land from farmers migh cause some hardship and resentment. However, if after being given an opportunity to protect the land from erosion, the present occupiers can not, will not, or for any reason, do not do so, the future of the nation demands that someone who can and will be given an opportuntiy to protect the land. Such a complex question will not be settled at the first meeting but a wide public discussion of the matter might serve to spur some hesitant farmers to take action.

The Development of the Soil Conservation Program in Taiwan

September 1959

This report is prepared particularly for the records of the Joint Commission on Rural Reconstruction as a more or less chronological history of the problems that have arisen during the development of the Soil Conservation Program in Taiwan and of some of the means employed to solve them.

Before my arrival in August 1954 to be JCRR Soil Conservation Adviser, two significant steps had been taken. A soil conservation reconnaissance survey had been made of the watershed of the Wusheh reservoir and a soil conservation demonstration area had been established on Tatu mountain above the town of Chingshui.

This first Chingshui Demonstration Area consisted of water retention and water spreading structures, some revegetation, some contour planting and some partial bench terracing. These practices resulted in the decrease of erosion in the watercourses below and they were convincing enough that the four hsiangs (Chingshui, Salu, Longchien and Tatu) immediately below, requested PDAF and JCRR to establish a demonstration area covering their entire townships.

In response to this request the first Soil Conservation Field Office in Taiwan was established in the spring of 1955 at Chingshui. Representatives of the hsien government, of these four hsiangs, of the Farmer's Association, the Irrigation Association and the Peoples Political Council formed the Tatu Mountain Soil Conservation Advisory Committee but the Field Office was administered directly by the Land Use Division of the Provincial Department of Agriculture and Forestry.

One small watershed in each township was designated by the local officials as a pilot or demonstration area. Work was first started on the watershed of a very actively eroding gully above the town of Chingshui. This watershed was approximately 15 hectares in area and extended up to the village of Chiao Tou Liao (橋頭寮), The chief of this village took an active part in organizing and encouraging the farmers to participate in the demonstration program. The Li chief from Hsi Shih Li (西勢里), who had been active in the first Chingshui Demonstration Area, was also very helpful in spreading the ideas of erosion control.

As a result of their efforts and several meetings conducted by the technicians in the Soil Conservation Field Office, most of the farmers in the watershed agreed to have their land treated. The slopes on the upper part of the demonstration area were very gentle and the soils were deep. Surveys were made to see how broad based terraces would fit into the local system of farming. The land here is owned and operated in small units so that if broad based terraces were constructed, each terrace would cross numerous individual tracts. With each farmer wanting to farm his tract to whatever crop that the weather and seasonal moisture favored, it would be difficult to maintain a free flowing drainage channel or a terrace ridge of adequate height. The matter of establishing and maintaining an adequately protected waterway on the steep lower part of the hill also loomed as a difficult and expensive undertaking.

After considering these deterrents and after making some simple percolation tests of both wet and dry soil, it seemed wiser to build level bench type terraces with no outlets. Dr. G. B. Bodman, Professor of Soils at the University of California was in Taiwan assisting the National Taiwan University at the time. After examining the site, he concurred in this decision.

In order to complete the bench construction more quickly, JCRR loaned to the project a D-2 Caterpillar tractor with a bulldozer blade. Although a larger tractor would have been faster and more economical, the little D-2 worked satisfactorily. Operations started at the top of the watershed and each farmer's fields were bench terraced as the work proceeded down the slope. Approximately seven hectares were benched and a ridge 20cm high was built around each bench.

The owners of several patches of sugar cane and miscanthus grass did not want to disturb them. There were also some village areas and some road surfaces that were not benched. Approximately 90 percent of the watershed area above a large gully head was benched. Since the spring of 1956 when this benching was completed, this gully head has made but little progress up the slope. This indicates that although the entire area was not treated, the runoff was materially reduced.

During a 24 hour period September 3-4 1956, 400mm of rainfall was reported at Taichung. An examination of the benched area three days later revealed that most of the benches had held all of the water that fell on them. A few were broken as the result of careless plowing during which the dikes surrounding these benches had been knocked down. Where this occurred, the water from several benches accumulated on a lower one and sometimes caused overtopping of the dikes. However, even with the careless handling, less than 5 percent of the benches failed to hold all of the water during this storm.

There had been some apprehension that holding all of the water would result in drowning the crops. An examination the third day after the storm showed on evidence of water damage. In fact, the crops on the benched land looked better than those on sloping lands nearby. It could not be determined whether this improvement was the result of extra soil moisture stored in the subsoil or because of loosening the soil to a greater depth during the bench construction. Whatever the cause, the results were good and the farmers were more than satisfied with their crop yields on the benched area.

In the spring of 1957 the Provincial Government announced the construction of the Kung Kwan Airfield on Tatu Mountain. This did not effect the demonstration area but the Taiwan Sugar Company also announced that it was taking over all of the cultivated land on the mountain not taken by the airfield. Rather than staying there and compete with the Sugar Company, it was decided to move the Field Office to Tsaotun and Nantou Hsien was declared to be the work area.

Some preliminary surveying had been done on the pilot watersheds in the other three hsiangs but no construction work was started.

Ah-kung-tien Watershed

The Ah-kung-tien Reservoir in Kaohsiung Hsien was completed in 1953. Sedimentation surveys soon showed that it was being silted up at an alarming rate. At one place as much as 8 meters of silt was deposited. The Ah-kung-tien Soil Conservation Committee with the Hsien Magistrate as convenor and all interested agencies participating, called several meetings to discuss ways and means of protecting this reservoir and prolonging its useful life. They drafted a plan which called for the reforestation of all lands in the watershed with slopes steeper than 5 degrees.

Most of the land in this watershed had belonged to two Japanese companies. After the restoration of Taiwan to China, the land of one of these companies was given to the Kaohsiung Hsien Government and that of the other was taken over by the Taiwan Forest Administration. There was some paddy land in the area which was privately owned. Approximately 1,000 hectares of sloping public land was being illegally cultivated by farmers who were simply squatters. There was a brown sugar mill whose raw materials were produced entirely within the Ah-kung-tien watershed. This mill earned considerable foreign exchange by exporting brown sugar to Japan every year.

When the plan of the Ah-kung-tien Soil Conservation Committee to reforest all of this public land with slopes greater than 5 degrees became known there was violent opposition by the effected farmers and by the sugar mill operators whose raw materials area would be practically all reforested. At this stage of the proceedings the JCRR Soil Conservation Adviser was invited to participate in the committee meetings.

There were two conflicting points of view. On the one hand the Ah-kung-tien Reservoir must, at all costs, be protected from siltation. On the other was the consideration of the squatting farmers and the sugar mill's interests. Both viewpoints needed to be considered. There was no other place or any better place for the farmers to go to earn their living. The foreign exchange that the Ponlai Brown Sugar Mill earned was a valuable asset to the economy of the nation.

A plan was worked out which would reconcile these two viewpoints. This plan was proposed to the Committee and, after considerable debate was approved for implementation. However, some of the Committee members who opposed its adoption, continued to oppose it and obstruct its operation where and when they could.

The essence of the plan was that each occupant, although illegal, could, if he wished, apply to the local land office of the Hsien or Hsiang, for permission to bench whatever portions of the land he was then cultivating that he considered to be worth benching. Each tract would then be inspected by representatives of the Committee to determine whether it was suitable for benching. If it was approved, permission would be given to the farmer who could then proceed to construct benches and waterways. After completion, the work would be inspected by technicians from the SCFO. If the benches and waterways met the PDAF specifications, the farmer would be given a legal lease on the benches area and would become a legal, rent paying tenant.

The philosophy behind this proposal was that, in spite of the fact that the occupants had no legal claim to tenure on the land, there was no better place available for them to go to make their living. Therefore, from a humanitarian and economic viewpoint they could not be dispossessed. The political pressure that they could apply to the township and hsien governments also gave the matter an ominous political significance. Added to this consideration of the farmers and their livelihood was the economic consideration of the foreign exchange being earned by the Ponlai Brown Sugar Mill.

Prolonging the useful life of the reservoir demanded immediate application of measures that would reduce the rate of siltation. There was no question but that a good forest canopy with a good forest litter would provide the needed protection. However, a minimum of 5 to 10 years would be required with a good survival rate, to establish this cover to the extent that it would furnish adequate protection.

An area that is bench terraced and provided with protected outlets will at once control the silt that has previously been coming from that area. It was not contemplated that all of the watershed would, or even should, be benched. It was advocated that all cultivated land should be either benched or reforested, thus effecting protection against siltation by one method or the other. It was considered to be more democratic procedure to allow each farmer to decide which method should be applied to the land he was concerned with. This permitted quicker protection to the land and at the same time gave humane and economic consideration to the people.

Although this proposal was made in November 1955, the meeting to consider it was not called until February 1, 1956. After the proposal was approved over the opposition of some members, they insisted on setting February 10 as the deadline, after which no more applications would be received. This allowed only 10 days in which to publicize the program and get the farmers to file their applications. In the meantime TFA planting crews were racing to get Acacia seeds planted in the recently harvested sugarcane fields before the farmers could start benching them. In their haste to beat the farmers to the job the TFA crews raked and burned what vegetative litter there was, thus destroying the little deterrent there was against erosion.

After the farmers application were received, the technical subcommittee inspected the designated tracts and approved most of them. A few were judged too steep or the soils were too shallow or stony so they were disapproved. As a result 40 hectares of benches were built and approved in the 1956 season.

Since it would be advantageous to the farmers to start their benching work earlier in the winter when the weather was cooler and when their other field work was not so pressing, it was requested that meetings be held in the fall of 1956 to discuss the benching to be done in the winter of 1956-1957. The same obstructionist tactics were employed to delay the consideration of the program but 29 days were allowed for filing applications this year. Approval on application was delayed and in at least one instance, TFA directed the police to arrest one farmer who started construction before his permission was formally chopped. There was no question as to whether or not this particular field was suitable for benching. The director of the Kaohsiung District TFA Office visited this field with JCRR representatives and agreed that the field was quite suitable for benching.

A Soil Conservation Field Office was set up at Kangshan in Kaohsiung Hsien to work in the Ah-kung-tien watershed. Since the Provincial Water Conservancy Bureau was responsible for the maintenance of the reservoir, they administered the SCFO. A small demonstration area was set up near Tien Liao village but a poor coöperator was selected and the SCFO had to do most of the work and even after completion this farmer did very little in the way of maintenance so the demonstration has not been considered a success.

In August 1956, PWCB established another Soil Conservation Field Office at Hsinchu to work on the watershed of the Tapu Reservoir which had just been authorized. When they did this they transferred away the two most experienced men from Kangshan to Hsinchu and at the same time handed over the administration of the Kangshan SCFO to the Kaohsiung Hsien Government, only one experienced man remained there and he was immediately drafted into the armed services. This left the Kangshan SCFO with no experienced personnel and under the administration of hsien officials who had no experience in conducting a soil conservation program. The quantity and quality of the work done there in 1957 were very disappointing.

In 1958 the SCFO was moved to Fengshan, the seat of the hsien government and the work area was enlarged to include all of Kaohsiung Hsien. A Kaohsiung Hsien technician who had attended the 1957 Soil Conservation Training School was put in charge and the quality and quantity of the work improved materially and has since been satisfactory. However with their efforts scattered over the entire hsien. The amount of work done in the Ah-kung-tien watershed decreased markedly.

A 1959 resurvey of the reservoir indicated that almost one million cubic meters of debris was being deposited annually. PWCB then asked for the establishment of another SCFO at the Ah-kung-tien dam site to concentrate its efforts solely on the watershed of the reservoir.

Other SCFOs Established

The Taichung City District had some soil erosion problems on their sloping farm land and proceeded very logically by sending one of their men to the Soil Conservation Training School and in November 1955 established a SCFO. This was the first of the SCFOs to be established without direct administration by either PDAF or PWCB. On a small budget contributed by the City Government, PDAF and JCRR, this SCFO has consistently done good, though not spectacular, job of establishing soil conservation practices.

In 1957, following the first expanded Soil Conservation Training School, SCFOs were established in Taitung, Miaoli and Taipei hsiens and in Minhsiung Hsiang of Chiayi Hsien. In the latter case the hsien government was not yet interested but this particular hsiang had a problem with which they wanted help. They too, sent one of their employees to the training school and followed up by establishing a SCFO to work in just that one hsiang. The following year the hsien government apparently decided that they had better keep ahead of the crowd if they were to be the leaders so the work area was expanded again to include all of Chiayi Hsien.

Shihmen Reservoir Watershed

In the summer of 1958 Taoyuan and Hualien Hsiens established SCFOs, Taichung Hsien that fall, and Penghu and Tainan Hsiens in 1959.

During the planning stages of the Shihmen Reservoir a great deal was said about establishing soil conservation measures in the watershed and numerous meetings were held. All of the administrators were in favor of soil conservation but the discussions revealed that to some of them, soil conservation meant simply reforestation and nothing more. In order to demonstrate to them a more complete soil conservation program that was suitable for that area, a small project was set up in August 1956 to build one set of bench terraces in an existing orange grove, one set on some abandoned cultivated land and a third set of benches with appropriate structural outlet control for some vegetable gardens at the edge of Fu Shing Village.

Following this a SCFO was authorized to be located at Fu Shing Village and to be administered by the Shihmen Local Development Committee. JCRR financed the construction of a permanent building for PDAF to be used as office and dormitory for the SCFO during the construction period and to be made available for an agricultural extension headquarters in the following maintenance period.

Funds for the budget of this SCFO were contributed by PDAF, JCRR and the Shihmen Development Commission. Technicians were contributed by PDAF, Land Bureau, Shihmen Development Commission and the Taoyuan Hsien Government. With a generous budget and a big staff, this SCFO has accomplished a large quantity of good work. They, more than any other SCFO, have emphasized the establishment of soil conservation practices in old, established, tea plantations.

SCFOs for Watersheds

PWCB is responsible for the maintenance as well as the construction of the major reservoirs in Taiwan. In order to push harder on the establishment of soil conservation practices in the watersheds of these reservoirs, both before and after their construction, PWCB established SCFOs on a watershed basis not only on the Ah-kung-tien but also on the Tapu and Tungshan reservoirs. They will retain the administration of the Ah-kung-tien SCFO and that of the Tapu SCFO at least for the next year. After the Tungshan SCFO was set up in Tainan Hsien, the location of the reservoir was changed to an adjacent valley so the SCFO worked there instead. This SCFO will be merged with the recently established Tainan Hsien SCFO and administered by the Tainan Hsien Government.

Taiwan Provincial Soil Conservation Technical Committee

In 1954 a Soil Conservation Technical Committee was organized with the PDAF Commissioner as its convenor. Its members were representatives of PDAF, TFA, TARI, TFRI, NTU, PWCB, JCRR, Land Bureau and MOEA.

One of the first matters upon which it deliberated was the priority of watersheds to be considered for soil conservation protection work. It established the following priority, Ah-kung-tien, Shihmen, Tachien.

After the benching of the public lands by the occupying farmers was started in Ah-kung-tien watershed, a similar program was proposed to this Committee for application to all of the sloping cultivated public lands. After considerable discussion and several subcommittee meetings a recommendation was approved by the committee and was prepared to be sent to the Provincial Government in October 1956. The substance of this recommendation was that any farmer who was cultivating public forest land without legal lease could apply to the local land office for permission to bench terrace as much of the land he had been cultivating as he thought would be profitable to him. These tracts would then be examined by technicians from the SCFO to ascertain their suitability. If approved, the farmer could do the construction work with the technical assistance of the SCFO which would also inspect the finished work. If the work was satisfactory, the land would be reclassified by the Land Bureau from Forestry to Agricultural use and the farmer would be given a lease on the land which he had benched. This program was recommended for only Kaohsiung, Hsinchu and Nantou Hsiens since those were the only SCFOs at that time.

After waiting for almost a year for approval or disapproval by the Provincial Government, an inquiry was made. This revealed that the Provincial Government had never received the document which had been either lost or sidetracked somewhere in the bureaucratic maze.

The subject was written up as an article which the Chairman of JCRR sent to the Provincial Governor. Shortly after this the Governor sent the matter to PDAF for study and recommendation. This brought it up to the same Soil Conservation Technical Committee that had passed upon it over a year previously. After more discussion it was again approved and passed on but was delayed by being "studied" (or stalled) by several Provincial Agencies. Finally, after a few minor amendments, it was reported to have been again returned to the Provincial Government for action. As of September 30, 1959 no report had been made of the action by the Government.

Ever since 1954 and perhaps before, the PDAF soil conservation budget had included an item to pay subsidies to farmers for the construction of bench terraces. A policy was established to pay a subsidy of NT$ 1,000 per hectare for bench terraces that met PDAF specifications. At first, this provided an extra incentive which resulted in the construction of additional terraces and it was an assistance to the program. After more SCFOs were established, the amount of money for this purpose had to be distributed among more and mose hsiens. The result was that by 1957 most hsiens had an allotment for only 20 hectares of benches per year.

The program was gaining more in publicity and farmer acceptance so that in each hsien, more benches were constructed that they had funds to subsidize. This NT$1,000 was not nearly the entire cost of construction which varied from NT$3,000 to NT$ 10,000 depending on the soil and slope of the land, the width of benches and the amount of stones or stumps encountered. This subject was presented to the Technical Committee in the fall of 1957 with the suggestion that subsidies were no longer necessary as the program was not well accepted and that, since the funds were inadequate for this purpose, they should be applied for some other purpose. The Technical Committee would not make any recommendation so the program was carried over into 1958 when the terrace construction again far exceeded the subsidy funds available.

In 1959 the situation was entirely out of hand so they finally agreed that the subsidy should be discontinued and that, where it seemed necessary, the SCFO should hire animal and labor to build one or two benches free as a demonstration rather than paying the farmer cash.

Another matter of policy which the Technical Committee should act upon but which they have not, is the matter of concentrating all of the efforts of a SCFO on a small watershed or scattering their work over the entire hsien. For the purpose of a demonstration of the effect of the soil conservation practices on the runoff, a concentrated approach is necessary. On the other hand, if the major purpose is to get more farmers to doing work on their own farms, there is much to be said for scattering the work. Not only are more people able to see the scattered jobs but, by working with those farmers who are willing and eager to cooperate, much time can be saved that would have to be spent convincing or cajoling uninformed and unwilling participants in the program. Most of the SCFOs are working with those farmers who request assistance, regardless of their location.

Research Activities

Before the Soil Conservation Advisor arrived, projects had been drawn up for the construction of runoff plots and catchment tanks to measure the soil and water losses from 7 different methods of growing tea. There were plans made for plots to be built of two degrees of slope at each of three Tea Experiment Stations, Yuchih, Pingchen, and Linkou. These plots were established with some minor changes in the equipment for measuring the runoff.

At the end of the first year it was found that some of the stations had arbitrarily changed the treatment so that the results could not be compared. All three supervisors were gotten together for an inspection trip and since then the treatments have been more comparable.

The outstanding results to date have been that plots mulched with straw lost no more soil or water than the benched plots and that other treatment were intermediate between these treatments and the check plots. On the Pingchen Station it was found that the plots on the steeper set of plots were yielding less runoff than those on the gentler slope. The explanation apparently lay in the different rates of permeability of the soils in the two sets of plots.

At the Fengshan Tropical Horticulture Experiment Station, fifteen soil and water runoff plots for pineapple were constructed. There are five treatments which were repeated at one year intervals for three years. The Taiwan Sugar Corporation set up similar plots near Taitung on the east coast. Here they compared the soil and water losses from sugar cane and from pineapples grown by three different treatments.

The preliminary results at each set of plots indicate that close planting of pineapples in contour rows with straw mulching between the rows is just as effective in controlling soil and water looses as bench terracing.

The Taiwan Forest Research Institute has also run some runoff plots on five different slopes at the Chungpu Station since 1951. Since the plots' treatments and the crops grown are different than those mentioned before, the results are not comparable.

Soil Conservation Training Activities

Beginning in 1953 soil conservation training classes were conducted. Mr. Emile C. H. Hsia represented JCRR in that year when the class was sponsored by the Taichung College of Agriculture. In 1955 and in 1956 the classes were conducted by PDAF in Taipei and consisted of a week of lectures by various specialists, followed by two weeks of touring by bus to observe erosion conditions and conservation practices which had been applied. These classes usually consisted of from 50 to 60 men from the Provincial, Hsien or Hsiang governments and agriculture organizations.

These classes aroused an interest in soil conservation but in such a short period they could not adequately prepare the trainees to undertake a soil conservation program in their home localities. It was determined to expand the course by including more subject matter interspersed with considerable field practice of all subjects. The first expanded class contained only 14 men and lasted for 10 weeks in the spring of 1957. It was conducted at Tsaotun in the upper floor of the Farmers Association's building which they were good enough to let us use. The trainees lived in a dingy dormitory and ate as best they could but the results were good. Of those 14 trainees, one was drafted into the army and one was appointed 4H club leader but the other 12 were employed either in SCFOs or on Agricultural Stations from which they could disseminate the information and skills which they had acquired.

In FY58 JCRR financed the building of a Training Center for PDAF at Tsaotun. This has been used primarily for soil conservation training classes but is available and has been used for other training work. This training center consists of 4 buildings. The lecture room will accomodate 60 to 70 people by crowding a little bit. The dormitory has 6 rooms, each containing 4 double deck bunks. The office building contains 5 single dormitory rooms and a storage room in addition to a commodious office which has been used by the Nantou Hsien SCFO, the fourth building contains the dining room, kitchen, wash rooms, and toilets. The Center is located on the east edge of Tsaotun.

In mid April 1958, a class for 42 men was started which lasted eight weeks. Starting so late, the class encountered hot weather and seasonal rains before it was completed. Consequently, the 1959 class was started the first of March and completed before May when the weather was more favorable.

The course in these expanded classes includes all of the major items that are applicable to soil conservation in Taiwan. Instructors are secured from the National Taiwan University, Provincial College of Agriculture, Taiwan Sugar Corp., and specialists from various governmental agencies and JCRR. In so far it has been possible to do so, complete lectures have been printed and distributed to each trainee AFTER the lecture was delivered. This procedure gives the student a permanent reference source for reviewing the subjects at some later date. It also provides a handbook which can be used for other instruction on other occasions.

The 1958 class consisted of 42 men, 11 of which were from the RETSER organization. The 1959 class had but 30 men which is a better size for conducting field work. A one week lecture course was also given to the 18 college graduates who were employed in the various SCFOs. PDAF intends to make this Soil Conservation Training School a regular annual event, starting in March if at all possible.

When the Soil Conservation Preparatory Administration is set up it will probably occupy the office building of the training center and the Nantou Hsien SCFO will be established at Puli. However, the facilities of the training center will be kept intact and available for whatever training needs that may arise.

Soil Conservation Organization in PDAF

A soil conservation section was established within the Land Use Division of PDAF in October of 1954. This has consisted of but 3 or 4 technicians and administrative assistants, two of which were in the training class of 1957 and have since been assigned to SCFOs to help new crews get started in doing soil conservation work in the field.

In earlier discussions relating to the form of organization that should be eventually used for the soil conservation work, the PDAF Commissioner favored the maximum use of Hsien and Hsiang personnel with only supervisory or inspection control by the central organization. With this in mind, an organizational scheme has been worked out which will consist, eventually, of a Soil Conservation Administration Chief with perhaps five subject matter specialists in the central office, supported, of course, by the necessary clerical and administrative staff. The plan is to eventually have two conservationists from the SCA stationed in each SCFO, one to be an engineer and one an agriculturist, either agronomist or forester. Only a few engineers are available at present but more will be recruited as rapidly as possible.

These conservationists will work with the SCFO staff, under the administrative directions of the SCFO Chief who will be designated by the Hsien Magistrate. However, they will serve the SCA as field inspectors or coordinators to check the field work against Technical Standards which will be prepared and distributed. They will also be responsible for the operation and maintenance of the SCA vehicles assigned to them to facilitate the field operations.

Where cars have been loaned or assigned to hsien governments and the hsiens have been requested to pay the operating expenses, there has been a definite tendency for the higher hsien officials to requisition these official cars for their personal use and convenience. It is to avoid such a situation that SCA will assign its vehicles to its own SCA technicians and will pay the operating expenses from the central SCA budget. Thus by paying the salaries and per diem expenses of the SCA personnel and the vehicle operation expenses all from the central SCA budget, a tighter control can be exercised over the technical program than if the funds and the equipment were handed over to the hsiens for administration.

On the other hand there are certain functions which can and should be administered by the local hsien officials. These are the administrative functions which have the greatest effect on public relations. The SCFO Chief, responsible directly to the elected hsien magistrate, is in a better position to determine the priority of the farms to be worked upon. He is also better qualified to fire laborers and draught animals, to buy brick, cement and other materials or supplies and to disburse the SCFO budget. The responsibility of the SCA conservationist will be confined to the operation of the SCA vehicles and to checking the technical excellence of the soil conservation program. In all other respects the SCFO Chief will be responsible.

The funds for the budgets of the SCFOs are contributed by the Hsien Government in so far as possible, with support from PDAF and from JCRR. Since the per diem and travel expenses of the SCA personnel are paid by SCA, the hsiens are requested to contribute their own funds for the per diem and travel of the hsien personnel on the SCFO staff. In the past JCRR has provided most of the funds for per diem in the SCFO budgets. There has developed what appears to be a tendency for too many higher officials to make trips to the field or to Taipei or elsewhere, ostensibly on official business and charge them against this SCFO per diem item. It is hoped that when they are supplying the funds locally, there will be less tendency to do this.

JCRR will continue to contribute to this per diem item where it is necessary because of limited local budgets, but in these cases the names of those individuals who may draw per diem will be listed in the project agreements.

The hsien contributions to the SCFO budgets has varied from nothing during the first year of operation to as much as NT $60,000 or NT$70,000 in some hsiens this year. Some of the less populous hsiens have very restricted resources and it will be necessary to assist them materially for many years. Other hsiens are better financed and can be expected to carry an even greater share of the SCFO budget. This is a matter of gradual growth which is being given attention as the budgets are prepared from year to year.

Soil Conservation in the Shihmen Watershed*

November 1, 1956

I have thought and talked a great deal about the soil conservation problems in the Shihmen Watershed. The following is my summary, presented to you for your consideration.

The construction of the dam has been approved. Before it is built, a soil conservation program in the watershed should be started. The purpose of this program should be to prolong the useful life of the reservoir by retarding siltation.

Reforestation and the care of forested lands will surely be the most extensive practices in such a program. However, there are more than 900 aboriginie families who make their living on some 4,600 hectares of cultivated land within the watershed. Of this, 1,000 hectares is paddy which is not subject to erosion. There are about 500 hectares of tea gardens within the watershed. The rest is used for non-irrigated crops such as sweet potatoes, cassava, vegetables and citrus.

It has been suggested that these farmers be moved out of the watershed. This is not feasible because there are no suitable lands to which to move them. With proper treatment, most of these 4,600 hectares can be continued in cultivation and yet not be a threat to the reservoir.

In planning and executing such a program, let me repeat, the primary purpose must be to retard siltation of the reservoir. Other benefits should be secondary. The farmers will profit from some of the secondary benefits so they should contribute as much as they can from their meager resources. The preservation of the reservoir for irrigation, power, and flood control over a long period is a matter of wide public interest. Therefore the public must make a major contribution to the protection program.

With the program being aimed primarily at protection rather than expansion or exploitation, certainly no presently forested lands should be cleared for cultivation. Presently cultivated lands must be given adequate erosion control or reforested.

There is a big job to be done here. How fast it can be done will depend upon:

1. the amount of the budget provided.
2. technical personnel to plan and direct the work.
3. the available supply of laborers and draught animals.
4. to a lesser extent, the use of building materials.

I believe that PDAF should set up a soil conservation field station within the watershed for a working headquarters. Fu Shing Village, centrally located, with bus communication and the location of the Township Public Office seems a logical site. Housing is scarce in Fu Shing and it will be necessary to build an office and dormitory for the field staff.

You should arrange for the services of as many technical personnel as are available. It appears to me that trained men will be the bottleneck on this undertaking. If these men will work together on a common plan it is not material whether they are paid by the Provincial, the Hsien or Township governments or by the Shihmen Commission. This is a matter on which I do not feel competent to advise you.

The construction phase of the program will extend over several years. Following this, there will be a need for a follow up

* Memorandum to Mr. Y. K. King, Commissioner, PDAF

or maintenance program of an extension nature, over an indefinite period. The office and dormitory built for the soil conservation staff could later be used for extension headquarters.

A cadastral map showing the location of the various tracts of cultivated land where the work is to be done, will be needed. After a look over the area, it is my opinion that more would be accomplished if we started at once doing erosion control work rather than use our funds and the time of the scarce, technically trained personnel to make extensive surveys of conservation needs.

Soil eroded from fields in the headwaters may possibly be trapped above the spillway level of the dam. Soil eroded from the fields adjacent to the reservoir will be deposited in the reservoir. So, though erosion control work done anywhere in the watershed retards siltation, priority should be given to work on fields near the reservoir. Work done with the most cooperative farmers will be the most effective. We should depend on the local township officials who know the farmers, to set up the priority of work locations. This would not only make our work more effective but would make the local officials feel like they were an important part of the total organization.

Unprotected tea gardens lose lots of soil. We should work with the Tea Corporation as well as with private planters to prevent erosion, starting with the best and youngest plantations. Some of the older ones are now ready for abandonment and should be reforested or replanted. Even these need some erosion protection until the forest cover is established.

In the construction of a dam, a bridge, or a building, it is necessary to plan the job in its entirety before actual work is started. This kind of an undertaking, consisting of a number of small individual projects, justifies a different appraoch. In view of the large amount of all kinds of work to be done and of the uncertainty about which farmers will first be ready to cooperate, it seems best to set up a budget for staff, labor and materials and then use this budget to do as much work as is possible. Considering that many agricultural jobs can be done best at only certain seasons, that individual farmers vary in their willingness and ability of participate, and the vagaries of the weather, to attempt to determine in advance which jobs will be done first and how much of each, would require a lot of the time of the scarce technicians and would, at best, be only an approximation.

With this in mind I would suggest that you set up a budget for so many technicians, so much for labor and so much for materials, place some one in charge and hold him accountable for making good use of the resources at his disposal.

Speech at Ah-kung-tien Watershed*

January 19, 1958

Mr. Vice President, Dr. Chiang Monlin, and other distinguished guests:—

We are honored to have this opportunity to show and explain to you a small part of the soil conservation work that has been done here and to discuss with you the progress and the needs of the program in Taiwan.

From this point you can see a few of the bench terraces that have been built since the first SCFO was established at Kangshan in 1955. Some of these benches and drop structures are close by so you can see them in detail. You see many more on the hills in the distance. The soil conservation program consists of a great number of small jobs like these, and seldom includes any large, spectacular undertakenings.

Bench terraces are not a new practice here. Farmers have been building them for 300 years in Taiwan and for much longer than that on the mainland of China. In the past they were built by human labor with hoe and basket. The SCFO has demonstrated that by using their own cattle and simple tools such as Fresno scrapers or V drags which can be made in almost any village workshop, the farmers can build equally good benches but do so much faster, cheaper and easier. One farmer with a buffalo and Fresno can move as much dirt as 4 men with hoe and basket.

We will speak mostly of bench terraces, not that they are the only practice used for we do use many others, but because of the steep slopes and torrential rains, bench terraces are most frequently recommended.

Soil erosion is a simple thing. It consists of moving soil particles from one place to another. In order for this to take place, two thing must happen (1) the particles must be detached from their previous place of attachment and (2) they must be transported. It is that simple.

If we can prevent either of these things from happening, there can be no soil erosion. Nature's method was to prevent detachment by a cover of trees or grass. That is hard to improve upon as the raindrops which are the primary source of detachment, can not strike the soil.

When we grow rice, sugarcane, vegetables or other crops we must cut down the trees and plow up the grass. This exposes the soil to detachment by the rain so we must depend upon preventing erosion by stopping transportation of the loosened particles.

The soil in a rice paddy is not only exposed to the effects of the rain but plowing and harrowing completely detach the soil into a thin soup. But there is no erosion in a rice paddy because there is no transportation. The water stands still aud the soil settles back down. Hillside benches are just like rice paddies except that there is no irrigation water supplied. When the rain detached the soil, it is held in place until it settles back down, whereas on sloping fields the rain carries the detached soil away in the runoff water.

The benches you see here serve three purposes:—

1. They prevent the siltation of the Ah-kung-tien Reservoir.
2. They prevent the destruction of the soil by erosion.
3. They make it possible to increase the production of crops.
   (a) By preventing runoff and increasing the supply of subsoil water.

* Briefing for Vice President Chen Cheng

(b) By preventing the removal of added manure, compost & fertilizer in the runoff water and permitting their accumulation in the soil.

The Ponlai Brown Sugar Mill, there behind the hill, buys the sugarcane from all of these farmers. Mr. Kuo the manager cites an example of the benched land producing 100-120 T/Ha. of cane while adjacent sloping land produces 30-40 T/Ha. That is not an optimistic estimate. He weighs the cane when he buys it and so knows how much is produced.

With a population of about 10 million, and that steadily increasing, to be fed from 870,000 hectares of cultivated land, Taiwan can ill afford to permit any of this arable land to be destroyed or damaged by soil erosion. Each hectare must be conserved and improved and made to produce maximum yields for a long time.

Soil Conservation is but one phase of a sound program of permanent agriculture. It is not a substitute for better seed, proper fertilization, adequate irrigation, or the control of insects and diseases. Neither are these programs a substitute for soil conservation. They are each like the legs of a stool. Each has a job to do. If any one is too short or too long, the stool is less satisfactory.

A total of 15 SCFOs have been established to guide the farmer's efforts on conserving their own farms. On small areas in each community, the SCFO demonstrates the new practices and methods. Then it loans the tools to the farmers and gives technical assistance to all who request it. Farmers are accepting the program and have asked for this assistance in numbers greater than the SCFOs have been able to supply it.

These SCFOs are only temporary organizations and have no legal status. In order to operate they have to beg, borrow, or steal personnel from the agriculture, forestry, or irrigation sections of the Hsien or Hsiang public offices.

PDAF with JCRR assistance has conducted Soil Conservation Training Schools and there are now available some 60 trained men. But when they return home, there are no soil conservation positions to which to appoint them so they have to return to their old jobs, regardless of the need for their new skills in the soil consevation program.

In view of the need of Taiwan to conserve its soils and in view of the acceptance of the program carried out by the SCFO, and in view of the lack of legal status of the SCFOs, I respectfully suggest that the government should consider giving the SCFOs a legal status with the budgets and personnel quotas that are commensurate with the job to be done.

Preservation of Forest Litter in Soil Conservation Demonstration Areas*

March 24, 1960

We are planning to establish watershed soil conservation areas at the head of some of the wild creeks on which work is being done under the Flood Rehabilitation program. While we were studying one of these areas in Nantou Hsien, we saw a girl raking up the leaves and other forest litter under a plantation of Acacia trees. The area was small and not particularly hazardous but this observation led to a discussion which concerns forest protection policy. For this reason I am writing to present for your consideration the ideas evolved.

This was a planting of Acacia trees on private land on the banks of a rather large gully. The trees were from 5 to 10 cm. in diameter and fairly evenly spaced about 2 to 3 meters apart. The soil was well covered with a collection of leaves, seed pods, twigs, weeds, and grass. This litter was being removed to be used for fuel. The local people said that the police would not allow the farmers to cut the trees without permission but that they did not interfere with the removal of the litter.

What we were looking for was means by which more of the rainwater that fell in the watershed could be induced to infiltrate into the soil and permit less of it to runoff, carrying with it the soil and rocks. This forest litter served as a cover to prevent the falling raindrops from pounding the soil, loosening the soil particles and sealing over the surface to prevent filtration. It also served as a blanket to absorb and hold the water in place until it could percolate into the soil instead of running off down the steep slope. When this litter is removed the protection is lost. The canopy of the trees furnish some protection against the beating rain drops but the litter is more effective in holding the water in place until it percolates into the soil.

We recognize that the farmers must have fuel and must find it somewhere close to their homes. We asked this particular farmer how large an area would have to be raked to obtain the fuel equivalent of an 8 cm. diameter Acacia tree. After some calculation he estimated that 30 ping (6'×6') raked twice a year would produce about the same fuel. This was, of course, only a rough approximation and may be far from exact. However, it is adequate for our use in the discussion of principles.

I am confident that, from a technical standpoint, the cause of soil conservation and flood control would be better served if the farmer were allowed to cut one 8 cm. tree instead of removing the litter from 30 ping twice a year. If left in place, these 30 ping of litter would prevent more soil detachment and would certainly prevent more surface runoff than the one Acacia tree. These 30 ping would contain from 15 to 20 trees so that cutting one each year would permit the maintenance of a good forest cover. This is considering the problem from only a theoretical technical viewpoint.

From an administrative standpoint, what would be the difficulties incurred if the farmers were permitted to cut a certain number of trees for fuel in return for maintaining a certain area of litter? It is my idea that such an arrangement should be tried out on an experimental basis within the demonstration areas. In order to prevent the program from getting out of hand and resulting in promiscuous tree cutting, would

* Memorandum to Mr. Y. T. Tao, Director, TFB

it not be possible to link permission to cut a specified number of trees (marked by the forestry or soil conservation technician), with the preservation of a certain specified area of litter (also indicated by the technician)? Thus if the farmer allowed someone else to remove the litter, the cutting permission would be withheld.

Since the cutting permits are given by the Hsiang, Hsien, or TFB depending on the size of the area to be cut, it would seem best to develop a policy at the provincial level and then hand it down through proper channels to those concerned. Would you please consider this matter, discuss it with your specialists, and later talk it over with us at your convenience?

A Policy Needed for the Planning of the Black and Muddy River Watershed Development

June 29, 1961

If any satisfactory progress is to be made in the planning of the development of the watersheds of the Black and Muddy Rivers, some policy decisions will need to be made to avoid interminable arguments and discussions among the technicians doing the actual field work. One of these questions which has been discussed and shelved many times without a settlement, is the treatment of lands which are classified as forests, but from which the forests have been removed. Many of these areas are being cultivated at present.

Even though this land use is contrary to the regulations and may not be according to our liking, this cultivation of lands classified as forest is a fact and should be recognized as such. The question is not, does it or should it exist but rather, what can be done to remedy or improve the situation.

The physical problems that exist are not altered by the classification of a tract as National Forest Compartment, Hsien Forest Land, Undetermined Forest or private land. The same natural laws apply regardless of the artificial or legal classifications that are applied to a certain tract. When rain falls on bare, sloping soil the result is not influenced by the color or label of that tract on the map.

The land use capability of a piece of land is the most intense use to which it can be put without destroying it. Technicians can examine and map the land, committees and conferences can debate the classification, and officials can approve or disapprove the tabulated results. One or all may be correct or mistaken, but none of these actions has the least effect on the true capability of the land. They represent only men's attempts to evaluate this capability which cannot be raised or lowered by official or technical pronouncement.

The purposes of the Black and Muddy River Watershed Development Project are, to prevent soil loss and deterioration, to control flood damages, and to develop the natural resources to the point of optimum production. In order to accomplish these objectives, watersheds must be considered as a whole and not as isolated portions. Therefore to withhold certain segments as being beyond the scope of investigation or planning, prevents the development of a logical and effective plan or program.

The Taiwan Forestry Bureau has been given the responsibility for the management and protection of the National Forest Compartments. To the extent that their programs have achieved satisfactory results, they should be commended and continued. But in those particulars in which the results are less than acceptable, maybe it is time to see if the existing procedures cannot be improved. The sore point, or the one over which there has been the most discussion and disagreement, is the treatment of lands classified as forest but which are, in fact, being cultivated.

Altho these lands are being cultivated illegally, the fact remains that they are being cultivated and that no feasible means has yet been developed by which this cultivation can be prevented. Whether or not the official figures show it, it is admitted by those who are acquainted with the facts, that the cultivated area within the forest lands is increasing year by year. The existing regulations and their present method of enforcement are not preventing the encroachment of cultivation in the forest lands.

Whether or not this encroachment is defensible or deplorable is not the question. The condition exists. It is also quite evident that merely protesting the violation of the regulations or denouncing the squatters does not, and cannot be expected to reverse the trend. If there were other, more suitable lands available onto which the squatters might be moved, that might be a solution. But there are no better lands available or they would have been occupied by these or other farmers. Some of the farmers who have been displaced from their paddy lands by highway, airport, or military construction or by urban expansion, might be absorbed in industry, but there are already hundreds of unemployed and underemployed people in Taiwan. As a matter of fact in supporting its expanding economy, Taiwan can use the food, fiber, and other products of these lands.

The illegal occupiers of these tracts recognize their precarious tenure and are hesitant to invest time or other resources in protecting the public lands from erosion. There is a noticeable difference in this respect between these illegally cultivated public lands and similar lands which are privately owned. The motivation of the owners to protect their own property doubtlessly makes the difference.

Policies employed in the past have not been successful in evicting the illegal cultivators or even in preventing their increase. These cultivated areas continue to suffer from soil erosion and contribute unduly to the siltation and flood hazards of the lands below them. Taiwan can make use of more agricultural products in its economic development plans. With these considerations in mind, is it not time to try a new approach to the solution of this problem?

Some of these illegally cultivated lands are not suited for cultivation, for grasslands, or for any land use other than forestry. They should be returned to that use. Many other tracts are such that, by the application of economically feasible soil conservation practices such as bench terracing supported by controlled waterways, they can be cultivated safely and permanently and produce satisfactory yields. Still other tracts with intermediate capability, can be developed as grass lands to give support to the livestock industry which is being fostered. All of these illegally cultivated tracts will fit into one of these categories.

Several alternatives should be considered. First, to continue as at present, flatly stating that forestry being the legal land use, is the only possible permissible use, and at the same time allow these lands to continue to deteriorate and the flood hazard to increase from year to year. Second; to recognize that history is never reversed and to undertake to protect and stabilize the lands which are under cultivation, this approach will reduce the soil and water losses and will result in the production of more agricultural wealth in the form of farm products. Other alternatives may be suggested also, but at least these should be considered.

There is no doubt but that forestry is and always will be one of the major industries of Taiwan. More than half of the land area is suited for forestry and for forestry only. The question under discussion is not whether cultivation should replace the forests on the mountains of Taiwan. That would be ridiculous and certainly not feasible. The illegally cultivated lands under discussion represent only a very small fraction of the Taiwan Forest Lands. That the exact area of such land use is not accurately known is immaterial for whether such lands amount to 0.01 percent, 0.1 percent or 1 percent of the total does not change the problem nor the method of its solution. Each tract of illegally cultivated land should be studied and treated according to its individual needs and capabilities, not according to some predetermined percentage scale.

This subject of the most desirable method of protecting and stabilizing these illegally cultivated lands has been discussed frequently at meetings of the Provincial Soil Conservation Technical Committee, at the meetings of the committee appointed to plan the establishment of MARDB, at meetings of the soils comittee appointed to determine lands use capability classifications, and elsewhere.

These discussions usually follow the same pattern. Whenever the subject is raised, the foresters simply state that the responsibilty for the Forest Compartment Lands has been delegated to TFB and that is the end of the controversy as far as they are concerned. That the cultivated lands are being allowed to deteriorate or that their areas is increasing each year is overlooked and any suggestions are met with either icy unconcern or impassioned oratory.

There has never been any serious denial that this problem exists, nor has there been any definite proposal as to how TFB was going to solve the problem. Most of the discussion has been negative—"this cann't be done"—"that cann't be done" etc. Quite a few of the defensive speeches have been prefaced by the remark "I'm afraid that..."

Fears have frequently been expressed that, if the presently cultivated land are allowed to be protected and stabilized and their production improved, the farmers will be encouraged to intrude farther into the forests lands and that the area in cultivation will be further expanded at the expense of the forests. There is no record of any one ever expressing any fear as to what will be the result if the present negative attitude is persisted in and the lands now being cultivated are entirely destroyed. No fear has been expressed about the steady expansion of the illegal cultivation under the present system of management. These latter dangers are just as ominous as the first mentioned.

Farmers without adequate land resources have been in the habit of going out into the forest, clearing a likely tract, and cultivating it. Without in any way defending this practice, it must be recognized that it exists and that neither TFB nor the police have been able to prevent it, much less evict the squatters after they have become established. The same practice would undoubtedly be continued if the program of protection, stabilization and improvement were undertaken. This cannot be denied. Neither can it be proven that this expansion would be greater because of the adoption of the conservation program.

This is the kind of a problem which cannot be expected to cure itself. If anything, it should be expected to become more acute. At this time when a concerted effort is to be made to develop a large area in which this problem will be met, should one group which has not been able to find a satisfactory solution to the problem, be allowed to block the efforts of others who might have a solution? Such an attitude recalls the story of the dog which, though it could not eat the hay, barked and bit at the cow and kept her from eating it to make milk.

Some legal technicalities will of course, have to be smoothed out to permit the employment of new procedures. Certainly, unworkable regulations should be rescinded rather than ignored or defied. The laws, rules, and regulations that made the TFB responsible for the Forest Compartment Lands were all made by men and presumably for the benefit of the Nation as a whole. If conditions have changed and the old laws are no longer adequate, these laws can be changed by the same bodies of men who created the first ones. If the need arises, they can be expected to do so also for the good of the Nation as a whole.

If the development and execution of logical and effective plans are obstructed by legal technicalities. These obstructions to progress should be removed speedily. The development of two river watersheds presents enough real technical and physical problems to be overcome without having the efforts of the workers hampered by needless technicalities.

Comments on the Whole Problem of Illegal Cultivation of Public Lands*

July 1961

Many public lands which have been classified as forest lands, are being illegally cultivated. This is to be regretted but it is a fact which must be faced. We feel that it is high time to consider some rational solution to the problem which such illegal land use presents.

The unauthorized cutting of public forests and the subsequent cultivation of the land is illegal and cannot be condoned. But when this process is viewed from the standpoint of the farmer whose lands have been taken from him for military establishments, new high ways, new airports, urban expansion, etc. this practice, tho still illegal, does not appear to be quite so heinous. The forests have been cut and there seems to be small possibility of reversing the trend. JCRR is of the opinion that, in addition to trying to prevent the expansion of such illegal cutting, some positive good can be accomplished by a program of helping to protect and stabilize the lands that are already under cultivation.

When the lands of Taiwan were originally classified as to land use, not too much information was available about land use capability and the needs of the nation were not nearly so great as they are now. Consequently, it is not at all surprising that small areas of land which are suitable for cultivation were included in larger tracts designated for forest use. It is not the reclassification of forest lands as a whole that in being suggested but the consideration of the reclassification of small tracts which are capable of more intensive use.

In a few cases, large areas have been illegally converted from forestry to agricultural use, but in most cases the areas have been small and isolated. Without condoning defiance of the law, it is possible that some of the land use classifications have become so badly out of date that they need to be reconsidered in view of the needs of the nation and the present knowledge about land capability classification.

Because of the elevation, topography, soils and other physical factors, far more than half of the land area of Taiwan can never be used for any other purpose than forestry. Only a very small percentage of the forest lands of Taiwan are concerned in this discussion as to their reclassification for agricultural use. Each tract, however small, needs to be considered on its own capability rather than in sweeping generalizations. It is a confusion of the issue to imply that there is any intent to convert all of the forest lands of Taiwan to cultivation.

Taiwan's population is increasing rapidly and there is need for more food and raw materials for industry. Some of this increase can be obtained by the more intensive use of lands now in cultivation but there is a limit to how much increase can be obtained in this way. At a time when immense amounts of public funds are being recommended for the development of tidal flats and mountain lands, it is quite fitting that something be done to protect the land resources that have already been opened up.

Whether a tract of land is designated as National Forest Compartment, Hsien Forest, undetermined forest or privately owned, does not have any bearing on the physical problems. The same rain storm on the same soil condition produces the same damaging erosion. Artificial legal classifications have no bearing on the technical

* Attachment of a Letter to Mr. F. H. Chang, Director, MARDB

problems nor their proper solution.

Whether a private land owner can or will take needed action, whether a public agency can or will take similar action are administrative problems that have no bearing on the technical requirements. The first question that should be asked and answered is "What is the most intense use to which this tract can be put, without deterioration?" After that has been determined comes the practical question "How shall we go about getting the required practices applied?"

The answer to the first question is not influenced by the ownership of the land but ownership or jurisdiction becomes important when we seek to get things done.

When we find in National Forest Compartment Lands contiguous areas several hundreds hectares in extent that have been in cultivation for several years, this would indicate the need for serious consideration as to the reclassification of such areas. The fact that such areas have been sequestered for agricultural use does not prove that is the correct land use, but it does justify taking a close look at them without being prejudiced by previous labels.

In any undertaking such as the Black and Muddy River Watershed Development, the controlling purpose should be to get the job done as effectively as possible. By combining the efforts of each of the agencies which have personnel trained and equipped to do special kinds of work, the maximum efficiency of the entire technical force of the Provincial Government can be achieved. Such improved efficiency comes about by making use of the specialized qualifications of the personnel of each agency and by eliminating duplicating and overlapping functions.

It has been announced that the Taiwan Forestry Bureau will handle the forestry work, PWCB the hydraulic structure work, and MARDB the soil conservation work on agricultural lands. There is little room for argument about such a logical division of responsibilities. As in most controversies, disputes are apt to arise only in borderline cases. Illegally cultivated forest lands is one of these disputed subjects.

After it has been decided that trees should be planted on a tract, there is no argument but that TFB should do the planting. After it has been decided that another area should be benched, it is equally obvious that MARDB should carry out this practice. Disputes are apt to arise over the decision as to whether a certain tract should be benched or reforested. This is a technical question which should be settled by qualified technicians on the basis of physical and economic facts. The "saving of face" of an agency, even if supported by outdated maps and regulations, should not be allowed to interfere with a logical and reasonable solution to such problems.

Therefore, the question of "what will be the land use of each tract" should be considered by technicians representing the combined staffs of the agencies concerned. It has been demonstrated that it is futile to sit around a conference table and rehash the same old arguments that have been worn threadbare by repetition. An examination of the area in question IN THE FIELD by qualified technicians will usually produce an acceptable answer in a short time. This is a reasonable procedure.

If existing rules, regulations, and classifications seem to conflict with logical and reasonable procedure, they can and should be amended. These regulations were made by human beings (who are subject to making mistakes) but presumably for the benefit and welfare of the nation as a whole rather than for the benefit of any particular agency or group of people. These regulations and classifications can and should be revised by similar authorized governmental bodies which are also concerned with the welfare of the nation as a whole.

Such changes should be considered whenever there is need for revision and action should be taken without undue delay. To perpetuate an error is to magnify the error and hamper progress.

Farewell Address at Taiwan Soil Conservation Conference

January 9, 1962

When I was first sent to Taiwan in 1954 I was assigned to get three things done. (1) To develop a technical program that would fit the needs of Taiwan. (2) To get a personnel training program in soil conservation organized and going. (3) To promote an organization to carry on the soil conservation work. I won't say that "I" have done these things but "we", collectively, have reached these goals.

A soil conservation program has been developed which fits Taiwan's present financial and technical capabilities, and the present stage of development in Taiwan. This technical program has been widely accepted by the farmers and supported by the government agencies. Therefore we can say that this part of the assignment has been accomplished. But this is not the end. You must always continue to develop and to improve your technical program or it will get out of date. There is no such thing as the "last word" in soil conservation, you must keep improving or fall behind.

The second part of the assignment was undertaken by working out in the field with the few technicians assigned to the Chinghsui Demonstration area. Next we helped with the Soil Conservation Training Schools. At first these schools consisted of one or two weeks of lectures, followed by an excursion around the island to see the soil conservation problems, as very little had been done at that time to solve them. In 1956 we held a ten weeks training school for 14 men at Tsaotun, using the upper floor of the Farmers Association for a classroom and a bamboo shed for a dormitory. The accommodations were crude but the school was a success. In 1957 JCRR built the present Training Center and since then, more than 40 men have received training each year. At first I gave most of the lectures, which were translated. But now, more and more of the subjects are given by professors from the universities or specialists from the agricultural agencies. The curriculum is well enough organized and the material printed, so that my leaving will hardly be felt in the training work. And that is the way it should be.

Eleven men from Taiwan have been given a year of training in soil conservation in the United States under the ICA-TA participant program. Part of this training was wasted because a few of the men didn't work at soil conservation when they returned to Taiwan. But the others have applied their acquired skills and training so well that the average cames out pretty well. So, on the whole the personnel training assignment has been carried out satisfactorily and there are men in JCRR, MARDB and in the field offices who are competent to carry on the program without any further help from me. It is the goal and purpose of all technical assistance programs for the adviser to work himself out of a job. I have done that, so now I can retire and play with my grand children.

The third phase of the assignment, that of setting up a soil conservation organization, didn't work out to suit me. However, you do have an organization in MARDB, set up the way the Provincial Government wants it and, since they will have to live with the results, I suppose I shouldn't complain. The overall size of any organization must be determined by the budget and the supply of technicians and administrators available. My objection to the way the planning committee set MARDB up, is that they put too large a percentage of the total personnel in the nonproductive overhead positions in the central office. However, that seems to be the Chinese Government's way of doing things and I can't change it—*but I don't have to agree with it.*

With all three of the assigned tasks

accomplished, I can return to Washinston and report "Mission accomplished" in all good conscience and retire. But as your "elder brother" and sincere friend, there are a few "words of wisdom" that I would like to leave with you to meditate upon whenever you think of me and of the days during which we swore and sweat while trying to build this soil conservation program. One of these is the necessity for maintaining a balance between the agronomic and the engineering phases of your programs and the relationship of each to economics.

When a merchant starts a new store he hires carpenters, painters, etc. to build or to remodel a store building, construct the shelves, tables, showcases, etc. and put the room in readiness for his new business. This construction work is very conspicuous and it is important, but it does not constitute "setting up business". It is just getting ready to do the actual business of the store which is to sell merchandise.

In the same way, when we build benches and waterways, these practices alone do not constitute true soil conservation or wise use of the land. They are merely the preliminary or preparatory stage, getting ready to make wise use of the land in the production of crops.

Until the merchant actually gets some goods on the shelves ready to sell, he can't say that he is ready for business. Likewise the farmer who just builds benches and quits, isn't making wise use of his land by just benching it. He has to go on and produce some good crops on it. Benching alone doesn't contribute to his living any more than the shelves in a store make the merchant any profit.

Which is the most foolish? A merchant with lots of shelves and show cases and no merchandise to display or sell? Or a merchant with plenty of merchandise but keeping it stuck away in boxes or piled in the corner so it can't be displayed or sold? It takes a combination to make either effective.

If a farmer applies fertilizers and manures to a steep slope, he *MAY* get some benefit out of it, but much of it will be washed away by the first typhoon rain and be lost. Even that which remains may not be utilized effectively due to lack of moisture, when the rain water was allowed to runoff of the field. But when he benches the slope he holds both the soil and the fertility and better crops result.

In the process of benching, the fertile topsoil is buried and the sterile subsoil is exposed so that there may not be enough fertility available to produce a good crop. Therefore, the wise use of the land, (to produce good crops) isn't accomplished by just holding the soil and water. That is like having a new store with empty shelves and nothing to sell. Wise use of the land isn't accomplished until the fertility needs are supplied to balance the soil and water saving practices.

It is so much easier to see the benches than the fertility. We do the benching first and it can be measured and reported in definite figures. People see and talk about the benches. It isn't surprising that when the benches are built, people are inclined to relax and say "Well, that farm is conserved". That is the thing I want to warn you about, it isn't completed, and the farmer won't be satisfied if the production of crops is low. You have got to continue to work with that farmer and continue to guide him in the use of fertilizers, green manures, composts and barnyard manures, until the effects of exposing that subsoil have been overcome and his production is good. Otherwise he will be dissatisfied and his neighbors will hesitate to continue the benching work.

Another rather intangible, but very important phase of soil conservation is soil conservation economics. However nice a store the merchant might make, and however good and attractive his merchandise, his store will not be profitable unless the goods are sold in large enough quantity and for a high enough price to cover the cost of the goods and the overhead and leave some profit for him.

The same thing applies to soil conservation practices. However well they may function in preventing the loss of soil and water, however effective they may be in producing good yields of crops, the practices are not economically feasible unless the benefits exceed the costs and leave a margin of profit. The benefits must exceed the costs. This is one phase of the soil conservation program that we have not stressed yet because we were busy learning how to take the first steps first. But sooner or later you must all master this phase. One man is being sent to the United States as a TA participant to study this for six months. When he returns we hope that he will be your leader in this phase of the total program for, in order to become permanent, the program must be profitable.

There is going to be a definite change in policy with the U.S. Aid funds beginning with the FY62 budgets. There will probably be just as much money available as in previous years but more of it will be made available for loans and less of it for grants.

In the past, part of the US commodities were sold here in Taiwan for NT$ which were then loaned on revenue producing projects such as Taiwan Power Co. which firms repaid the loans in NT$. Other commodities and some USdollars were made available as grants. The commodities were sold for NT$ which became a part of the Counterpart Fund which was used to defray the expenses of the U.S. Embassy, ICA, visiting U.S. Officials and other U.S. project expenses. These grants of counterpart or of US Dollars did not have to be repaid.

Under the new procedure, commodities will still be imported as needed and will be sold for NT$ but all such commodities must be paid for in US Dollars altho low interest rates and plenty of time will be allowed. Under this arrangement, any project which produces revenue will be given loans rather than grants and they will repay their loan according to the terms of their agreement.

Many projects such as research stations, extension work or demonstrations will not produce any revenue and therefore will not be able to repay loans. They can still be given grants but the Provincial Government will have to agree to repay the loan when it becomes due. Therefore, before a grant is made to such a project, it will be screened to determine whether that project will result in the production of enough new wealth in Taiwan, to justify the government in repaying the loan. Thus a research project which is expected to develop information by which more wealth can be produced can be given a grant and the government can collect enough from the added wealth to repay the sum of the grant. But a project to build a new Art Museum would have a hard time showing that it could bring in enough tourist dollars to repay the loan.

This screening to determine economic justification will eliminate a lot of projects which are culturally desirable but not economically self liquidating.

Now, for one more item and in my opinion it is of utmost importance.

There is no substitute for individual integrity. Each man has to be his own inspector and be guided by his own conscience. No one can do this for you-you have to police yourself and retain your own self respect or all else is futile.

If you make a mistake in designing a structure and the structure fails because of that mistake, it is too bad. But, such mistakes have been made before and will be made in the future. They can be made in all honesty and, while there will be materials loss as the result of the failure of the structure, it need not reflect on the individual's integrity.

But if you "squeeze" the cement that is supposed to go into that structure and it fails because of skimpy materials, the failure is worse because it discredits the integrity of the "squeezer". You can help to clean up and preserve your own individual integrity and the moral tone of your own family and community. That you can do. The question is—will you?

Suggestions Regarding an Inter-agency Technical Committee on Soil Conservation*

October 8, 1954

The functions and scope of such a committee should be kept on an advisory rather than an executive basis, recognizing that any intervention between responsibility and authority leads to confusion. Each agency of government charged with the responsibility of carrying out certain activities must retain the administrative authority necessary to do so. However, consultation with other competent parties is not an infringement of delegated authority.

The responsible agency is not bound to accept the advice of the committee merely because it is a majority opinion, for it is still responsible for the results of its actions. If the committee can present facts or philosophy which convince the responsible agency that a change in policy or procedure would be in the public interest, the desired changes might reasonably be expected on the basis of reason but not compulsion.

There is an old saying that "A man convined against his will, is of the same opinion still". Therefore this committee should assemble and present facts and philosophy to form the basis of a concerted action, each agency performing its prescribed functions thru its own organization and under its own authorization.

A sub-committee could be set up to review existing laws, regulations and by-laws pertaining to the field of soil conservation and land use. The need for such a study is indicated by an instance in which one agency of government, presumably acting in conformity with the laws governing it, leased a tract of land to a farmer for cultivation. Another agency of government, also acting under its regulations, prepared to plant trees on this same tract, not considering it suitable for cultivation and hence not available for leasing. Undoubtedly there have been other examples of this kind of confusion and others will occur.

In the interest of clarifying the law and of eliminating confusion which breeds disrespect for government, this subcommittee should review such situations with representatives of the agencies concerned, and determine first whether the conflict was due to provisions in the basic laws enacted by the legislative yuan; to departmental regulations and by-laws or merely to erroneous interpretation by some individuals.

In the latter case, the matter could be clarified by administrative instructions within the department concerned. If the conflict in procedure was based on departmental regulations or by-laws promulgated by the agencies, a recommendation based on pertinent facts should be presented to the heads of the two agencies, suggesting such amendments of regulations as seemed necessary and desirable to obviate the recurrence of such conflicts and to promote the public welfare. These recommendations should be on the basis of "selling" the agencies on the desirability of the amendments rather than "telling" them to do it "or else".

If, as is possible, the confusion was based on conflicting basic laws; an analysis of the issue, the conflicting laws, the public confusion and possible unwise land use resulting, together with recommendations for rectification should be submitted to the committee as a whole, and with their approval and endorsement, to the legislative yuan for remedial action.

A second subcommittee might concern itself with drafting overall conservation plans

* Memorandum to Mr. Y.K. King, Commissioner, PDAF

for selected watersheds, suggesting to the several agencies functions appropriate to each which fall within the responsibilities assigned to that agency. For instance, on an imaginary watershed the committee might suggest a program in which:

1. The TFA in conformity with their regularly delegated authority would:

a. Establish and maintain as a Protection Forest at certain critical areas.

b. Produce planting stock and supervise the reforestation of certain burned-over areas.

2. The Power Company, being vitally interested in the control of erosion in the watershed of their reservoir, but not being technically or possibly legally authorized to do so directly, might be asked to encourage the reforestation or fire control work with financial grants.

3. The Hydraulic Department might be asked to give priority to supplying irrigation water to certain arable areas to relieve steep erodible areas from cultivation.

4. The soon to be constitute Soil Conservation subdepartment of PDAF might be asked to assist the farmers in making plans for and then in establishing soil conservation practices on the cultivated fields.

Such a planned coordinated approach would avoid some of the conflicts, duplications and omissions that might occur; would make the fullest use of the technical and material resources available; and by concerted effort create much better public support than if each agency went its own independent way.

The various phases of the overall watershed conservation program having been assigned and accepted by the several agencies, a fourth committee or survey team should make periodic inspections of the progress and efficacy of the work underway and submit to the committee as a whole recommendations for the further improvement of the plan and its application. For instance, is the contour cultivation recommended and applied to a certain sloping field actually controlling erosion adequately; if not, what additional practice can be added before requiring that the land use be changed.

Another dissociated but equally important subcommittee would be one on promotion. This committee should by consultation and constructive criticism, coordinate the efforts of all agencies relative to publicity, extension education, training of employees and recognition of accomplishments in the field of soil conservation.

The success and effectiveness of such a committee will be dependent upon its acceptance by each of the agencies as a sincere effort to improve the effectiveness of the soil conservation program. It should make it plain to the various agencies that it is working in such a way as to not detract from nor belittle the efforts of any agency nor does it seek to appropriate any of the credit due them individually for their accomplishments.

A Permanent Soil Conservation Organization

April 4, 1959

There are now approximately 12 people in Taiwan for each hectare of cultivated land on the island. Population is increasing at the rate of 3.5% annually. More land is being taken over by airfields, highways, army camps, and urban expansion each year than is being added by the development of mountain areas.

Scientific agriculture has increased the production per hectare many fold and will, do doubt, continue to make further increases. But, there is a limit to how far yields can be increased by science. There is no apparent limit on the increase in population.

Even if the population should level off at 10 million. Taiwan can not afford to waste a single hectare of its precious cultivated land. There is need for every new hectare that can be economically developed in the hills.

Nearly all nations face this same problem, it is simply more acute in Taiwan than in most other nations. Some nations have faced this problem and have taken the first steps toward solving it.

In 1933, the United States established a Soil Conservation Service. In the following 25 years 1,200,000 farm plans covering 200 million hectares have been put into operation. Many other nations have followed the same pattern and now have similar organizations at work conserving their agricultural lands.

PDAF started work similar to this in 1954 when a Soil Conservation Section was set up in its Land Use Division. JCRR has given technical and financial support in increasing amounts.

One Soil Conservation Field Office was set up in 1955 on a temporary basis. In 1956 three such offices were in operation. In 1957 there were seven and in 1958 there were 15. Two more have been started this year. The help they have given to the individual farmers has been appreciated and the demand for such assistance is increasing.

Many men from the Provincial Agencies and from the Hsien and Hsing Public Offices have been trained in the annual Soil Conservation Training Schools so that there is an increasing number who have become both interested and experienced in planning and applying soil conservation practices.

Because the Soil Conservation Field Offices were only temporary, there have been no permanent positions to which qualified men could be appointed. What work has been done to date was with personnel that were "borrowed" from other divisions of the Hsien or Hsiang Public Offices. The work done to date has demonstrated not only that soil can be conserved but that the Soil Conservation Field Office is a practical way of doing this important job in the Hsiens and Hsiangs.

Therefore, it seems appropriate that at this time the Provincial Government should set up a permanent Soil Conservation Service, (calling it by whatever name is appropriate in the Chinese Language) to continue and to improve upon the work now being done in the various Hsiens and Hsiang Soil Conservation Field Offices on a temporary basis.

Such a permanent organization needs first, to be given official status and then supported with elastic personnel charts and budgets. The temporary and "borrowed" personnel and the make-shift budgets are almost adequate for present needs. But as more and more farmers call upon the Soil Conservation Field Offices for help in solving their soil erosion problems and as more personnel become trained and competent, there will be need to expand both personnel and budgets to meet the demand before more soil is lost, and more hectares of cultivated land are destroyed. JCRR has given generous support to this, as well as other programs and can be expected to continue in the immediate future, but some time the Republic of China will be expected to carry on this and similar programs in Taiwan and in the other Provinces after the mainland is reoccupied. A well organized and efficiently functioning Soil Conservation Service here will not only meet the needs of Taiwan but will also serve as a pattern for the other mainland Provinces later on.

Before discussing how the Soil Conservation Service should be organized, it seems wise to discuss what, in my opinion, its scope and functions should be:

A. Its primary purposes should be to

1. Provide leadership in developing and shaping the soil conservation program in Taiwan.
2. Coordinate and uphold the technical quality of the soil conservation program in all Hsiens and Hsiangs.
3. Determine the allocation of Provincial Soil Conservation funds to the Hsien and Hsiang Soil Conservation Field Offices.
4. Provide trained conservationists from the Soil Conservation Service staff to guide and assist the Hsien and Hsiang Soil Conservation Field Offices.
5. Conduct a Training Program to prepare men from the Hsiens and Hsiangs to do conservation work.

B. The scope of the activities of the Soil Conservation Service and the Soil Conservation Field Offices should include, but not be limited to

1. Obtaining proper land use.
2. Maintaining soil organic matter content.
3. Revegetation of eroding areas.
4. Establishing more and better contour cultivation.
5. The construction of level bench and broad based terraces.
6. Establishing and stabilizing waterways.
7. Controlling gully erosion.
8. Stabilizing road fills and steep slopes.
9. Constructing farm ponds.
10. Farm land wind erosion control by farm windbreaks, strip cropping or residue management.

C. The Soil Conservation Service should *not* compete or duplicate the services of

1. TFA on reforestation or seacoast windbreaks.
2. PWCB in irrigation, drainage or river training.
3. PDAF in conducting fertilizer, crop variety tests, etc.
4. The Extension Service in organizing educational campaigns.

The Soil Conservation Service will deal primarily with farm land and give assistance to farmers. Therefore it should be set up within the Provincial Department of Agriculture and Forestry. It will also have many contacts with other agencies outside of PDAF such as PWCB, the Land Bureau and others. If it is set up as a separate organization it will have more prestige in these contacts than it would enjoy as a section within an old division.

Before going into the immediate needs of the Soil Conservation Service as it is being set up. Let us first consider what it should ultimately be, realizing that these long time goals can not be achieved for several years. It would be well to consider these goals.

Every organszation must have an executive, whatever title is given to him. In the US he was called the Chief of the Soil Conservation Service.

1. This Chief should be responsible to the PDAF Commissioner for all of the activities of his Service, and, within Provincial Regulations, should control its personnel.
2. He should establish soil conservation policies and promulgate pertinent regulations.
3. He should confer and make agreements with PWCB, TFA, Land Bureau, Hsien

and Hsiang Governments and any agencies regarding soil conservation.

4. He should prepare the soil conservation budget for submission to PDAF and the Provincial Government, and should control the distribution of funds allotted for soil conservation purposes.

5. In order to discharge his administrative responsibilities, he should have an administrative staff sufficient in number and quality to handle the current business load.

6. He should have adequate technical specialists to advise him on the technical phases of the soil conservation work. The following are suggested:

   a. A Soil Conservation or Farm Planning Specialist to guide the farm planning, and to coordinate the application of the various conservation practices.

   b. An Engineering Specialist to train and guide the engineers in the various Soil Conservation Field Offices and to insure the professional standards of the engineering phase of the program.

   c. A Soils Specialist to interpret the Marginal Land Surveys, to train field technicians in proper land use and to consult with them regarding problems of soil fertility and the use of fertilizers on the land disturbed by terrace construction.

   d. A plant materials specialist to lead in determining the adaptation of various new plants for controlling erosion, to advise in their propagation and use for revegetation and for farm windbreaks.

   e. A specialist in Soil Conservation Economics might be added at a still later date.

   f. Teams of conservationists (1 engineer and 1 agronomist or forester) for assignment to each Hsien Soil Conservation Field Office.

If this Soil Conservation Service Chief is to function as I have described, his duties will be largely administrative and he should be selected for his ability to deal with the heads of other organizations and to lead and inspire his own people. It would, of course, be desirable that he also know the details of the soil conservation program. However, the technical phases can be handled by the technical specialists. A technically minded Chief who failed as an administrator would handicap the new Service.

Each Hsien Soil Conservation Field Office should be under the administration of a Hsien Soil Conservation Field Office Chief who would be appointed by and responsible to the Magistrate of that Hsien (by way of the Reconstruction Chief if the Magistrate so desired).

The responsibilities in every Soil Conservation Field Office will fall into either (1) the administrative or (2) the technical classification. The administrative responsibilities affect public relations, and so should be handled by the Hsien Soil Conservation Field Office Chief who is responsible to the elected officials. The technical responsibilities should be handled by technically trained men who will be directed by the Soil Conservation Service. If these responsibilities are clearly separated at first, there need by no confusion or conflict between them.

A. The Hsien Soil Conservation Field Office Chief should be responsible for:

   1. Determining which farms will be worked on.
   2. Hiring laborers and work animals.
   3. Purchasing supplies.
   4. Care of property and equipment.
   5. Disbursing the Soil Conservation Field Office budget.
   6. Making all needed reports.

B. The Soil Conservation Service Conservationists assigned to assist a Hsien Soil Conservation Field Office will be under the technical direction of the Soil Conservation Service Chief and his technical specialists. Their salary, travel, and per diem will be paid from the Soil Conservation Service budget. While working in the Hsien Soil Conservation Field Office they will conform to the local administrative regulations. Their (technical) responsibilities will be to

1. Make or approve all technical decisions such as:
   a. Proper land use.
   b. Design of structures.
   c. Decide height and width of terraces.
   d. Location and method of protecting waterways.
   e. Other technical matters.
2. Exercise similar supervision over the technical programs of any Hsiang or Watershed Soil Conservation Field Offices in that Hsien.
3. Guide or supervise larger construction jobs.
4. Make required technical reports to the Soil Conservation Service.

C. In each Hsien Soil Conservation Field Office, in addition to the two Soil Conservation Service conservationists, there would be the Hsien Soil Conservation Field Office Chief and as many clerks, drivers, janitors and soil conservation assistants as necessary to handle the current work load. All of these (except the Soil Conservation Service conservationists, who would receive salary, travel, and per diem from the Soil Conservation Service budget), would receive their salary, travel and per diem from the Hsien Soil Conservation Field Office budget.

They would work under the direction of the Hsien Soil Conservation Field Office Chief in executing the plans made or approved by the Soil Conservation Service Conservationists.

D. In some Hsiangs (or Watersheds above reservoirs) where the volume of work and the distance from the Hsien Soil Conservation Field Office justified it, Hsiang (or Watershed) Soil Conservation Field Offices could be established to work in those areas. Where such Hsiang (or Watershed) Soil Conservation Field Offices are established they should have a budget of their own and operate in the same way as the Hsien Soil Coservation Field Office.

The Hsiang Soil Conservation Field Office Chief would be appointed by and be responsible to the Hsiang Chief. (The Watershed Soil Conservation Field Office Chief would be appointed by and be responsible to the agency responsible for protecting that watershed i. e. Shihmen Development Commission at Shihmen, PWCB at Ah-kung-tien, Ta-pu, Tung-shan etc.).

It would be desirable to have the Hsien SCFO station a conservationist from its staff, in each Hsiang SCFO in that Hsien. But the technical program would be under the guidance of the Soil Conservation Service Conservationists in the Hsien SCFO.

We must recognize that there are not enough adequately trained conservationists at present to set up such an organization if it was authorized and budget provided. Perhaps this is fortunate, for if an organization is developed thru steady, healthy growth, the result is better than if it mushrooms overnight.

The personnel now working in the Land Use Division and in the temporary SCFOs is almost adequate for the present needs of the program. Therefore, no immediate increase in presonnel or budget is required to start this permanent Soil Conservation Service. No positions should be filled until competent men are available by transfer or thru training.

There are not nearly enough competent men available for the Soil Conservation Service conservationists to be stationed in all the Hsien SCFOs. In October 1958 fifteen college graduates in forestry and agronomy were given temporary appointments and assigned to work in the SCFOs. This spring some engineering graduates were given similar appointments and assignments. While these men are making good progress they are not yet adequately trained to assume the responsibility for the technical program in their Hsiens without supervision.

There are a few Hsien SCFO staff members who have shown outstanding ability. I suggest that they be retained in their present positions but that their abilities be used by considering than "Consulting or Coordinating Technicians".

It is fortunate that four of the best technicians now employed in the SCFOs are well distributed geographically. I would suggest that all of the SCFOs except Penghu, be grouped as follows and the following technicians be designated as the technical consultants for the groups.

Eastern group:

Taitung and Hualien SCFOs

Southern group:

Kaohsiung, Ah-kung-tien, Tainan, Tungshan, Chiayi SCFOs

Central group:

Nantou, Taichung City, Taichung Hsien (Long Chien) and Miaoli SCFOs

Northern group:

Taipei, Taoyuan, Shihmen, Hsinchu & Tapu SCFOs.

As other SCFO technicians acquire and demonstrate their proficiency, they too could be designated as consulting technicians and the groups could be subdivided to utilize their abilities.

The 19 college graduates now on temporary appointments and working in the various SCFOs are making good progress. By July 1, 1960 they should have demonstrated their fittness for permanent appointments. Therefore, in the FY61 Provincial Soil Conservation Budget, provision should be made for including in the Soil Conservation Service staff those who are deemed adequately trained. This graduating from a probational, "Temporary" status to a permanent appointment would be an added incentive for diligence and industry.

By following the scheme suggested there need be no sudden personnel upheaval. Yu Hwei-sen, upon his return, could assume the post of Soil Conservation Specialist. The Engineering and Soils Specialists should be appointed as soon as competent men can be obtained.

The personnel in the SCFOs need not be disturbed, but recognition should be given to the outstanding men as consulting technicians. Within the year those temporary technicians who demonstrate their proficiency should be promoted to permanent status but remain in their same SCFOs.

The Ultimate size of the organization planned would be:

1 SCS Chief

1 SCS Chief secretary
Clerical and administrative staff as needed.

4 SCS Technical Specialists

32 SCS Hsien Conservationists:

- 16 Engineers
- 16 Agronomists or Foresters

Office space would be required at the Provincial level for the SCS Chief, 4 Technical Specialists, and Clerical staff.

All Hsien Conservationists to be stationed in Hsien SCFOs.

At each *Hsien* SCFO

1 Hsien SCFO Chief

2 SCS Conservationists

Administrative and technical staff commensurate with the work load in that Hsien. Office space for the Hsien SCFO Chief, the SCS Conservationists and necessary clerks.

At each *Hsiang* SCFO

1 Hsiang SCFO Chief

1 Hsien SCFO conservationist

Conservation assistants as needed.

It is suggested that the SCS Conservationists assigned to assist the Hsien SCFOs be not only shown on the Provincial SCS organization chart but that their salaries, travel and per diem expenses be paid from the SCS budget. This will give tighter control on their activities.

When it is necessary to call them in to

the central office or to send them on special detail to the Hsiang or Watershed SCFO, the Hsien SCFO will not be burdened with their travel or per diem expenses and hence will have less cause to complain.

Likewise, Hsien personnel stationed in the Hsiang SCFO should be paid from their home office.

Eventually each Hsien SCFO should have a pickup for transporting personnel, equipment, and materials. This could also be used for moving Fresno scrapers, V drags, planting stock, etc. for the Hsiang SCFOs in that Hsien.

The SCS Conservationists stationed in the Hsien SCFOs should eventually have motorcycles so they would be free to move about without tying up the Hsien pickups. Motorcycles for each Hsiang SCFO would probably be adequate transportation for their needs.

It might be necessary or advisable to give the Watershed SCFOs at Shihmen, Tachien, Wusheh and Ah-kung-tien, the same status as Hsien SCFOs, with SCS conservationists stationed there as long as they were needed.

Personnel for such assignments are not now available but after they are, SCS Conservationists should direct the programs supported by SCS funds.

I have purposely made this write up rather detailed and lengthy, hoping that it will serve as a basis for discusson when the form of the new, permanent soil conservation organization is being considered.

New Soil Conservation Organization

The name by which an organization is called may be descriptive of the purposes for which it is formed or of the scope of its action. If, for the purpose of assuring better budgetary support by the Provincial Government, it seems desirable to use some more popular terminology, this need not deter the functioning of the organization.

So far as JCRR is concerned, we have no hard and fast ideas as to the name the organization is to be called.

Since it is the wish of the Provincial Governor to include in the responsibilities of the new organization, the development of the agricultural lands of the mountainous areas, the original work plans and organization chart will have to be enlarged to cover this additional phase of work. There is no doubt but that such development work is needed and will add to the productive capacity of Taiwan.

The program of the presently operating Soil Conservation Field Offices is the conservation and improvement of the private or public lands which are already under cultivation, rather than the opening up of additional wild or forest lands. When the development of public lands is added to the work load, new types of responsibility are involved.

It will be necessary to train some one to deal with the Land Bureau in matters pertaining to land titles and the securing of permits, in the matters of leases, rents, sales of public lands, and with the Land Bank or some other agency in the matters of loans, grants, and collections of money advanced. There may be other such functions for which the present staffs of the Soil Conservation Field Offices have not been trained.

Since the present staffs of the SCFOs, both at the provincial and the hsien levels, have been partially, if not completely, trained to do soil conservation work and since there is more of this type of work to do than they will possibly be able to accomplish in the near future, it would be desirable not to disturb them by assigning them additional functions for which they are not trained but to allow them to continue with the type of work they now have under way. The additional functions should be assigned to other personnel which will be recruited and trained for this particular type of work. The basic academic requirements and working experience needed are quite different.

If the titles or permits are secured by the development personnel and the benching, contour ditches and waterways are taken care of by the soil conservation personnel, there will still be need for agriculturists to develop and manage the pastures, livestock farms, and crop production enterprises in order to make them fully productive. This is a third type of personnel required.

Since all of these phases of the overall program of Land Development need to be coordinated and made to work in harmony, it is desirable that the three phases be administered under one Bureau chief. But since each of the three phases follows more or less chronologically and involves different skills, separate divisions, branches, or services should be organized to perform these functions. All three divisions under the administration of one Bureau Chief could be serviced by one set of controllers, auditors, personnel and general affairs officers. This joint administrative and fiscal control would insure better coordination than could be expected by three separate organizations.

The principal reason for ICA agreeing to my return for a third tour of duty in Taiwan was that I could devote most of my time to mountain road stabilization and mountain land development. This was before the inclusion of the latter into the proposed soil conservation organization was proposed. In any event, most of my time will be available to help to get this new phase of the program under way.

In doing this I would suggest that we follow roughly the plan that we did in starting the Soil Conservation Field Offices. In 1955 the first SCFO was started at Chingshui. PDAF assigned two technicans successively to handle the project and to head up the field work. By spending considerable time with these men, a pattern of appropriate field operations and office procedures was established.

The next year a second field office was established at Kangshan and because of the different soil conditions there, different methods had to be employed. These methods were worked out IN THE FIELD to fit the local conditions. That next year a third SCFO was set up at Hsinchu. After that, since the general pattern needed had been established, the setting up of and staffing of SCFOs proceeded more rapidly and with rather satisfactory success.

In starting the Mountainous Land Development work I would suggest that this same plan be followed. First by appointing, or by temporarily, detailing two men to undertake the work of getting the permits or titles to permit development work to be initiated on public lands. Presumably this will have to be undertaken with the Land Bureau and the respective Hsien or Hsiang Land Offices.

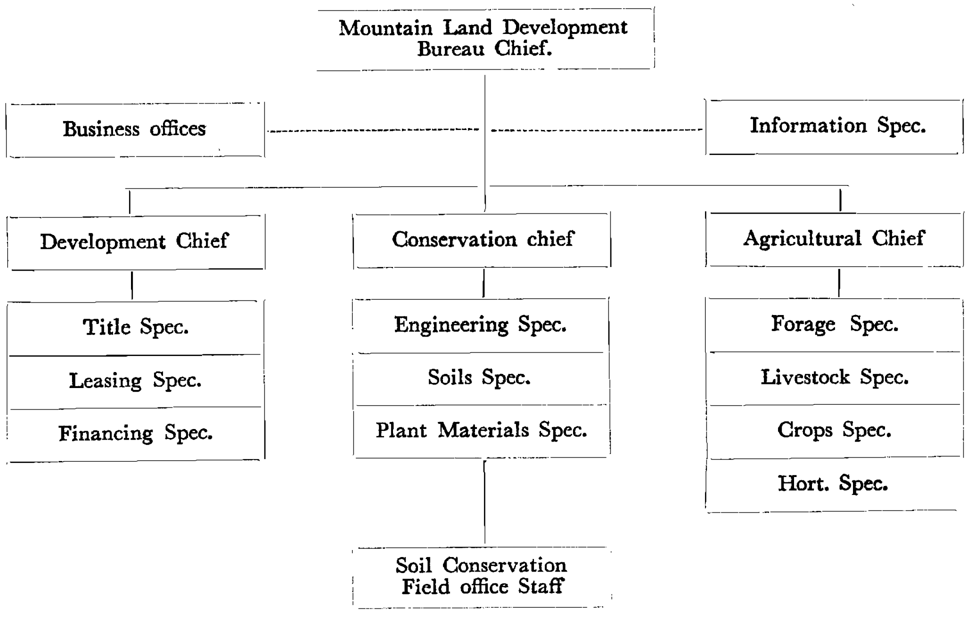
After consulting with appropriate agencies several possible sites for development would be selected and these men would start getting the required clearances for field operations. No funds are now available for extensive operations but it is doubtful whether large scale operations could be undertaken before July 1, 1960 after which date FY61 funds would be available (at least thru JCRR)

As soon as clearance to work on specific sites was obtained, the soil conservation technicians from the appropriate SCFO would be called on to do the surveying and planning for the benches, hillside ditches, outlets, and other soil conservation practices. When the work had been planned a budget could be submitted and after it was approved, work could be undertaken. In the meantime, these Development Personnel could be making the initial preparations for the next pilot project in some other hsien.

Thus a comparatively small group of Development Personnel could keep ahead of several SCFOs. After the soil conservation work was completed, and it should be largely done before farmers are permitted to come in, a second group of development personnel should take over to handle the leasing or renting or sale of the land and any financing that was necessary.

Before or as soon as the farmers are admitted, there should be a crew of agricultural technicians available to establish pastures, supervise the planting of orchards and permanent crops, and to work with the farmers in getting the newly benched lands into production. These agricultural personnel might be temporary or permanent as the progress of the work indicated the need.

It would be highly inadvisable and inefficient to try to start a large number of these new projects at once. Confusion would be sure to ensue. It would be inefficient to appoint the agricultural specialists too far ahead of the availability of the land on which they were to work. One of the most pressing needs in the development of land in Taiwan is the stabilization and improvement of the illegally cultivated sloping public lands. This undertaking would fall naturally into the scope of such a land development organization. While there are possibilities of developing some lands which are not now being cultivated, the opening of these lands should wait until the lands now exposed to the hazard of erosion have been stabilized. Eventually we should arrive at some organization pattern something like the following:



Mountain Land Development Bureau Chief.
Business offices
Information Spec.
Development Chief
Conservation chief
Agricultural Chief
Title Spec.
Leasing Spec.
Financing Spec.
Engineering Spec.
Soils Spec.
Plant Materials Spec.
Forage Spec.
Livestock Spec.
Crops Spec.
Hort. Spec.
Soil Conservation Field office Staff

For Presentation to Mountain Agricultural Resources Development Bureau Planning Committee

August 1960

Making the plans and specifying the details for the temporary and later the permanent set up of the Mountain Agricultural Resources Development Bureau will be quite a laborious undertaking. It is hardly to be expected that the full membership of this large committee will be able to meet often enough or remain in session long enough to attend to all of these details. Would it not be wise to appoint a working subcommittee of five or fewer, under the leadership of the deputy convener to work out a detailed proposal to be presented for discussion and approval to this full committee at its next meeting?

There are a great many subjects which should be considered and I have listed here only a few that occurred to me as being significant. Many others will also need to be considered and recommendations made.

Headquarters Location for MARDB. Most of the PDAF divisions and offices, are located in the Chung Hsin Village. That would seem to be the logical location for the MARDB headquarters if office space can be found for it. The office building of the Training Center at Tsaotun could be used temporarily, altho it will not be large enough for the completed organization. A training school in soil conservation is to be held there in October-November so the lecture room, dormitories and dining hall should be kept free for that purpose.

Organizational scheme. Most of the discussions regarding the organization of MARDB have contemplated having three or four technical divisions in addition to the standard administrative offices of controller, cashier, general affairs, and personnel. The technical divisions discussed in the past have been a legal division to handle the title to the land, the permits and the subsequent leasing of the developed lands; a soil conservation division to direct the technical program in the Soil Conservation Feild Offices and the benching, waterways, and other soil conservation practices in the Operating Stations; and an agricultural division to supervise the soil fertility work and the establishment of planted fruit trees, pastures, and special crops. The livestock work could be included in the agricultural division or it could be set up as a fourth division.

My particular concern is with the soil conservation division, its specialists and their relationships with the Soil Conservation Field Offices and the Operating Stations. I have worked out a suggested organization chart which shows my ideas of how the various divisions and specialists should be coordinated. The committee will of course make its own organization scheme. This is submitted only as a starter or a basis for discussion.

The Soil Conservation Field Offices are under the administrative direction of the hsien governments who determine the priority of applications for assistance, hire laborers and disburse the SCFO budget. However, the technical aspects of the program are the responsibility of PDAF. To represent PDAF, there are one or more conservationists appointed by PDAF and assigned to work in each SCFO to inspect and approve the technical phases of the soil conservation program. It is logical to expect that, after it is established and in operation, the MARDB will assume this responsibility for PDAF.

Since this technical soil conservation program and these PDAF conservationists will be of concern particularly to the soil conservation division, it would seem logical that they should be under the direct supervision of the soil conservation division chief. By this organizational scheme, the conservationists in the SCFOs would be responsible to the MARDB director thru the Soil Conservation Division chief rather than directly.

These SCFOs administered by the hsien governments and working mostly on private lands, carry out their program primarily by conducting demonstrations of new practices and new methods of applying old practices, and then encouraging the farmers to complete the job of protecting their own farms with their own resources and facilities. We think that this is a sound approach which should be continued.

Conditions will be somewhat different in the new areas where the development of marginal and mountainous lands is to be undertaken, and also where the protection of the watersheds of important reservoirs is the objective. A great deal of this will be on public lands and there will be greater urgency for completing the progam rapidly. Therefore this committe should consider whether, and to what extent, it is desirable to provide additional facilities such as direct operation by hired laborers, additional subsidies, sharing of the cost of seeds and construction materials or a combination of such incentives.

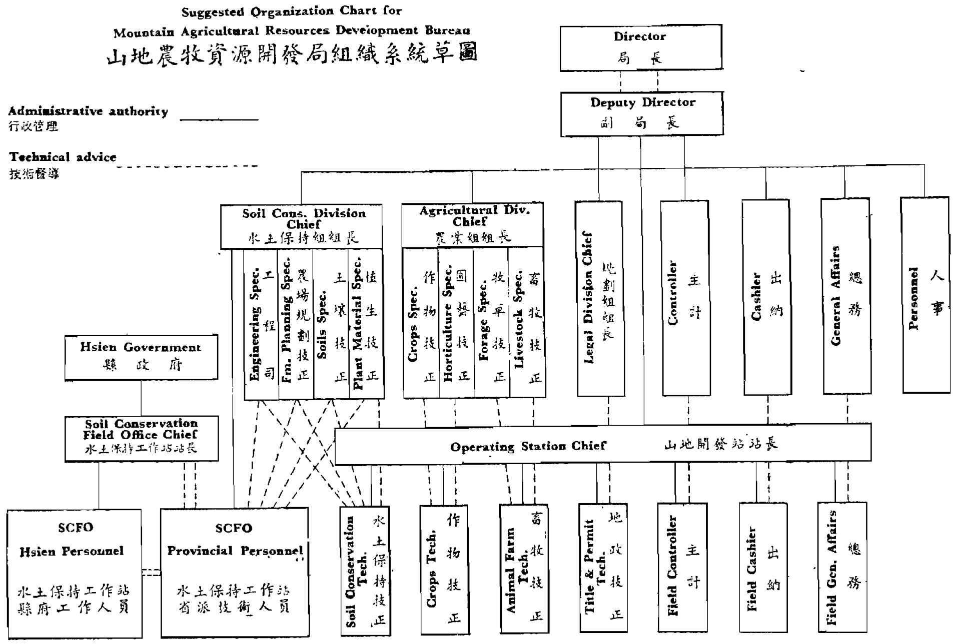
Since the conditions in these places will be different than those in the SCFOs, the field organization should logically be different. To distinguish between these two types of organizations I suggest that the latter be called Operating Stations. Each Operating Station should be under the direction of an O.S. Chief who would be directly responsible to the MARDB director without reference to the hsien governments which will continue to direct the work of the SCFOs.

The number of specialists in the different MARDB divisions and the number and diversity of the technicians to be placed in each Operating Station should be determined by the work load that develops in each place. It is desirable to start with a small staff and increase it as the need for more personnel is demonstrated. One thing that I would strongly recommend, especially during the time of the preparatory organization, is that the organization chart not be frozen, but that it be kept flexible so that it can be adapted to fit the growing needs of the job.

In the past years the Land Use Division has administered the soil conservation program for PDAF. They have never had an adequate staff of technically trained men and those who were capable were tied down in the office with desk work. Consequently the conservationists in the SCFOs have not had the technical leadership that they needed. With budget disbursement and other procurement being handled by the PDAF Controller, General Affairs and other administrative offices, the results have been very discouraging. Therefore I would recommend that at the first possible date, MARDB be set up with its own administrative offices.

It is not my place, and I have no wish to point the finger of scorn or accusation against any individuals, but the fact remains that the present arrangement for administering the soil conservation program has not operated satisfactorily. Whether or not this condition can be remedied is not for me to say but if MARDB has its own administrative offices, they will be in a better position to insist that the work be handled on time and in good order.

Setting up budgets. Because of the delay in the appointment of this committee its actions are unavoidable delayed. The budgets for the support of the Hsien/City Soil Conservation Field Offices and for the support of the PDAF conservationists working in the SCFOs will terminate on 30 Sept. Consequently it is necessary that new budgets be approved for the continuation of these existing activities so the new funds will be available by October 1, 1960. Therefore, we have proceeded to make up budgets for these activities and have submitted them to JCRR for approval of the Joint Commission of the contributions to each.



It will be the responsibility of this committee to prepare and submit budgets for the support of the MARDB central organization for the Opearting Stations when and as they are established. These budgets can wait until you take action but the others had to be ready, after formal approvals by JCRR, PDAF and the individual Hsien Governemnts, before October.

Organizing the Work of a Soil Conservation Field Office

October 1958

The efficiency of a Soil Conservation Field Office is measured by the amount of well planned and executed work that is accomplished. The only purpose in establishing a SCFO or assigning men to them is to get soil conservation practices applied to the land. Reports, budgets, speeches, farmer interviews and tours and meetings, are important only as they contribute to this major objective.

It is all very fine that you attend the office regularly, that you spend many days in the field and collect your per diem, that the budget be expended on appropriate items down to the last dollar. But the real and effective measure of whether your SCFO was well managed is, how much soil conservation did you get established? There should be a direct relation between the size of your budget and the amount of work done.

One way to double efficiency would be to discharge half of the staff and those who are left accomplish just as much work as was being done before. A second way is to retain all of the present staff or even to increase it, and then plan and organize the work so that more is accomplished per man. I recommend the second approach.

There are many ways to waste time and so hold down the work. One of the most obvious ways to do this is to have the entire staff sitting around the office, doing nothing productive. Most of the productive work must be done out on the farms. Some reports have to be made, some maps and plans have to be drawn and other administrative chores are required, but these are unproductive overhead and do not add to your soil conservation production. Most of the reports and administrative paper work must be done by the SCFO chief and the members of the staff are seldom involved in this kind of work.

If the SCFO is well managed, the SCFO chief will have planned the field work for the crew to do while he is occupied with these administrative chores. If all productive work stops while the SCFO chief sits down at this desk, it is a reflection on his ability as a manager.

One good way to keep everyone conscious of the necessity of doing productive things is to keep posted on the office wall a job assignment sheet. On Saturday, he should make a list of the work each man is assigned to do for each day of the following week. He must allow enough of his own time to take care of the administration and should call it what it is—unproductive administration or overhead. May be Ching will be assigned to supervise terrace construction on farm No. 43 while Chang and Chung will be planetabling the benches which were built on Farm No. 36 last month. In addition to his administrative work, the chief may schedule himself to supervise the construction of structures on Tuesday and Thursday, of Farms No. 17 and 19.

A good way to waste manpower is to assign 3 men to make a survey that 2 men can make or to assign 2 men to supervise a job when 1 is enough. If on a certain day, one man is not needed at any job—be honest and just leave his assignment blank or call him idle, rather than add him to a crew where he is not needed.

If you show too many men idle too many days, it will become a little embarassing. That is all right, it should be embarassing. You have probably had that situation before but, since it was not written down in public, you were not conscious of it and no one was embarassed. What I am suggesting is that the facts be made public. This will make you conscious of the situation which will lead to embarassment. If you get sufficiently embarassed about it, you will find a way to cure the trouble. One way to do this would be for the SCFO chief to figure out some productive work for the otherwise "idle" man to be doing. Then he would be adding to the productive total of the SCFO and the nation.

We can expect several typhoons during each year and you can be working in the field during a typhoon. That fact we all recognize. You can seldom predict on Saturday when the next week's schedule is being prepared, just which or how many days it will rain enough to stop field work. If you have work planned for each day and the weather prevents you from doing it, the work can be carried over until the next week's schedule. But if you plan for only 3 days work and the weather remains good all week, do you think that you will get 6 days work accomplished? The odds are against it. People seldom exceed the goal that is set for them.

If you use nice weather the first of the week or month to do your required paper work and then it rains, you have nothing for the staff to do. Reverse this and do the field work while the weather is good and reserve the paper work for rainy days and you can keep the crew employed all of the time.

Some members of the staff will be sick or absent for some other legitimate reason. Then the work schedule must be revised. If the absent man was to be working alone, his work can be postponed until his return. If he was a member of a team, someone else will have to be sent to replace him or a temporary man employeed. Schedules must be kept flexible. They are only a tool to help maintain an orderly flow of work. There is nothing scared about them. The man that made them can also change them, and should do so when that is necessary for better production. Changing a schedule is not a matter of "losing face" but rather a matter of "winning a race".

Some members of a staff will have more training and experience in surveying, construction and other items of work. These differences in experience should be considered in making the schedule. This also points out the need for personnel training—on the job—so all will become better qualified for each of the jobs to be done.

Scheduling work for the entire staff for the coming week also permits better planning of the use of the level, the pickup, or other equipment. We do not have an unlimited supply of tools but by keeping them busy everyday, lots of work can be done with what we have.

Land Use Capability Classification Based on the Permissible Intensity of Use and Need for Protection*

December 10-13, 1954

Usually it is only after the soil has been destroyed or impoverished by ignorance, selfishness, or force of circumstances and man perishes or is forced to migrate or lower his standard of living, that it becomes evident how dependent man is upon the soil, not only for his food but also for clothing, shelter and fuel.

In the world there are about 1.6 billion hectares of land immediately available for cultivation. The world population is well above 2 billion and is increasing annually. This average of 0.8 ha. per person must produce not only his food and fiber crops but the raw materials for industry as well.

This world supply of land is being depleted at the same time that the demand upon it is being increased by the expanding population and the rising standard of living, of which we approve. Technical advances in agriculture can increase food production some, but there is a limit to the relief that can be expected from that source. The pressure on the land is becoming greatest in densely populated lands, one of which is Taiwan, with nearly 10 million population and only 829,200 hectares of arable land. Here, each hectare must support 12 people. With the population increasing 3.4 percent annually and the need for a higher standard of living, Taiwan can ill afford to neglect the conservation of its soils.

Dr. Robert M. Salter, former chief of the Soil Conservation Service, U. S. Department of Agriculture, defined soil conservation as: "Proper land use, protecting the land against all forms of soil deterioration, rebuilding eroded and depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income-all at the same time".

To accomplish these laudable objectives, an often quoted slogan is "To use each acre of land within its capabilities and to treat each acre of land according to its needs." Whether your immediate interests are in crops, soils, fertilizers, forestry, horticulture, agricultural engineering, agricultural economics or any other related agricultural science, this motto should appeal to you as promoting your special interest.

By the term "intensity of land use" is meant the frequency and extent of plowing and cultivation which hasten the oxidation of the soil organic matter, thus tending to destroy its structure and to increase the erosion hazard. To illustrate, land producing two crops of rice, a crop of wheat, and perhaps a crop of vegetables each year, is being used more intensively than land producing one crop of corn. Corn is a more intensive land use than wheat because it requires more cultivation. Land in hay or pasture is being used much less intensively and forest land is perhaps the least intensive land use of all.

Before undertaking to classify any group of objects, some understanding should be reached as to the purpose of the classification and as to the characteristics which are to be given consideration.

Motor vehicles are usually classified as $^{1}/_{2}$, 1, 2, 3, 5, or 10 ton trucks, solely on their rated load capacity. There are some correlations between load capacity, horsepo-

* Presented to the Joint Annual Convention of the Agricultural Association of China, the Society of Soil Scientists and Fertilizer Technolgists of Taiwan etc.

wer, gross weight and cost price but these factors do not enter directly onto the classification by rated load capacity.

When land is classified according to its ability to sustain intense cultivation without deterioration, only those factors which effect this ability should be considered. Unless fertility, cost price, or difficulty of cultivation, eliminate a tract of land from consideration as agricultural land, these factors have no bearing on agricultural land capability classification.

Such classifications should not be made capriciously but should be based upon facts—physical characteristics of the soil which can be seen or measured in some way—characteristics which have a bearing on the ability of the soil to sustain intense use or which limit its use to lower intensities if permanent damage is to be avoided.

Some of these factors or characteristics are very apparent and their effect on the limitation of use is quite obvious. Others are less conspicuous and their effect in limiting land use is not so readily recognized. However, each characteristic, like the factors in a mathematical equation, has a bearing on the final result.

One of the most obvious soil characteristics—one that can be seen at a distance and can be measured readily—is the slope. Its importance as a limiting factor to the permissible intensity of land use is generally recognized, even though some individuals differ on the extent of the limitation. The determination of *quantitative values* is a matter to be settled by examination in the field and not at a convention like this. Therefore, we will confine our remarks to the principles involved in the consideration of classification.

We all recognize that on steeper slopes there is a tendency for soil to move down hill faster during cultivation and also that loose particles erode worse on steeper slopes. Slope is one of the *most important* factors in limiting land use and it must not be minimized.

Another characteristic of the soil which is recognized as a limitation on use, is the texture of the surface soil. Very sandy soil has a loose structure and is characteristically low in organic matter. If it is cultivated too much, the structure is destroyed and the organic matter decreased. This of course can be off-set to a degree by supplying more organic matter in the form of compost, manures, or crop residues. Nevertheless, this sandiness constitutes a limitation on land use and may necessitate wind erosion protection.

At the other extreme, dense clay soils are limited in their use by the slowness with which they take in water and by the tenacity with which they retain it when the plants need it. There are also difficulties in the cultivation of clay soils due to their structure.

The texture of the subsoil, though not so readily seen, also has a bearing on the use that can be made of the land. Loose sandy subsoils will not hold enough water to carry a crop through a dry spell and so, only certain crops can be grown on these soils. At the other extreme, some lands with nice surface soils have such heavy, impermeable subsoils that water penetrates them only very slowly and vertical root growth is retarded. Thus their use is limited by this factor.

The manner in which the individual soil particles are joined together into larger, semi-permanent units determines the soil structure. Incorporating more organic matter into the soil or allowing it to lie undisturbed for some time after successive wettings and dryings, tends to make the individual particles collect into aggregates. This arrangement permits better aeration, better internal drainage and easier root penetration, all of which favor plant growth.

Excessive cultivation, especially when the soil is too wet or too dry, the reduction in organic matter, or the accumulation of certain alkaline salts like sodium carbonate, tends to defloculate or disperse the soil aggregates. This results in either a massive or an incoherent structure which reduces aeration, infiltration and root penetration.

Since structure is so directly effected by management and can be manipulated by the farmer, it is not an inherent physical characteristic which determines land use capability. Therefore, altho it is recognized as an important attribute of any soil, structure apart from texture is not considered, in land capability classification.

Though the surface soil may be of good texture and structure, if it is extremely shallow or thin, there is not sufficient space for the feeder roots to develop nor for moisture storage. Thus the depth of the soil, though not evident from the surface, is a characteristic which can impose severe limitations on the use of land.

Some other characteristics which cannot be seen but which can be measured, are the reaction or pH value and the salinity or alkalinity. Slow, inadequate internal drainage or susceptibility to frequent overflow are factors which limit the use of land for many crops, although they would not interfere with rice production. Land with a loose subsoil which would not hold water for rice might be very suitable for sweet potatoes. Thus a limitation for one crop may be an asset to another.

By the expenditure of labor or materials it is sometimes socially desirable and economically feasible to alter certain characteristics and, by so doing, change the permissible land use. A good example of this is the construction of level paddy fields on the side of a hill. In this operation the slope factor of the land is eliminated and, if other conditions are favorable, the potential land use is the same as in the valley floor.

Each characteristic must be considered separately as well as associated with the others because any one of them, if sufficiently disadvantageous, can make the land unfit for a certain land use. Excellence in one characteristic cannot be substituted for a deficiency in another, any more than a surplus of petrol in the tank will permit driving a car without oil in the crankcase or water in the radiator. Any one of these characteristics may be the limiting factor. With this in mind we can see that it is necessary to evaluate all pertinent factors.

Suppose that you were the administrator of a large hospital and clinic with numerous patients coming for diagnosis daily and, as is frequently the case, you were short of technical staff. Now suppose again, that some one came forward with a proposal to speed up and simplify the diagnosing of the patients by merely taking their temperatures and referring to a chart for treatment. All with temperatures below 98 to get blood transfusions, all over 100 to get a purgative and if over 102 to have their appendix removed.

The advantages of such a system are evident and should appeal to an efficient administrator. By such a system, large numbers of patients could be diagnosed each day. Therefore it would be speedy. It would also be economical. Instead of hiring more high salaried doctors and laboratory technicians such as are doing the diagnostic work at present, the new system would operate with relatively inexperienced and much cheaper personnel. Wouldn't that be simple, fast and cheap? What more could an administrator want?

But—you wouldn't accept any such scheme even though it was fast, cheap, and simple to administer. Why? Because it would miss the mark so often and with such disastrous results that it would be criminal.

In diagnosing land capability it has sometimes been suggested that the slope alone be taken as the criterion because it would be a quick, simple procedure, easily understood by the farmers. Slope is *one* of the most important items in determining land capability class just as temperature is important in medical diagnosis. However, there are other considerations such as accuracy and dependability that are more important than speed, cost, or simplicity.

It is true that any system of land capability classification which requires the examination of each field by trained personnel will, like the medical clinic, be slower and more expensive than mass diagnosis. It is also reasonably certain that the survey approach will be more effective and produce better results than any oversimplified method, the principal merit of which is that it is cheap, quick and easy to administer.

When the Agricultural Adjustment Administration in the United States was forced by legal action to change from a purely acreage control program to one of soil conservation, it was proposed that, along with liming, fertilizing and green manuring which could easily be measured by the acre, terracing and contour cultivation should also be included as soil conservation practices for which farmers would be paid after satisfactory performance.

I well remember the consternation of one of the old time extension supervisors when this proposal was made. He recognized these as desirable conservation practices but was sure that such a program could not be administered. Therefore, he was opposed to even considering such a proposal. By the prestige of his position and the amount of disturbance he created, this man was able to block the inclusion of these good practices in that state that year.

The officials of the program were, at that time, simply afraid to face the problems of writing specifications, training lay-out men and inspectors, and devising methods of reporting accomplishments. But by the next year the plans were all made, specifications written and training schools scheduled. Now, both of these are accepted conservation practices and the arguments presented that day sound as ridiculous as the old denials of man's ability to build an aeroplane that would fly.

In considering the matter of classifying land, does it not seem logical that we should first agree upon what approach is the most desirable? Then, having come to agreement on this approach, proceed to work out the details of rules, specifications and procedures for getting that approach into operation. The procedures used elsewhere have not been as simple as reading a clinometer but, when perfected, they have been quite satisfactory.

Would it not be desirable to first make some broad divisions in potential land use capabilities and then, at a later date, make as many sub-divisions as seem justifiable? We might first divide all lands into two major classifications: (1) those *suitable for some* degree of cultivation and (2) those *not suited for any* cultivation. We could easily agree that such a division *should* be made, even though we did not all agree, at first, just *where* the dividing line should be drawn. Again let me say that I believe that the exact specifications of such a division should be determined in the field while examining the land in question, rather than here in convention.

Among the soils which are admittedly cultivatable, there will be some with so little slope, such good texture, structure and depth and which have so few, if any, limitations on their use that they can be used for practically any rotation of climatically adapted crops. These, we might designate as Land Capability Class I Soils, since they have practically no limitation on use and require practically no protective practices.

Class II might be set up to include those soils which, because of mild slope presenting a slight sheet erosion hazard, slight sandiness presenting a possibility of wind erosion, poor drainage limiting the time of year that it could be cultivated, susceptibility to flooding which makes crop production more hazardous or heavy subsoil making it susceptible to drought damage. These characteristics singly and in slight degree are not serious but, nevertheless, they are limitations on the use of the land and require some simple protective practices or mild restrictions in the use of the land.

The next class might include soils with the same characteristic but present in greater degree, necessitating more restrictions in use and more extensive or intensive conservation practices. The number of classes and subclasses could be multiplied indefinitely and the tendency is to do just this. Since each additional class adds to the complication of administration, the number of classes should be held down as much as is possible, compatible with adequacy in covering the various conditions. After all, these classes are man-made rather than natural.

To illustrate the difference between natural and man-made classes let us take a little example. If we pour out a box of mixed machine bolts, we will find that they can be classified into definite length and diameter classes with no "in-betweens". Now, if we pour out a sack of potatoes we will find all different sizes but they will not fall into distinct classes like the bolts. There will be a gradation from large to small and you can line them up in order of their size, largest on the left and smallest on the right. I expect that most of us would agree quickly on this order or at least we could determine the order by weighing the disputed ones.

But, if each of you were asked to locate the division between the large and the small potatoes, there would be a lot of different lines drawn. The difference in your opinions could not be settled by measurement nor argumentation. This sort of question, being arbitrary in nature, can only be settled by agreement among all of the disputants or by delegating to some individual or committee of authority necessary to make an administrative decision.

After such an administrative decision is made and the location of the dividing line becomes definite, those potatoes to the left are "officially" big potatoes and those to the right are "officially" small potatoes. The administrator might, of course, divide the potatoes into 3, 4, or more piles if there was sufficient reason.

The major class of lands not suitable for any cultivation can be divided into subclasses, the most intensive permissible use of which is: (a) watershed protection, recreation or wildlife preserves, (b) production of forest products or, (c) grazing. Thus intensity of land use would be recognized, even on non-agricultural lands.

One such class that has been set up in the United States and which seems to be applicable here, includes those lands too sterile, too stony, too steep or too erosive even for the production of forest products. These lands are considered suitable only for recreational or wildlife purposes (hunting, fishing, game preserves, etc.) or for watershed protection purposes.

In the United States the Soil Conservation Service with which I worked, has set up eight Land Use Capability Classes. However, that is no indication that here in Taiwan you need the same number of classes. Your classes should be based on Taiwan soils, Taiwan conditions and the needs of Taiwan's agriculture.

This classification scheme was first proposed and adopted some 20 years ago and is still in the process of being changed slightly now and then. As we study the soils we learn more about them and their capabilities. With this added information the classification scheme can occasionally be improved and you cannot make progress without making some changes. Therefore, it will not be surprising if you here in Taiwan do not succeed in settling the subject of Land Capability Classification at your first committee meeting.

Should we not, after considering the matter, first decide on whether or not it is desirable to set up Land Use Capability Classes? If you decide in the affirmative, then you can set up working committee to draft the definitions of the classes and start the demarcation of the boundaries between the several classes. In such a diverse island with such an intensively developed agriculture, this will not be easy to do. But, because of these same reasons, it will be well worth the time and effort. That it will be difficult and time consuming is all the more reason for starting the job at once.

Just defining the different classes and agreeing on the slope, depth, texture and other specifications of each, does not solve the problem of soil conservation. Land Use Capability refers only to the permissible intensity of land use or to the need for protective or remedial conservation practices. These practices will have to be devised, tried out, and finally approved for each soil condition in each Land Capability Class.

There will be a number of different soil conditions in each class and each of these conditions may require different treatment, for instance:

A Class II land that is sandy enough to present a wind erosion hazard might require only the establishment of a field windbreaks. Another Class II land that was poorly drained might require the establishment of a drainage system. Still another sloping Class II field might need contour cultivation. Thus, though the intensity of the need is the same in each of these instances, the practices themselves vary with the soil conditions.

The motto of the U. S. Soil Conservation Service, which I pass on to you is as follows: "Use every acre of land within its capabilities and treat every acre of land in accordance with its needs".

Whether your immediate interest is in crops, soils, fertilizers, forestry, horticulture, agricultural engineering, agricultural economics or any other allied agricultural science, this motto should appeal to you as promoting your special interest. The matter of setting up Land Capability Classes is one of the first or basic steps in using each hectare in accordance with its capabilities and treating it in accordance with its needs.

Construction and Maintenance of Bench Terraces in Taiwan.*

Jan 13, 1961

WHAT is a bench terrace? It is any artificially levelled piece of land. They may be large or small but the determining characteristic is that they are level or approximately so. They may or may not have a dike or levee around them to retain the rainwater.

What is the purpose of making bench terraces? Surplus water which collects when the rain falls faster than the water can percolate into the soil, will runoff of sloping land. This causes erosion in direct proportion to the quantity and velocity of the runoff. It also results in the loss of water which, if retained and stored in the subsoil, would supply the crop plants with moisture during periods of no rain. The principal purposes, then, for the construction of bench terraces are to prevent erosion and to store water.

Are there other types of terraces? Yes. Most of the terraces in the United States and other parts of the world are broad based terraces. These are essentially ridges of dirt built approximately on the contour across sloping fields. Their purpose is to prevent the accumulation of large amounts of water which would cause erosion. By keeping the slopes short between the broad based terraces, the runoff water causes less erosion and is removed from the field on a very gentle slope and at very slow velocity. Broad based terraces have the advantage of being cheaper and easier to construct than bench terraces and no land is lost from cultivation because the ridges, and the channels formed above them, can all be cultivated.

Why are bench terraces preferred in Taiwan over broad based terraces? There are some broad based terraces in Taiwan but they are confined to gentle slopes of ten percent or less and are practical only in large fields. Most of the erosive soils now in cultivation in Taiwan are on slopes steeper than ten percent. Most of the cultivated uplands are owned and operated in very small individual tracts or fields. If broad based terraces were constructed, each terrace would have to cross many fields operated by many farmers and growing many different crops. This would make it difficult or impossible to keep the channels open. Also, the torrential rains that occur during typhoons would tax the capacity of broad based terraces as they are constructed in America. Therfore, bench terraces are used mostly in Taiwan because of the steepness of the slope, the small size of the individually owned land tracts and because of the typhoon rains.

If ten percent is the upper limit for broad based terraces, what is the slope limitation for bench terraces? Theoretically, bench terraces could be built on any slope but practically, sixty percent is about the limit. The reason is that the steeper the slope, the more dirt that must be moved to construct a bench terrace of given width. Eventually, a point is reached at which the value of the bench for cultivation will not justify the expense of construction.

Why does a bench on steep land require more work than one on gentler sloping land? (Sketch on a blackboard a bench one meter wide. Then show two slopes from the lip of the bench. Also show the slope of the riser at 1:2 slope and where it intercepts the two slope lines. The area between the upper and lower slope lines represents the extra soil that must be excavated and moved on the steeper slope.)

* Speech at Provincial College of Agriculture

Another important consideration in the expense of constructing benches is the width. The amount of excavation (and the fill) varies with the square of the width of the bench. If the width of the bench is doubled, the amount of soil moved is increased by four, but since the area would contain two of the narrower benches, the work for the entire area would be only twice as much for the wider bench. If the bench were three times as wide, the dirt volume would be increased by nine times but, divided by the three benches, this would mean that it would require three times as much excavation and fill to make the benches three times as wide. The cost would be greater than that because the wider benches would require deeper excavation which would be harder to do, and the excavated soil would have to be moved a greater distance. (Illustrate with diagram on blackboard)

The fundamental operation in building bench terraces is to cut soil from above the finished grade line and use it to make a fill below this grade line. The cuts must equal the fills. Ordinarily, three lines of stakes are set for the construction of bench terraces. The center line is the point at which there will be no cut and no fill. This stake determines the elevation of the bench. A top line of stakes is set to make the upper limit of the excavation and a lower line marks the lowest extent, or toe, of the fill.

Depending on the permeability of the soil and the crops to be grown, these lines of stakes may be set on the exact contour or they may be given a slight grade toward one end where the surplus water is to be discharged. Pineapples will not grow well with wet feet and consequently require a well drained soil on the other extreme, it is necessary, or at least desirable, that benches for growing paddy should be level and constructed to retain all the water.

On the demonstration area on Tatu-shan, the benches were made level with no outlets. Because of the rapid rate of percolation of the red lateritic soil at that location, crops of sweet potato, sugar cane, peanut, etc. suffered no water damage even when the rains amounted to 16 inches in 24 hours. Having no outlets on these terraces also eliminated the work and expense of constructing a water disposal system. ON THIS SOIL, this system of holding all of the water has worked satisfactorily. This is not the case on all soils.

Where the soils are impermeable or only slowly permeable, the accumulated surface water must be removed before it damages the crops. This requires that outlets be constructed and that the benches themselves be built so that water will be removed slowly as it accumulates. This can be accomplished by building the benches with a reverse slope, or a slope back toward the hill side of the bench. This reverse slope causes the surplus water to collect at the back side of the bench where it can be collected in a drainage furrow and taken to the outlet.

On level benches a ridge or dike is built along the lip or front edge to retain the water and prevent it from flowing down over the face of the bench. But if water is collected and held for some time on filled soil, the soil will become saturated. In this saturated condition it will be softer than the natural soil and is prone to slip or slide and cause a failure of the bench. If the water is collected on the natural soil at the back side of the bench, that soil will not become so soft and, in addition, soft soil at the back side is not as apt to slip as if it were on the lip of the bench.

Unless very unusual procedures are followed, the filled soil will not be as compact as the natural soil and, after a season of wetting and drying, will settle in making a fill, you should always anticipate that the settling will be at least 10 percent of the depth of the fill. Therefore if a fill of 80 cm. is required to attain the desired grade, make the fill 88 cm. so that after settling it will still be 80 cm. If the fills are made entirely by hand labor, the settling will probably be more than 10 percent and allowance should be made accordingly.

Since the farmers of Taiwan are already familiar with benching as a practice, it is not necessary to spend a lot of time convincing them of the merits of benches. They have been making them for hundreds of years and appreciate them. What the PDAF/JCRR soil conservation program has done is not to introduce a new practice but a new way of doing an old, accepted practice. The traditional method of benching has been to chop the dirt loose with a hoe, scrape it into baskets and then carry the baskets on a pole over the shoulder to where the fill was to be made. Very good benches can be made by this method but it is a hard, slow, expensive way to get the job done. What we have done is to introduce some tools that the farmers can pull with their own draught cattle to do the same job easier, quicker, and cheaper.

These tools are of two kinds. The Fresno scraper made in Taiwan workshops, is merely a scoop, like a big shovel, with a handle to control it and arranged so the cattle can do the hard work. With such a scraper, one man and a buffalo can move as much dirt as four men working with hoes and baskets.

The other type of tool is the V drag which resembles a small road grader with the blade mounted on a sled rather than on wheels. These tools can also be made locally and without great cost. This V drag is made so that it can be reversed at the end of the row and will move the dirt toward the downhill side regardless of which way it is pulled.

The V drag is used primarily for the construction of narrow benches of 3 meters or less in width. The Fresno scraper is used for the wider benches where it is possible to turn with the cattle and scraper. Both of these tools are limited in their use to lands that are free of large stones, free of roots and stumps, all of which would prevent the operation of the tools. If the soil is wet enough to stick to the iron blades of the tools, they will not work well as they will "ball up" and the dirt can not be dumped where wanted.

It is customary, but not desirable, when construction is being done by hand labor, to start the excavation immediately above the no-cut-no-fill line and the fill immediately below. As work proceeds the cut becomes deeper and the loose dirt is dumped over the face of the fill. This makes it impossible to compact the filled dirt. When using the Fresno scraper, excavation must begin at the top of the excavation area and the fill must be started at the toe stakes. If you start excavation at the no-cut-no-fill line, you soon have a ledge over which it is not feasible to drive the scraper. If the fill is started at the no-cut-no-fill line, it becomes necessary to dump the dirt over the edge of the fill which is very difficult to do. But if the fill is started at the bottom, each successive scraper load of dirt being dragged over the previous fill, serves to compact it.

With the V drag, the excavation is started at the top line of stakes and the dirt is moved by successive steps, down the slope until the desired width of bench is developed. Since the toe of the slope keeps moving down hill, it is not possible to compact the fill. Therefore, when benching with a V drag, at least 20 percent should be allowed for settlement of the fill.

On drainage type bench terraces, or whenever the surplus water is removed from the bench, a waterway must be provided. The importance of waterways cannot be overemphasized. Many otherwise good terracing systems, both broadbased and bench type, have failed because the outlets were neglected. The waterways are usually constructed after the benches because it is difficult to estimate just the exact location and elevation of the outlet before the bench is completed. However, the protection of the waterway against erosion should receive immediate attention as soon as the benches are completed.

The size of the waterway and the kind of protection can be determined only after the maximum flow has been calculated. It is easy to see that the amount of runoff will be proportional to the area of the benches drained. It is also easy to understand why the intensity of the rainfall has a direct effect on the amount of runoff. Some other factors that affect the amount of runoff are the texture and structure of the soil which control the rate of percolation. The moisture content of the soil at the time of a big rain and the cover of crops or mulch also affect the rate of percolation and runoff.

It is the velocity of flowing water that causes it to erode the soil. If the water can be made to move slowly enough, it will cause little damage. What are the factors that control the velocity of water flowing in a channel? The most obvious factor is the slope of the channel. The steeper the channel the faster the velocity but it is more than a direct proportion. Another factor is the friction between the water and the lining of the channel. Water flows much more rapidly thru a smoothly cemented channel than thru a grass lined one and the friction is also the controlling factor when the depth of flow is varied. This is particularly true of grass lined channels.

When the depth of the flow is less that the height of the grass lining the channel, all of the water is impeded in its flow and the velocity is held down. When the depth of water is several times the height of the grass, the water above the grass is free of this friction and that part of the water flows much more rapidly—all on the same slope. The practical application of this is that if the given amount of water flows too rapidly in a narrow, deep channel, it can be slowed down by making the channel wider, which will automatically spread the water in a thinner flow and reduce the velocity.

Before building drainage type benches, you should study the location to decide where the best place is for the outlet. Other things being equal, the gentlest slope will be the easiest to protect. However, if all possible sites are so steep that grass cannot be used and structures are required, sometimes it is desirable to choose the steeper sites if there are good foundations for structures.

A good sod of a sod forming grass like Bermuda grass, will safely carry water at a velocity of 5 feet per second or 1.5 meters per second. Unless the flow of water can be held to this velocity, at its maximum flow, the grass will probably be destroyed and the waterway will fail to protect against erosion. Sometimes the topography is such that a part of the fall can be handled by structures and the remainder by sloping grass waterways. This will be more economical to construct than to use structures entirely. Hovever, even tho structures are more expensive to build, if they are properly designed and constructed they should be a permanent answer to the waterway protection problem.

One frequently overlooked feature of building a line of structures is that construction should start at the bottom of the slope. Sometimes you have to go a long way down the slope to find a stable grade. If you do, that will make the structural approach more costly and laborious but that is the way to do it. Terracing, on the other hand, should begin at the top of the slope and proceed downward.

Some of the Wild Creek control structures that failed in the flood of August 1, 1960 were built in the midlle of a slope with no protection below them. When the flood came, they undercut their stilling basins and in some cases the entire structure failed. Of course, the runoff from two or three small benches would not cause any damage as great as that but the same principle applies.

Benches and drop structures, like houses, require occasional maintenance. Even a well built house may occasionally need a leak in the roof patched or some other minor repairs. Benches should be inspected after each big rain to see whether or not they need any repairing. A small break in the retaining dike can be repaired easily with a few shovelfuls of dirt but if this is neglected, the concentration of runoff thru the break may cause a major gully to develop. In maintenance, as in protecting your liberty, vigilance is the basis of success.

After raw subsoil has been exposed during the construction of bench terraces, the crops produced on such sterile areas will be low in quantity and quality. In order to bring the fertility of the soil on the bench back up to the average of the field it is necessary to apply fertilizer, compost, manure or to grow green manure crops to increase the organic matter content. While constructing terraces will prevent erosion and conserve more water, the benches themselves will not add to the fertility. They only make it possible to retain the plant nutrients that are applied.

As the benches are cultivated from season to season and from crop to crop, every effort should be made to maintain a level, even surface so as to prevent the ponding of water that might be detrimental to the crops. In plowing the benches, care should be exercised to prevent the cattle or the plows from knocking down the water retaining dikes, permitting water from the bench to concentrate on one place and cause erosion.

If drop structures are to be used for outlets from the benches, the use of step type structures should be considered. Having available a convenient and stable means of entry and exit will discourage climbing up and down the earth fills. Continued use of the fills as pathways, especially when wet, will encourage erosion.

If rock are encountered in the bench construction, they can be used to construct a stonewall face on the risers. However, it would not be economically feasible to transport rocks very far for this purpose. The risers should be shaped at a slope of 1:2 or one unit of measurement horizontally to two units vertically. If the risers are shaped too steep, they will eventually weather and slough away to the natural angle or repose for that soil texture. Establishing a cover of grass on the risers will protect them from the beating effects of the rain and will prevent erosion. The grass can be harvested for forage for the cattle but the risers should never be scraped bare with a hoe as is sometimes done when the farmers want to make them "look nice" for an inspection.

Which Soil Conservation Practices Should be Used?

October 1958

There are many, many different soil conservation practices. Under specific conditions, each of these has a place of usefulness. But certain practices are appropriate more frequently than others. The best practice for a given set of conditions can be selected only by considering a number of factors.

Of all of the factors, slope of the surface soil is the most easily seen and understood. Steep slopes which are prevalent in Taiwan, make broad-based terraces impractical on many hillside fields. But on some fields with gentle slope, this practice is appropriate and should be recommended. Other factors beside slope must also be considered in choosing between broad based and level bench terraces. The size of the field and the kind of equipment which will be used in cultivating it must also be considered.

Even if the slope is such that the construction of broad-based terraces is feasible, if the land is owned and operated in small patches, each of which is going to be planted to different crops, broad-based terraces would lead to confusion and dissatisfaction. The channels, if planted to different crops, could be kept open and functioning, only with the greatest of difficulty.

For this reason bench terraces, with each operators land being in separate benches, were planned and constructed on Tatu Mountain above Chingshui. If the Taiwan Sugar Corporation were to operate these fields of such small dimensions with their tractor equipment, the results would not be as satisfactory as with broad-based terraces. Hence, even on the same fields, different practices should be recommended for different operators.

The practice of contour cultivation has wide application on sloping land. On short, gentle slopes of permeable soil, it may be sufficient, but usually it is best combined with broad-based terraces or strip cropping, or as a starting practice, preparatory to these more complete practices. When used alone it may prove to be inadequate in several ways.

The intensity or rate of the rainfall, and the infiltration rate or rapidity with which the water soaks into the soil, determine how effective contour cultivation will be. If the intensity of the rain does not exceed the rate of infiltration, all of the rain will be absorbed as it falls and none will collect on the surface. When the intensity of the rainfall does exceed the infiltration rate, the excess will collect on the surface and, if the ground is sloping, runoff will occur. Contour furrows act as reservoirs to impound this runoff until the rain slackens and it can be absorbed. After this happens, the entire capacity of the contour furrows is again available for storing runoff water.

If the intensity of rainfall exceeds the infiltration rate for a long enough time, the furrows become completely filled. After that the excess must runoff and will probably cause erosion. Since it is not practically possible to have all points along the ridges between the contour furrows at exactly the same elevation, runoff will occur first at the lowest point in each ridge. The concentration at this one low point, of all of the water collected by the entire furrow will probably cause severe erosion unless one point is intentionally left low and some protection is provided at this point by grass sod or by mechanican structures.

Contour furrows used in the production of sugar cane, corn, kaoliang, sweet potatoes, etc. are large and their capacity can be maintained throughout the production cycle. Therefore, contour cultivation is more effective with these crops than with peanuts, for instance, in which the furrows are small and are soon obliterated. Cassava could be grown in fairly large furrows but, after harvesting, all of the erosion protection which they had furnished would be lost.

Consequently, contour cultivation alone furnishes adequate protection against erosion only on permeable soils, on gentle slopes, and in areas where the rainfall is well distributed and of low intensity. This last requirement practically eliminates contour cultivation as a single practice on Taiwan, because of the frequent typhoons.

Strip cropping with contour cultivation is more effective than contour cultivation alone, but even the combination should be limited to areas of low rainfall intensities. The infiltration rate on the erosive strips is less than on the protective strips. Therefore, at a certain intensity of rainfall, runoff will collect on the erosive strips and flow down into, and be absorbed by, the protective strips. When, as during a typhoon or torrential rain, the rainfall intensity exceeds the infiltration rate of the combined strips, the excess will runoff and erosion will result. Erosion on a strip cropped field will occur less often and will not be as severe as on a field protected by only contour cultivation but, in a typhoon country, protection will often be inadequate.

The fact that many hillsides in Taiwan are farmed in small tracts by the multiple owners, achieves the principal advantage of strip cropping. Since the different farmers grow different crops and plow the land at different times, the entire slope will not be in the most hazardous condition at any one time as it might be if it were farmed as one field.

Contour cultivation and strip cropping may occasionally be recommended, particularly as a starting practice. Broad based terraces are appropriate on large fields and gentle slopes. Bench terraces will fit more conditions and provide better erosion protection, although they have the disadvantages of costing more to construct and of exposing infertile subsoil on a greater proportion of the cultivated area. Their advantages are:

1. Bench terraces are more adaptable to the characteristic Taiwanese pattern of small field ownership and operation.
2. Bench terraces with reverse slope or with a retention dike along the lip retain more excess water than any other practice. This not only prevents runoff and the attendant erosion and flooding, but also increases the subsoil moisture for the use of the crop plants.
3. Bench terracing is adaptable to steeper slopes, practically eliminating the slope factor from consideration if the soil is deep.
4. Bench terraces with retention dikes do not require outlets on permeable soils, as all of the water is absorbed. This is not the case in heavy, impermeable soils which do require protected outlets.
5. Bench terraces with their greater storage capacity, can withstand without damage, more intense rains than broad-based terraces or than strip cropping.

Land Use and Soil Conservation Planning

The degree of soil erosion and the kind and amount of practices needed to control soil erosion are determined largely by rainfall, kind of soil, slope and land use. The permissible intensity of land use is ordinarily determined after considering the climate, soil, slope, and possibly other factors. Any possible land use seems to be permissible in Taiwan because of the population pressure. Because of this, the procedures used in determining land use in the United States and many other countries, are not applicable here. However, the basic considerations are the same, i.e. "How can land be used permanently for adequate production without destroying it?".

The population of Taiwan is steadily increasing. This increases the demand for the products of cultivation. The area of arable land is not increasing. In fact, it is being decreased each year by land being destroyed (1) by soil erosion and (2) by the occupation of arable lands for industrial and military purposes. The farmers who are dispossessed by military and industrial encroachment on the arable lands, have moved to the hills, cleared the forest, and have started farming there. Often, there has been little regard for the consequences.

There they are illegal occupants, or "Squatters", with no legal rights of tenure. Nevertheless, the combined police and armed forces apparently dare not evict them. Even buying out their nonexistent rights to tenure would be futile. There is no better place for them to go to farm. Furthermore, if these farmers were forced or induced to move out, some other squatters would probably occupy the land the next day so the problem would not be solved.

It appears then, that we may as well face the fact that the steep lands are going to be cultivated permanently or until they are destroyed to the point where cultivation is not profitable. I don't believe that there is any "quick, cheap, and easy" solution to this problem. But let us face it and see what can be done.

If you wish to build a table 2 meters long, you would try to buy boards 2 meters long for the top of it. But, if the longest boards that you have or can get are only 1.5 meters, what will you do? There are at least two solutions. The simplest is to make your table 1.5 meters long instead of the 2 meters that you want. The more laborious solution would be to splice short boards together to make the 2 meter table that you want and need.

Applying this same principle to land use problems, we would like to have level or only slightly sloping land to cultivate. We find that the limited supply of level land is already taken. We know that the steeper lands (1) will yield less crops per hectare, (2) will soon be destroyed, and along with their destruction (3) will cause severe damage to lands and canals below them. So, what shall we do?

We must either (1) contract our needs to what can be produced on the arable lands, or (2) continue to ruin the steep lands, or (3) apply conservation practices to the steep lands, which will protect them from further damage. In many cases this will mean contouring or benching of the steep slopes that must remain in cultivation to supply our needs.

Most of the literature regarding land use will tell you that lands of a certain degree of erosion hazard because of slope, soil type, or climate, are not suitable for cultivation, but should be used for forest or pasture. Those statements are correct when applied to those lands in their present condition. The need for food or a place to earn a living must be considered from a social, political and a humanitarian standpoint. However pressing the need, this does not in any way reduce the erosion hazard. This can only be accomplished by changing one of the physical factors.

We recognize that there are variations in the amount and intensity of rainfall from year to year. But we know, too, that there is nothing that we can do to change or to control this rainfall factor. We know that some types of soil are much more susceptible to erosion than other types. But, aside from slightly increasing the organic matter content, there is nothing that man can do (on an economic basis) to change the texture of the soil.

That leaves only slope to consider if we intend to contine the intensive land uses. In many countries where there is plenty of land available, the land use factor is the one that would be changed to reduce or control erosion. Land formerly eroding under cultivation, can be protected by planting to grass or aforest cover. But, in densely populated lands like Taiwan, such a change in land use would reduce food supplies below the national needs. Therefore, we must consider changing the slope.

Changing the slope by constructing bench terraces is an old and accepted practice in Taiwan. So, you will not have to explain the merits and advantages of level benches. The farmers know what they are. They like them and they want them.

They have already built them where irrigation water is available so they can grow paddy. Some have also been built on the weather depending fields and on uplands, above the sources of irrigation water. Without irrigation the returns or profits per hectare are not so great. Therefore some of the farmers have felt that they were not justified in spending the money or time to build the benches where they could not irrigate.

In the past practically all of the benches have been built by hand, chopping the soil loose with a hoe and carrying it in baskets to make the fills. Even with the cheap labor in Taiwan, this method of construction is expensive. If you can demonstrate to the farmers a cheaper, easier method of accomplishing this same job, they will do more of it. So, your job as soil conservationists in this case is not to introduce new practices, but to work out and demonstrate new and better methods for doing old, accepted practices.

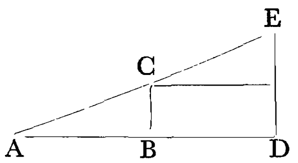
Let us not fall into the error of thinking that there is only "one best way" of doing this or any other job. You will have to adapt your demonstrations to the slope of the land, to the amount and size of the stones present, to the width and length of the benches to be built and to the tools and sources of power that most of the farmers in the community have available. In other words, if you wish to succeed you will have to keep thinking and not just proceed on the basis of custom or habit. Following precedent is mentally the easiest way but seldom the most effective or efficient way.

One problem that is always present and one that materially effects the cost of construction, is how wide to make the benches. The farmers naturally like to have wide benches since this makes cultivation more convenient. We must know, and then explain to them, that the wider benches cost more to build. If the slope is not steep, even the increased cost may be within what the farmer is willing and able to pay. But it will be more for the wider benches.

Whatever the slope, whatever the method of construction and regardless of how much rock is present, the amount of dirt to be moved, increases as the square of the width of the bench. This means that if you make a bench twice as wide you must move four times as much dirt. If you make it three times as wide, you must move nine times as much dirt.

There are also other factors which are against wide terraces. (1) As the benches get wider, the depth of the cut becomes deeper and usually this deep cutting is harder to do and the exposed subsoil is less fertile. (2) As the bench becomes wider, the volume of dirt to be moved not only increases but the distance it must be moved also increases.

A simple diagram will illustrate this.



The amount of the cut will equal the amount of fill in all cases so we can consider only the cuts and the distance the soil must be moved to the center line. Let us assume a cut AB 2 meters wide and 1 meter deep BC. The cross section of the cut will then be found by the formula $\frac{\text{Width} \times \text{depth}}{2}$ or $\frac{AB \times BC}{2}$ or $\frac{2 \times 1}{2}$ which is 1 $M^2 \times 1 = 1$ M^3 Now if we make the width twice as wide or AD is 4 meters then DE is 2 meters and $\frac{AD \times DE}{2}$ is 4 $M^2 \times 1$ $M = 4$ M^3 or four times as much volume per unit of length.

Now if we assume that the dirt from ABC must be moved an average of 1 meter to the A centerpoint, in the wider bench the ABC section would have to be moved this same distance. But the BCDE section of 3 M^2 would have to be moved an average of 3 meters to the centerpoint.

Thus, the 2 meter bench would require moving 1 M^3 for a distance of 1 meter. The wider bench would require this same work plus moving 3 M^3 a distance of 3 meters or a total of 10 $M^3 \times M$ units. The ratio of required work then would be 1:10 though the amount or dirt moved was only 1:4 and the width 1:2. This ratio of 1:10 makes a great difference in the construction cost.

The actual width of bench needed for convenient operation will vary somewhat with the crops to be grown. For tea or pineapples a bench with as little as 3 meters of flat surface is satisfactory. For sugar cane or other crops where more of the work is done with cattle and where carts and other implements must be turned on the bench, wider benches are more convenient. However the farmer needs to consider the balance between the added convenience of the wider benches and the added cost of their construction.

Although sometimes our budgets will permit us to spend the money to make wide benches, we should at all times consider that what we demonstrate must be practical for the farmers to imitate. Therefore, we should not demonstrate anything that is too costly for the average farmer to duplicate.

Another problem that you will frequently have to deal with is, "How steep a slope can be economically benched?" That will be determined by several factors such as (1) how badly the farmer wants or needs more land to cultivate, (2) the nature of the soil and (3) the presence of rocks.

How steep can you make the banks of the bench fills stand? The angle at which any soil material will stand permanently is called its angle of repose. This varies with the texture of the material. By handling it wet or by packing, you can perhaps cause it to stand, temporarily at least, at a steeper angle. But nature will not be cheated. Unless you use a stone wall or vegetative binding cover, the earth will seek its natural angle of repose when it weathers.

If there are enough stones in the excavated material to construct a stone wall, this will make it possible to make the fill stand much steeper, with but little added expense. But transporting stone for any distance makes the wall expensive. Lateritic soils or soils with a high clay content will stand steeper than the loose soil put in the fill above this natural soil.

The PDAF specifications for benches that they will pay a subsidy for, call for ½ laterally to 1 vertically unless there is a stone wall. On sandy soils it is doubtful whether even this angle would be stable.

If the natural slope of the land is 20% or 5 laterally to 1 vertically, a bench 5 meters wide would have a vertical interval of 1 meter. This must include the horizontal space occupied by the bank as well as the flat bench. With a V.I. of 1 meter, the bank on a ½:1 slope would occupy 0.5 meter leaving 4.5 meters for the flat bench.

On a 40% or 2.5:1 slope, using a V.I. of 1 meter the horizontal spacing would be 2.5

meters but since the bank would occupy 0.5 meter the flat bench would be only 2 meters. In order to get a 4 meter bench you would have to use a 2 meter V.I. and move 4 times as much dirt and increase the amount of work (volume × distance) by ten times.

A 50% slope (2:1) would have only a 1.5 meter flat bench with a 1 meter V.I. or 3 meters with a 2 meter V.I. A 60% (1.67:1) slope with a 2 meter V.I. would have only 2.33 meters of flat bench which would be at or beyond the limit of economical construction unless the farmer had stones available to make stone walls or was desperate for A LITTLE MORE LAND TO CULTIVATE.

You see, then, that the width of the benches is a matter that needs to be planned if we are to render proper and useful service to our farmer clients. You are the specialists who, as a result of this training course and subsequent experience, should be able to do for each farmer, certain calculations which he is not trained to make, but for which he must pay the bill.

What kind of tools should be used? One of the first considerations is what kinds of tools are available. Then, what kind of power is available? Bullocks, buffalos or just man power?

If plenty of tools and power are available, Fresno scrapers are worth considering for benches 4 or more meters wide, where there is room to turn easily. Provided, that is, that there are not too many rocks which would interfere with its operation. You will use Fresnos.

If the slope is steep and the benches are to be narrow, a V drag will probably work better than the Fresno. It can be used to move dirt laterally for several meters but is not too satisfactory for moving dirt 4 or 5 meters. If the benches are narrow but very short, it may not save any time to try to use animal power. Also, if there are a great many stones large enough to interfere with the use of animal drawn tools, hand labor may be the most satisfactory method. You can always build terraces that way, but if animal power can be used, it will usually be quicker and cheaper.

When a bench is being built there are several things that should be given attention:

1. The soil should be compacted as it is placed in the fill. There will be some settling anyway, but unless you compact it as the soil is placed, the settling will be excessive. If the entire fill is made with loose dirt, it is not possible to compact it after it is completed.

2. In order to get proper compaction, the fill should be started at the lowest point. The soil should be placed in approximately level lifts or layers each 10 to 15 cm. thick. Each lift should be compacted by trampling under the feet or by tamping with a heavy weight, before the next lift is placed.

3. The practice of starting a fill in the center of the new bench or at the no-cut-no-fill line and merely dumping dirt down over the slope as the fill progresses is apparently very common but it makes it nearly impossible to properly compact the fill. Instead, the filling should start at the toe of the fill and be made in lifts, each of which will be compacted by walking over it during building.

4. Excavation should start at the highest point to be excavated. This is especially true when animal drawn tools such as a V drag or a Fresno scraper are to be used. If excavation is started at the center line, soon there is a step off which makes it difficult to use the tools. Whereas by starting at the top, a continually widening level area is available for the cattle and tools to work on.

By starting the cut at the top and the fill at the bottom, not only is the fill compacted by the cattle during the construction but much unnecessary work can be avoided. It is seldom possible to calculate just exactly how much cut and how much fill will be needed at all points in the bench. By starting in this way, work can proceed until the cut has supplied just enough dirt for the fill and the finished bench contains all of the excavated dirt. If you try to calculate just where the finished grade will be, you may err and have to haul dirt back in to fill a place that you cut too much soil from.

6. Benches should be finished with a slope of at least 10 cm. toward the hill. This is called a reverse slope. There are two reasons for this recommendation. First. Almost any man made fill will settle some. If the fill is made level, any settling will make it slope forward and drain water over the bank. If it has a reverse slope, a reasonable amount of settling will still leave some reverse slope. Second. If water collects on a bench with reverse slope it will stand on the inside or on solid ground. If water collects on a bench with a forward slope it will run down over the bank and cause erosion. Some people try to stop this and do, temporarily, by putting a levee or dike along the lip of the bench. This holds the water for a while but it soaks into and saturates the filled soil and frequently causes it to slip or slide out. Then water from the entire bench will flow out through this break and the erosion may become severe.

Contour Cultivation and Strip Cropping

You will remember that the two principles of controlling soil erosion are (1) preventing detachment and (2) preventing transportation. After you have done as much as you can to prevent detachment by providing a good cover of trees, grass, crops or mulch, there will be some areas which will not be protected at all times. Therefore, in cultivated lands, we need to consider means of preventing soil loss resulting from the transportation of the detached particles.

Transportation of the soil particles requires flowing water. If the water can be made to stand still, there will be no transportation and so, no erosion. If it is not possible to make the water stand perfectly still, the slower it moves, the less it will transport. So, let us consider the matter of slowing down the movement of the runoff water.

First, let us try to get as much of the water absorbed where it falls, as the conditions and crops will permit. That will reduce the amount of the total that must runoff. Next, let us impound as much of the excess water as we can. What is impounded will be standing still and so will not cause erosion. On relatively flat lands which are permeable, this is not too difficult to do. But on impermeable soils or on very steep slopes it is not possible during a typhoon to impound all of the water that falls until it can percolate into the subsoil.

If we try to do this and fail because of inadequate storage capacity, the water will overtop our storage and runoff. In doing this, the consequences may be serious or even disastrous. Therefore, we need to carefully calculate our chances of storing ALL of it before we undertake to do so. In calculating this we must consider both (1) the expected intensity of the rainfall and (2) the rate of percolation. The excess of rainfall over percolation constitutes the runoff. If you calculate that the maximum excess water at any time will be 200mm., you can construct a dike or levee of more than 200mm. height around a level field and contain all of the water. If you build your levee only 100mm. high and the excess exceeds this amount, it will start to flow over at the lowest point. If the overflow is considerable it will probably scour away the dike at this low point and concentrate not only the excess but *all* of the water, which can cause considerable erosion as well as water loss.

On many cultivated fields which have not been benched, it is not possible to store or impound all of the storm waters. What shall we do then? If we can't impound the water, the next best thing to do is to control them and decrease the damage they can do. We do this by decreasing the velocity of their flow.

If we place a furrow, a sweet potato or sugar cane ridge on the exact contour, it will impound water until it is full. If more water falls, it will overtop the furrow and start eroding at that low point. When one row overtops and starts scouring at its low point, that concentrates the excess water from the entire furrow at this weak point. It not only erodes this ridge here, but it also imposes an extra heavy load at a corresponding point on the row below. Consequently, it increases the possibility of this second row breaking at that place. When the excess water from two rows is concentrated on the third, the results are even more certain to be bad. And so on down the slope. Therefore, it is very important that we take steps to prevent the first row from breaking.

A contour row will hold all of a small rainstorm. But the small storms are not the ones that cause the damage. It is the big storms that we must provide protection against. If an army cannot repulse an attack, it must have plans for an orderly retreat. In boxing they call that "rolling with the punches". If we can't make our furrows or levees big enough to hold all of the water, we must make plans for "rolling with the punch" and getting rid of the excess water with the minimum of damage. That calls for a "modified" contour.

By a modified contour we mean a line which, while approximately on the contour, actually has a slight gradient or slope in one direction. The entire line may slope in both ways from the middle but obviously cannot slope in both directions at the same place. The gradient or degree of slope in the modified contour determines how fast the water will flow in it and how much water will be removed. While we *do* want to make the water flow fast enough to remove the excess, we do *not* want it to flow fast enough to cause erosion.

This gradient should not exceed one percent or 1 cm. per meter. With a deep flow of water in a smooth channel, 1 percent slope would give enough velocity to cause erosion. But with shallow flows in rough, cultivated channels this is usually a safe gradient. If we make gradient too nearly level, and then there is some minor obstruction in the channel or furrow, this obstruction may cause impounding and overtopping. Therefore, if we are not going to make the furrow exactly level, we should give it enough gradient to insure that it will have a continuous slope to the outlet end.

If after you lay the row out with only a very slight gradient, during the process of plowing or cultivation, some deviation from the staked line occurs, there may be a reversal of the gradient at some section. This will cause impounding and overtopping. That is why we should not use too slight a gradient. A gradient of 1/10 percent will keep water moving along uniformly in a concrete flume which has no interruptions. But a plowed or cultivated furrow cannot hope to maintain such uniformity. Therefore, we must allow for irregularities by planning a steeper gradient.

When we lay out a furrow so as to discharge excess water at a given point, we must at the same time, plan some means of handling the water when it arrives there. If we do not do this, we have merely transferred out problem and not solved it. When you go to some public office with a question, the clerk there can tell you to go to some other desk or office and you are used to doing this. But when water arrives at the low point in the furrow, it won't go to some other place. It keeps piling up until it breaks over and follows the law of gravity by running down the hill, right there.

Unless there is a field of grass sod or trees handy, we should prepare a protected waterway to remove the excess water that has been collected and has been delivered by the modified contour. This waterway may be merely a narrow strip of grass with the sides elevated enough to contain the amount of water delivered or it may be something more elaborate, constructed of rocks or masonry.

Strip Cropping

There is a difference in the erosibility of different crops and the protection that they provide both against detachment and against transportation. One crop may provide fairly good cover at one season of the year but very poor protection at other times. A second crop may provide no protection at the first season we just mentioned but will provide good protection when the first mentioned crop provides none. We can then use these two crops to complement one another, so that all times there will be some, though not complete, protection in the field.

We call the planting of alternate bands of such crops, "strip cropping". This is an effective practice where the rains are of a gentle nature but is not so effective against torrential storms such as your typhoons. The whole theory and practice of strip cropping is based on the fact that the wider the sloping strip, the greater the runoff and erosion. You can easily understand this if we consider a wide field on a uniform slope. Let us divide this slope into 10 equal strips and consider what happens when it rains.

Small rains will be absorbed at the point where they fall and will cause no runoff. Whenever the rate of precipitation exceeds the rate of infiltration, excess water will collect on the surface and will cause runoff. Assuming that the rainfall is uniform and that the soil conditions are uniform over the entire slope, we will have the following conditions arising. The excess water will collect at the same rate and in the same amounts on each strip.

Strip No. 1, at the top, will have X amount of water collect and runoff. Strip No. 2 will also have X amount of water collect and runoff, but it will also have the X amount of water which ran on to it from Strip No. 1. So, the total runoff from strip No. 2 to Strip No. 3 will be 2x. The same will happen as we proceed down the slope, each strip adding its increment to the total until the bottom of the field receives 10x of runoff water.

Now, if the even numbered strips were in a crop that would cause the soil to absorb more water, they would not have any runoff themselves and might possible be able to absorb the runoff from the unevenly numbered plots immediately above them on the slope. If this were the case, strip cropping would have controlled all of the erosion except that which occurred as the result of water collecting on each unevenly numbered plot and running off to the even numbered plots.

Thus, even though there would be some movement of soil down the slope, most of it would be retained within the boundaries of the field.

The proper width of strips will be determined by the slope and will depend upon the condition of least protection which is that of cultivated land with no cover. The kind of soil and the intensity of the rain, as well as the slope, influence the degree of erosion on a strip of specified width, but there is no doubt that the narrower the strip, the less the erosion. On the other hand, strips made too narrow are too inconvenient to work and will suffer from too much border effect. Some compromise between convenience and control must be made. An effective, but still practical, width of strip is arrived at by the same formula that is used for spacing broad based terraces $\frac{S+2}{3}$=V.I. in feet or $\frac{S+6}{10}$=V.I. in meters.

Strip cropping should be laid out on the contour and, in addition, the crops in the strips should be planted in contour rows. This will reinforce the protection afforded by the strips.

One chronic and well founded complaint about strip cropping and contour cultivation, either exact or modified, is based on the presence of short or point rows. If the slope is perfectly uniform, two contour lines will be spaced the same distance apart, horizontally as well as vertically. Unfortunately, slopes are seldom uniform. That means that if we maintain a uniform vertical spacing by using our levels, the lateral or horizontal spacing will vary inversely with the slope of the land. When the slope becomes steeper, the contour lines become closer together horizontally and vice versa.

With sod crops like grass or with broadcast crops, having the strips of variable width is not much on an inconvenience. But with crops planted in rows and cultivated, this variability becomes inconvenient. Although the width between rows varies with the crops and the other conditions, it will be uniform throughout the field. The result is that there will be room for more rows between two contour lines, on those parts of the field which have gentler slopes. To meet this situation by making the rows wider apart there would make it difficult to cultivate the weeds out of the crop and would lower the yield. The most practical solution is to plant as many rows as usual at the place where the contour lines are closest together and then to fill in the wider spaced placed with additional rows which will not extend for the full length of the field. These are the so called point or short rows.

If a field is being cultivated by hand the point rows are not difficult. They are some inconvenience when using animal drawn tools, but are a real nuisance when operating tractor drawn tools which cultivate perhaps four rows at once, since they necessitate turning the tractor in the middle of the field. This takes time and destroys some of the crop.

If row crops and broadcast crops are being grown in alternate strips, there is an easy and simple solution. You merely plant the row crop in a strip of uniform width, or uniform number of rows, with the contour guide line in the center of the strip. Then plant the broadcast crop to occupy the areas of irregular width between. If the entire field is being planted to row crops, this does not help solve the problem. In a case like this, we just have to plan how to do the planting so the inconvenience will be the least and yet the protection afforded by the contour rows will be maximum.

Let us work out a hypothetical case and see what should be done. Assume an average slope of 14 percent. Then, applying the formula $\frac{S+6}{10} = 2$ m. V. I. With a vertical interval of 2 meters on a 14 percent slope the horizontal spacing of the contours would be 14 meters. If the rows of our cultivated crop were placed 1 meter apart, there would be 14 meters or 14 rows between the contour guide lines.

Now, suppose we come to a place in the field where the slope is 10 percent for a short distance. If we continue to use the same two guide lines, they will be 2 meters apart vertically as they were before, but will be 20 instead of 14 meters apart horizontally. That will mean that there will be room for 20 instead of 14 rows.

Starting from the bottom contour with an elevation of 0.00 throughout the row, let us see what would happen if we planted parallel rows above this guide line.

On the 14% slope the elevation of the rows would increase 0.14 for each row above the guide line. On the 10% slope the elevation of each row would increase only 0.10 so that after 14 rows the elevation at the 10% end would be 2.00 and at the 10% end only 1.40 or a difference of 0.60 from end to end in the 14th row. This would be pretty steep.

Suppose we plant 7 rows up from the lower guide line and 7 down from the upper guide line. The difference in elevation of these 7th rows would be 1.00-0.70 and 1.00-1.30 or 0.30 in each row. This is only half as much maximum slope as we had before so that is better. If you feel that 0.30 m. slope in these rows is not too much we can let this arrangement stand.

But if we feel that even 0.30 m. is still too much slope, we can lay out another guide line at elevation 1.00 and plant on this line and three rows on each side of it

Row No.	14%	10%	Dif.	10%	dif.	10%	dif.
0	0	0	0			0	0
1	.14	.10	.04			.10	.04
2	.28	.20	.08			.20	.08
3	.43	.30	.13			.30	.13
4	.57	.40	.17			.70	.13
5	.72	.50	.22			.80	.08
6	.86	.60	.26			.90	.04
7	1.00	.70	.30	1.30	.30	1.00	.00
8	1.14	.80	.34	1.40	.26	1.10	.04
9	1.28	.90	.38	1.50	.22	1.20	.08
10	1.43	1.00	.43	1.60	.17	1.30	.13
11	1.57	1.10	.47	1.70	.13	1.70	.13
12	1.72	1.20	.52	1.80	.08	1.80	.08
13	1.86	1.30	.56	1.90	.04	1.90	.04
14	2.00	1.40	.60	2.00	.00	2.00	.00

and then three rows from each of the other guide lines. This will bring the difference in elevation down to 0.13 m. which is negligible or not over 1% if the rows are at least 13 meters long.

Now under either of these arrangements there will be room for 6 short rows at the 10% end, tapering off to none at the 14% end. How shall we plant these short rows? If in the first example we continue planting up from the lower guide line to the upper, we will have quite a bit of slope since the 14th row had 0.60 m. slope. If we started planting the short rows parallel to the upper guide line the slope would not get too bad in 6 rows. In the second example, the amount of slope attained would be the same whether we followed the upper or lower set but we could plant the longest row in the middle and taper off in each direction and minimize the slope. Of course, the best but most bothersome solution would be the third example. There we would have two sets of three point rows each with very little slope on any rows.

This subdivision of intervals could be carried on to the point of absurdity but that would not be practical, even though it is theoretically correct. In practice, we should decide on how far from the true contour we are willing to deviate and then, when that limit has been reached, lay out another contour guide line and plant both above and below it.

You should also give some consideration to which side of the field you want the water spilled out on. This will ordinarily be determined by the outlet facilities. Remember this, planting *UP* from the contour guide line sends the runoff water toward the gentler slope end of the field while planting *downward* from the true contour line sends the runoff water toward the steeper end. This should be considered in deciding how to plant your main rows as well as the point rows.

Hillside Ditches and Broad Based Terraces

In the discussion of strip cropping we considered how the width of the unprotected strip of soil effected the soil and water losses. If the length of the slope is not too great, the losses will not be so great as to cause serious damage. But if the slopes are long and all of the land is to be cultivated, we need to break these long slopes up into a number of short slopes. This can be done by building ditches at regular vertical intervals to intercept the runoff water from above and conduct it to prepared protected outlets.

These ditches are sometimes called HILLSIDE DITCHES. Since they serve the same purpose as broad based terraces, they will be discussed together. The only difference is the cross section of the ditch. Either can be level to impound or hold the runoff until it percolates into the soil or they can be made with a slight gradient to conduct the excess water off of the field. In either case, the needed capacity of the ditch or terrace will be determined by:

1. The drainage area.
2. The anticipated intensity of rainfall (mm. per hour).
3. The permeability of the soil under the worst conditions.
4. The gradient of the ditch or terrace.

It is obvious that a wider terrace interval will collect more water than a narrower one and that the longer the terrace, the more water it will accumulate at the lower end. In order to simplify construction, hillside ditches and broad based terraces are usually made the same cross section thruout their full length.

As discussed previously, a small rain causes little runoff and no erosion. Moderate rains may be controlled by mere contour cultivation. It is the typhoon or torrential type of rain that does the damage and which the contour cultivation will not protect against. Ditches or terraces must be designed and built to handle the maximum runoff, not the average.

On very permeable soils the ditches may be made level to hold the water for infiltration, only if they are made large enough to hold the maximum runoff until it is absorbed. If they do not have this capacity and are overtopped, the damage will usually be servere. The problem is the same as with exact contour single rows except that since they will contain more water, the damage from overtopping will be proportionately greater. In calculating the permeability of a soil consideration must be given to the fact that sometimes it will be saturated before the period of maximum rainfall occurs.

For the above reasons, ditches or terraces with a gradient are much less likely to overtop because they start removing water as soon as it begins to collect in them. Consequently have more of their capacity available when a heavy downpour occurs. The steepness of the gradient permissible will depend upon (1) the texture of the soil and its ability to resist erosion and (2) the maximum velocity that is computed for the water when the terrace is running at capacity. Except for very short terraces or short sections at the upper end of longer ones, the gradient should not exceed 0.4 percent. Under most conditions gradients of 0.2 to 0.3 percent are preferable.

It is frequently desirable to vary the grade, making it steeper near the outlet end to give the channel more capacity without having to change the cross section. This is true because the lower parts of the terrace will be draining a greater area and consequently will have more water to carry. Increasing the grade and consequently the velocity as the flow progresses, is permissible within limits but to decrease the grade and the velocity will cause silt to be deposited in the terrace channel or hillside ditch. This will obstruct the channel and may be the cause of overtopping during hard rainstorms.

Consequently, when laying out a channel with variable grade, never reduce the gradient. One exception to this is that it is sometimes necessary, in order to avoid serious point rows, to make the upper 30 or 40 meters of a terrace steeper than the remainder in order to get a more farmable layout. This is permissible because of the small quantity of water handled by the terrace at this point so the siltation, if it occurs, will not be serious.

If the slope of the field is not more than 8 percent, or certainly not more than 10 percent, the cross section of the channel may be made so wide and the slopes of the filled ridge may be made so gentle that the entire area can be used for cultivation. This is called a broad based terrace. If the slopes are steeper, it will be advisable to make the channel narrower and deeper and devote the channel area entirely to carrying water without trying to cultivate it.

This construction is called a hillside ditch. Both names being self explanatory. There is an intermediate type of construction which you may read about called the Nichols type terrace. In this a channel is excavated but little attempt is made to build or maintain a broad ridge which can be cultivated.

Because of the prevailing steep slopes and the small size of the average fields in Taiwan. Broad based terraces will seldom be as suitable as bench terraces. However, on the gentler slopes on larger fields you may have occasion to use them now and then.

Whenever gradient terraces or hillside ditches are used, it is very important that the outlet be protected. Unless an adequate outlet is provided, you may be doing more harm than good, if you build such terraces. In locating terraces, it is advisable to first locate a suitable outlet point and start staking the terrace from the outlet end. The whole layout will be more satisfactory if you select good outlets even at the expense of having to make the terrace intervals wider or narrower than the formula calls for.

The proper spacing of terraces or hillside ditches is determined by the same formula that we discussed in connection with strip cropping $\frac{S+6}{10} =$ V. I. plus or minus 25 percent. This last factor indicates or recognizes the fact that no formula is applicable to all conditions. On permeable soils with regular slopes where water does not tend to concentrate, the Vertical Interval may be "stretched" 25 percent with comparative safety. On the other extreme, on impermeable, badly eroded soils with irregular slopes which cause the concentration of the runoff into many gullies, the formula should be "shrunken" by a like percentage. This allows considerable leeway for locating the terraces at the best outlet points and for manipulating the layout so that the terraced field can be cultivated more easily.

Particularly for broad based terraces where the entire field area is to be cultivated, it is desirable to "smooth out" the sharp bends in the staked lines by resetting the stakes across depressions. This will mean that extra fills will have to be made at these points to maintain the desired grade. However, this will result in cultivated rows with broad curves instead of sharp kinks. The extra work of making the fills across the depressed areas will be compensated for by the facilitation of cultivation for many years in the future. It should be emphasized that a little investment of thought, technical time and labor at the time of construction will pay handsome dividends and win the everlasting gratitude of the cultivators.

Hillside ditches should be reinforced at every place in which they cross definite gullies. Gullied areas in which water concentrates even in the narrow areas between the hillside ditches tend to carry more sediment and more runoff water than the remainder of the area. Consequently, when the runoff is checked at the hillside ditch, the siltation will be more rapid at the foot of these gullies. Unless the hillside ditch is reinforced at these points, this siltation will block the channel and overtopping will occur. If the top ditch overtops that will place an exagerated overload on the next lower ditch which will probably also break and the process of destruction will proceed down the slope.

Therefore in constructing either terraces or hillside ditches, always start at the top of the slope and construct each one completely before starting construction of the lower terraces. This will give adequate protection as far as the construction has proceeded. If the construction is started at the bottom, concentrated runoff from above may easily overwhelm and destroy the benches that are built but are not protected from such overloads.

In terrace or hilliside ditch construction, the effective depth is measured from the bottom of the excavated channel to the height of the ridge on the lower side. In either level or gradient terraces or hillside ditches, care must be taken at the time of construction, that there are no low spots in the ridge. These low spots will not only determine a lower effective height and lower capacity but they also invite severe damage in case the runoff water of the entire terrace is discharged thru these unprotected low spots.

Preliminary data from the runoff plots indicate that in pineapple production a combination of hillside ditches to handle the runoff during typhoons and mulching to prevent detachment and to hold the moisture against evaporation, may be just as effective as bench terracing in preventing soil and water losses. This combination of practices should be cheaper and easier to apply than the benches.

Runoff Water

The unending circulation of the earth's moisture and water is called the water—or hydrologic—cycle. It is a gigantic system which operates over the land and over the oceans of the earth and in the atmosphere which surrounds the earth.

The cycle has no beginning or ending. Because our discussion must start somewhere, we can think of the cycle as beginning with the water in the oceans which cover roughly three fourths of the earth's surface.

The water from the surface of the oceans is evaporated into the atmosphere. That moisture is eventually condensed and falls back to the earth as precipitation. This may be in the form of rain, dew, snow, hail or sleet. The part that falls on the land area —as distinguished from that which falls back into the ocean—is of particular interest to man and to agriculture.

What happens to the rain that falls over the land?

1. Some of it evaporates
   a. Back into the air before it reaches the earth
   b. From the surface of vegetation on which it strikes
   c. From the surface of the earth-soil, streams or lakes
2. Some of that which strikes the earth
   a. Percolates into the soil to
      i) be used by the plants (transpiration)
      ii) be added to the underground water supplies
   b. That part which is not evaporated or percolated runs off

It is this runoff portion that causes erosion. Therefore, our efforts should be directed toward keeping this fraction small. The runoff collects in small rills which collect into larger and larger streams until they reach the rivers and flow back into the oceans to start the cycle all over again. That part which is transpired by plants or which evaporates from the surface of the plants or the earth, bypasses the ocean and enters the atmosphere directly.

The volume of this water cycle is tremendous. There are about 80,000 cubic miles or 320,000 cubic kilometers of water evaporates from the oceans each year. In addition to this there are about 15,000 cubic miles or 60,000 cubic kilometers of water evaporated from the lakes and land surfaces. About 24,000 cubic miles, which is 100,000 cubic kilometers, of rain falls on the land surfaces each year. If this rain all fell on Taiwan and could be held there, it would cover Taiwan to a depth of 3 kilometers. That will give you some idea of the proportions of the hydrologic cycle. It is big.

We would prefer to have all of the rainfall percolate into the soil where and when it falls. That would be an ideal situation which will seldom be achieved. There will frequently be periods during which the intensity of the rainfall will exceed the rate at which it can be absorbed by the soil. When this occurs there will be runoff. In order to avoid serious damage by erosion, we must prepare for such events.

Annual rainfall or seasonal distribution are important from the standpoint of (1) crop production and (2) yield of water for reservoirs, but it is the intensity of rain for short periods that determines the peak flows, the flash floods, or other runoff occurrences which are the cause of erosion by water. Many of the experiment stations in the United States report that 75 to 90 percent of the total soil loss which occurs during the year, occurs during 3 or 4 intense storms. For this reason, we will here deal with the short intense storms rather than with the daily or annual averages or maximums.

If the soil is dry and the surface is in a condition that favors rapid percolation, a small, gentle rain will be entirely absorbed and none will runoff. If the rate of precipitation is increased or if the rate of infiltration is decreased because of conditions less favorable for absorption, the excess water will collect on the surface and we will have runoff. The unfavorable surface conditions which reduce the rate of infiltration may be due to a compacted, crusted surface or to a puddled or sealed over condition or to the fact that the soil has been saturated before the intense rain occurs. Whatever the cause, our calculations of runoff must be based upon the worst conditions that can be expected rather than upon average conditions. A bridge is not designed to carry the average load, but the maximum. Likewise, any waterway or hydraulic structure must be capable of handling the maximum load of water.

Because of the frequency of typhoons in Taiwan, with their intense rainfall, it will be necessary to base our calculations on a higher peak flow than would be used in many other parts of the world. Even tho you may have complete and accurate records of the maximum intensity of rainfall at your home for the past 50 years, that does not guarantee that it will not rain harder this coming summer. Therefore, we must estimate on the basis of past records from all over Taiwan, rather than on the records at one place.

The length of time or duration of the rainstorm we should consider will be determined by the length of time it takes for water falling at the most distant point to flow to the point under consideration. This is called the time of concentration. It might take a drop of water falling at the top of the watershed ten days to flow to the mouth of a river. If we were planning a structure at the mouth of this river we should be concerned with the amount of water that might fall within any ten day period. Water falling on the first day would have flowed out of the river into the sea before any rain falling on the eleventh day could possibly effect or pile up on it. If we were planning a dam and spillway halfway between the mouth and the source, we would be concerned with a spillway that would handle the maximum flow to be expected on the basis of a 5 day rainfall period.

Most of your work will be with individual fields or paddies which will discharge the water that falls on them within less than one hour after it falls. Many in less than 15 minutes. The same set of factors must be considered on any watershed. You can figure it out on the basis of 1 hectare and then expand or contract the data to figure each watershed area.

The factors which determine the peak runoff are:-

1. The area of the watershed.
2. The intensity of the rainfall during the time of concentration or for the length of time required for a drop of water falling at source to flow out of the watershed.
3. The percent of the total rainfall that can be expected to run off. This will be affected by (a) the rate of infiltration (b) the slope and (c) by the land use or surface cover.

At the peak of the storm during a typhoon, 100 mm. of rain may fall in one hour. There will seldom be a condition under which 100 percent of the rainfall will runoff but, after the soil is saturated or sealed over, runoff may approach 100 percent for a short time.

In order to be on the safe side and to use an even figure, let us assume that our maximum runoff will be 100 mm. in one hour. If we provide for the disposal of that much water we will seldom get into trouble. Please note the method used in the following calculations rather than trying to remember all of the figures.

What would be the volume of 100 mm. of runoff from one hectare? One hectare contains 10,000 M^2. Multiplying this area by 100 mm. or 0.1 M which is the depth, we get 1,000 M^3 which is a lot of water from one hectare. One thousand cubic meters is the runoff for one hour. While rains do not continue at this maximum rate for a whole hour, the temporary ponding and time that it takes for the water to runoff will even up the flow so that we can calculate that in one minute, 1/60th of 1,000 M^3 or 16.66 M^3 will be discharged. Since most formulae are in discharge per second we will again divide by 60 and find that the discharge per second will be 0.278 M^3 per hectare for a runoff of 100 mm. per hour.

Accordingly, if we have a one hectare watershed shaped so that it requires 1 hour for the water to drain from the most distant point, we should have an outlet capable of handling between 0.25 and 0.3 CMS or cubic meters per second. Now, if you should have a different shaped watershed of 1 hectare from which the most distant water would drain out in half an hour or less, the peak flow would be greater than 0.278 M^3/s. On the otherhand, if you have a 1 hectare watershed that is long and narrow and relatively flat, it will take longer for it to drain and the peak flow will be less than 0.278 M^3/s. So, unless you can predict (1) exactly how intense the rainstorm will be, (2) exactly how much will percolate into the soil and (3) exactly how long the time of concentration is, the best that we can do is to estimate these factors and allow a reasonable margin of safety when we plan the capacity of our outlet structures. You can not, and you need not try to calculate the EXACT runoff. If you did succeed in doing so for one storm, the next storm would be different.

If the area of a watershed, or field, is less than 1 hectare, the time of concentration will be less and the peak flow will be relatively larger in M^3/sec/ha. If the area is greater and the time of concentration is longer, the PEAK FLOW WILL BE RELATIVELY SMALLER in M^3/sec/ha. Therefore if you are calculating the runoff from a watershed of, say 0.5 ha., you might estimate the peak flow to be 0.33 M^3/sec/ha. and if the watershed is 3 ha. you might use 0.2 M^3/sec/ha.

Suppose that you have built a series of 4 small benches, each 5 meters wide by 25 meters long. Then each bench would contain 125 M^2 and the total area drained would be 500 M^2 which is 0.05 ha. If we assume that the peak flow will be 0.33 M^3/sec/ha. then the discharge will be (0.33×0.05) 0.0167 M^3/sec. Next, we must figure how big a waterway we will need to carry this peak flow at a safe velocity.

It is the velocity of flowing water that causes the soil to erode. If the soil is protected by a grass sod it will withstand higher velocity than bare soil, but we should not plan to have water running faster than 1.5 M/sec even on a permanent sod. Now what is the relation of these figures to the size of the channel needed?

Let us visualize a section of waterway 1.5 M long, representing the distance that the water will flow in one second. Now, in each second we have calculated that 0.0167 M^3 or 16.7 liters of water will flow through the waterway. If we distribute this 16.7 liters in a waterway 1.5 M long, the cross section of the water will be $\frac{16700 \text{ cm}^3.}{1500 \text{ cm.}} = 11.2$ cm^2. This will be the cross sectional area of the stream of water of 0.0167 M^3/sec. flowing at the ate of 1.5 M/sec. But if the velocity of the flow was only 0.5 M/sec. the cross-section of the stream would be found by dividing the volume (in cm^3.) by the velocity (in cm.) $\frac{16700}{500} = 33.4 \text{ cm}^2$.

We know that with the same slope and the same channel lining and friction coefficient, the deeper the water, the greater the velocites will be. If in a given section of a channel you have water flowing 15 cm. deep and the velocity is too great, by making the channel wider the same quantity of water will be spread over a wider area and will not be so deep. This will reduce the velocity at this point. That is the principle to use. Now, to apply that principle, we have prepared a table for you to use. It is based on Manning's formula for water flowing in a channel. (see page 116). This is a somewhat complicated procedure and since it might confuse some of you, just take my word for it that the table is properly calculated and checked by the engineers.

This table is calculated for four different depths of water, 2.5 cm., 5 cm., 10 cm., and 15 cm. in a channel 1 M wide. It includes slopes from 1 to 20 percent. If you are in the habit of thinking in terms of degrees rather than percent of slope, one degree is roughly equal to two percent on the lower slopes.

After you have measured the slope of the waterway location, select the appropriate line in the table by referring to the slope figure on the left hand column. Now, move horizontally to the pairs of columns representing each of the depths of water previously mentioned. In each pair, the column headed *V* indicates the velocity of the water in the waterway at that depth and that slope. The column headed *Q* indicates the quantity of water in M^3/sec that will flow through the grass lined channel on that slope with that depth and velocity.

Referring again to the example we calculated just now, the 4 small benches would discharge a maximum Q of 0.0167 M^3/sec. If the slope of the waterway should be 10 percent, the table tells us that with a depth of 2.5 cm., the velocity of the water would be 0.96 M/sec. which is a safe velocity. It also tells us that at a depth of 2.5 cm. and a V of 0.96 M/sec. the Q would be 0.0237 M^3/sec. which is about 50 percent more than the load we have to carry. Therefore if we turn 0.0167 M^3/sec. of runoff into a grass lined channel 1 M wide on a 10 percent slope, the depth of flow will be less than 2.5 cm. and the velocity will be less than 0.96 M/sec. So that waterway would be safe.

Now suppose the slope was 6 percent. Looking again at the table we see that at a depth of 2.5 cm. the water would have a V of 0.74 M/sec and the Q would be 0.0184 M^3/sec which is just a little more than the 0.0167 M^3/sec of our problem. Since the Q is adequate and the V is within safe limits, a waterway 1 M wide on a 6 percent slope would be more than adequate for the runoff from the four benches under consideration.

Sometimes your waterways will not have much slope. Suppose that the slope was only 1 percent. The table indicates that water flowing in a waterway 1 M wide on a 1 percent slope would have a V of only 0.29 M/sec and that the Q would be 0.0072 M^3/sec. This velocity is safe enough but the Q would not be enough to carry the discharge from our 4 benches. Since the velocity is so slow we had better look for a deeper flow rather than a wider channel. The table shows that at a depth of 5 cm. on 1 percent the V would be 0.31 M/sec and the Q would be 0.0153 M^3/sec. which is still not enough for our problem. At a depth of 10 cm. on 1 percent the V would be 0.46 M/sec. which is still safe and that the Q would be 0.0475 M^3/sec which is more than adequate. Therefore if we turn our flow of 0.0167 M^3/sec. into a grass channel 1 M wide and with a slope of 1 percent, the velocity would be between 0.31 and 0.46 M/sec, either of which would be perfectly safe, and the depth of flow would be more than 5 cm. but less than 10 cm..

Now take a piece of paper and try working out the Velocity and the Quantity if the slope were 3 percent. With a depth of 2.5 cm. what would be the V and the Q? The V of 0.52 M/sec is safe enough but the Q of only 0.0129 M^3/sec is less than the Q of our problem so, at this depth the 1 M wide waterway would not handle the maximum discharge.

Now look at the V and the Q for a depth of 5 cm. on this same 3 percent slope. V is 0.58 M/sec which is safe and Q is 0.0287 M^3/sec which is more than adequate for our problem. So how deep would the 0.0167 M^3/sec flow in a waterway 1 M wide on a slope of 3 percent? The table tells us that it would be somewhere between 2.5 and 5 cm. deep and that the velocity would be between 0.52 and 0.58 M/sec. Since either of these velocities is safe, we need not take the time to try to figure out just exactly how fast and how deep the flow would be. A lot of time and paper can be wasted in figuring out such details. As long as either extreme which we have figured is safe, we don't care to know the exact figure.

Now, try working out some more problems, using the same procedure.

Imagine a drainage area of 0.75 ha. Since this is less than 1 ha. we should figure a slightly higher peak runoff. Assume that it will be 0.3 instead of 0.278 M^3/sec/ha. To get the Q for this problem, then we multiply the area, which is 0.75 ha. by this discharge figure of 0.3 M^3/sec/ha. and get a Q for the problem of 0.225 M^3/sec.

Next we must measure or assume the slope of our waterway. Since this is a theoretical problem, let us assume a slope of 4 percent. Looking at the Q columns for 4 percent in our table, we find that even our 15 cm. depth will carry only 0.1738 M^3/sec when the waterway is 1 M wide. Since our Q in this problem is 0.225 M^3/sec we will have to make the waterway wider or deeper to permit it to carry the Q we have. The table shows that at a depth of 15 cm. the V will be 1.17 M/sec. While this is not the maximum permissible V, it is getting pretty close to it, and it would not be wise to make the water run much deeper since this would increase the V. In this case we had better plan a wider rather than a deeper waterway.

If a grasslined waterway 1 M wide on a 4 percent slope flowing 15 cm deep has a velocity of 1.17 M/sec and the Q is 0.1738 M^3/sec, how wide a waterway of the same slope and depth will be needed to carry a Q of 0.225 M^3/sec? While changing the width will theoretically change the velocity slightly, for our purposes, we can disregard this minor difference and widen the waterway proportionally to get the needed capacity.

We have then a problem in simple proportion or ratios of:

0.225 M^3/sec : 0.1738 M^3/sec = X : 1M

Solving by division we have $\frac{0.225}{0.1738} = 1.3$ M

so we will need a waterway 1.3M wide on a slope of 4 percent and flowing at a depth of 15 cm. with a V of 1.17 M/sec to carry the 0.225 M^3/sec of our problem.

Suppose, now, that you have a drainage area of 2.5 hectares for this larger area you could use a discharge factor of may be 0.2 M^3/sec/ha. rather than the 0.278 M^3/sec/ha. we figured out for 1 ha. The Q for this problem then would be 2.5 ha. × 0.2 M^3/sec/ha. which is 0.5 M^3/sec.

We must first look at our table to find the depth of flow at which the velocity will be safe, that it will not exceed 1.5 M/sec, on the slope of the waterway. Realizing that we will have quite a bit of water to handle we will look for the gentlest sloping waterway site that we can find. Suppose that the best site available has a slope of 7 percent at the critical area. We always have to figure the data for the worst area, realizing that if we can control that area, the same treatment will be more than adequate for the less critical areas.

As we examine our table we see that the velocities for the 2.5 cm. the 5 cm. and the 10 cm. depths are less than 1.5 M/sec but that at a depth of 15 cm. the velocity on a 7 percent slope is 1.58 M/sec which is too fast to be really safe. If we accept the V of 1.26 M/sec of the 10 cm depth as being satisfactory, how wide a waterway will we need to carry the Q of 0.5 M^3/sec?

Again using our ratio

0.5 M^3/sec : 0.1249 M^3/sec = X: 1

we solve by division $\frac{0.5}{0.1249} = 4$M.

According to this calculation we would build a grass waterway 4 meters wide to carry the Q of our problem, the depth being 10 cm. and the V being 1.26 M/sec.

Now, if you build and could successfully maintain, a grass waterway 4 meters wide on a 7 percent slope, it should be adequate to carry a Q of 0.5 M^3/sec. But a waterway that wide is hard to maintain and few farmers are willing to give up that much of their land for a grass waterway here in Taiwan where land is so scarce. So what should we do? If we make the waterway narrower, this discharge will flow deeper and the velocity will get dangerously high and might erode our waterway and cause failure.

In a case like this, it is probably best to resort to masonry structures to take a lot of the fall out of the waterway channel. Then with a flatter slope, the water can be piled up deeper without getting the velocity fast enough to cause severe erosion in the grass channel.

Therefore this waterway table tells us not only the size of waterway, depth and width, that are required for a given Q on a given slope. It also tells us when we should supplement our waterways with structures.

You should remember that each set of benches or each watershed presents a separate problem which can be solved by this method. In saying that, I am not suggesting that you must or should set down with paper and pencil and this table and calculate the dimensions and check the velocity of the runoff for each waterway that you build. But you should be able to do this and you should do it for the first ones and keep on doing it until you become familiar with the limits of the sizes and slope you use most frequently. After that you will need to calculate only the unusual situations.

You will note that this table is made up primarily for small flows of water from small areas which you may wish to handle on grass waterways on fairly steep slopes. It is not desirable to try to handle large flows of water on steep slopes with grass waterways. Such conditions call for the construction of mechanical structures. Our last problem illustrated that.

Whenever the quantity of water and the slope of the waterway will permit, it is better to use vegetated waterways than structures. The first reason is that the farmers are more familiar with handling grass than they are with handling masonry and will probably do a better job of it. Next, a vegetated waterways has some chance of healing or repairing itself if it should be damaged. Masonry never heals itself but damage grows. And last but not least is the cost. Practically all of the expense of constructing vegetated waterways is labor which the farmer can do himself. On the other hand, structures call for the purchase of cement, at least, and sometimes the hiring of a mason or the hauling of sand or stone.

One precaution that should be observed in this connection is that you should never, never let referring to a book, table, or regulation take the place of THINKING about THIS job. This job may be unique and the generalized pamphlets may not be applicable. But THIS is the job to be done. THIS is the job that must be made to work satisfactorily. So be prepared to make special studies or to ask for special assistance from some engineer if you dig into something that is beyond your ability to handle. You will lose face worse by having your work fail than by asking for advice and using it. When you need help on a problem of handling water—go see your irrigation specialist of the PWCB branch office.

In planning waterways, remember that small flows of water are not nearly so hard to handle as large ones. If putting the runoff from two fields together makes such a large flow that it is dangerous to handle, see if you can't keep them apart and handle each separately. Sometimes you will find it possible to have an outlet at each end of a large field and drain water in both directions, thus making two small streams instead of one larger one. By doing this you may be able to keep the flow down small enough that you can safely handle it in grass waterways and not have to build structures.

If you do this you will be saving the farmer's money and will be planning a safer layout.

If one narrow waterway will not handle all of the water and a very wide one is called for, there are some difficulties in keeping the water spread evenly over a wide grassed waterway. It tends to collect in one spot and cause erosion there instead of spreading out evenly, as you plan it. I have frequently seen two grassed waterways side by side, with each carrying the water from a separate plot. In one case I saw three waterways with a small grassed ridge between each to keep the flows of water from concentrating in one channel.

These were unusual solutions to unusual problems or situations. You may have the occasion to do something like that yourself sometime. If the situation calls for it—just be sure that you are right and then go ahead and do it. If anyone questions your plan, be prepared to defend it with technical explanations. Facts can't be denied.

Waterways that are too broad have another hazard. There is a temptation to use them for cart roads and cart tracks up and down the slope which will start gullies and aggravate erosion. Narrow waterways only 1 to 2 meters wide will be used for nothing worse than cattle trails. While this is not desirable, it is not as bad as cart roads.

Because of the scarcity of land in Taiwan you will seldom be able to get a farmer to agree to making a waterway too wide. But the volume of the water and the steepness of the slope are the factors that must be considered in determining the needed width and depth. When you have a lot of freight to haul you order a big freight car or a big truck to fit the load. When you will sometimes have a big lot of runoff water, you will need a big waterway. There is one difference, however. If the truck you get is not big enough to carry all of the charcoal or other freight that you have, part of it can be held over for another trip. But, if you have more water that your waterway can carry, it won't pile up and wait. It is going to flow NOW.

The most obvious thing would be for the water to run over the sides of the grassed waterway and out on to the bare soil beside it. This would probably cause erosion. If the flow is big enough and if it continues long enough, this erosion may destroy the waterway and a gully will result. If the shape of the waterway is such that it does not overflow the sides but merely runs deeper that had been planned, the extra depth may result in added velocity which can tear out the grass lining and in this way cause failure of the waterway. Just shutting your eyes or turning your head won't solve such a problem. By some sort of stratagem involving the manipilation of the slope, depth and width factors, you must control that velocity.

It is customary in Taiwan and almost every other place in the Orient, to overload. People are overloaded. Bicycles are overloaded. Carts, trucks and boats are overloaded. Sometimes the bicycle tires carry the load and sometimes they blow out. Sometimes the carts carry the load and sometimes their axles snap off. Sometimes the overloaded boats make the trip and sometimes they sink and people are drowned. In such an atmosphere it is expecting a lot to ask that waterways not be overloaded.

Every machine just like every waterway has a safe limit. If it is used within that limit you can expect reasonable service. If it is continually overloaded, that is a false economy and eventually someone will have to pay the consequences in the form of a failure at some critical time, just when its service is needed the most. So don't make your waterways too small and then overload them.

One thing that you should always keep in mind is that merely because people have not been in the habit of doing things right, or that they refuse to follow your recommendations to do so, is no excuse for not making the best recommendation nor for not trying to get them to follow the proper recommendations.

It will be up to you to lead the way even though all of them do not follow your leading. Some of them will follow and they will be satisfied. The fact that what you recommend is not popular does not mean that it is wrong. On the other hand, before you undertake to change the established ways and customs, be very sure that you are correct in your recommendations.

So figure out the data on the first few benches you build and see what your peak flow will be. Get the slope of the best waterway site and check the velocity of this much water at different depths and widths until you find one that is safe—less than 1.5 M/sec.

If the velocity is even close to this

maximum. You had better try to make the waterway wider and run the water in a shallower flow to cut down the velocity. If this makes the waterway too wide, try using two waterways or put in some structures to take part of the slope out of the waterway so the slope of the remaining portion will be gentle enough to keep that velocity slowed down, even though the water must run fairly deep.

The water disposal system is the skeleton or backbone of the entire soil conservation plan. If it fails the whole plan collapses. If that happens you may have done more harm than good by concentrating the runoff water into one place instead of letting it run in little driblets all over the place as it did before.

Runoff water follows certain natural laws which no administrative or even military officer can repeal or change. It is our business to become familiar with these laws and to build our waterways and structures in conformity with them. Runoff water pays no attention to red banners, gilt letters or shouted slogans. It follows its own natural laws and if you abide by them, you will have no trouble.

If the quantity of water that you expect, is going to run too fast on the best slope available—so fast that grass sod cannot be expected to hold it—you may have to resort to structures. Structures are expensive. Structures will not repair themselves like grass sods. Structures are a nuisance to have around but sometimes we need them and they may be the only answer to the problem. When you need a structure bad—you need it good.

The purpose of an overfall structure is to let the water down at one place under controlled conditions. Having taken this much of the fall on one place, if the rest is spread evenly over the rest of the length of the waterway, perhaps the slope and the consequent velocity will not be so great but what the grass can handle it.

In order to be satisfactory there are several things that must be considered about each structure:

1. It must be big enough to successfully handle the quantity of water at that place.

2. The water must go over the structure and not around it. This is perhaps the most common cause of structure failure.

   a. The wing walls must be high enough to direct the flow to the weir of the structure.

   b. There must be cutoff walls behind, beside and below the structure to prevent the water from seeping down behind, under or around the structure, eventually causing tunnels.

3. It must have an apron or stilling basin to absorb the energy of the falling water and prevent undermining.

If you attend to these details properly, your structures should perform satisfactorily. Now let us study these details closer.

The simplest form of a structure is an overfall or drop structure. This is essentially a stone or concrete wall to hold the dirt in place, some arrangement to make the runoff water flow over the structure instead of around it, and some arrangement to keep the runoff from undercutting the structure. The top of the wall or the edge over which the water flows is called the *weir* of the structure. The width of the weir and the depth of the water which flows over it determines the capacity or Q of the structure. The height which the water falls has no bearing on the Q. This is determined entirely as the water falls freely over the weir.

To confine the flow of water to the weir proper, some sort of wing walls should be included in the structure's design. These may be earth embankments higher than any expected flow and extending to the weir section. It is safer to have short wings of concrete or masonry built as an integral part of the structure. Otherwise, large rocks or bricks should be placed on the earth fill to prevent the flowing water from scouring away the fill.

Before constructing the wall of the drop structure, the earth should be excavated below the level of the outlet or discharge. The wall should be laid in this excavation to make a cutoff wall so the water will not seep under the structure from above and cause the earth to tunnel out and later cave in, destroying the structure. The depth of this cutoff wall excavation depends on the height of the drop and the texture or permeability of the soil. Under the conditions you will be working, 50cm. should be enough depth for the cutoff wall.

There will be a pressure on the wall by the water and wet soil which will tend to make it fall over forward. The higher the structure, the greater this pressure and the more necessity for building the structure to withstand it. The wall can be made to slope backward, leaning on the fill. If the wall is perpendicular it can be braced by wings on either side, extending straight to the front or flaring out diagonally. Or the entire wall can be constructed as an arc which will brace itself. As long as you do not build your structures more than 1 meter high, this will not be too serious a problem.

Water falling, even from comparatively low heights, exerts force acquired as the energy of falling, which will scour the soil away from the foot of the structure wall unless prevented. This energy can be absorbed by constructing a masonry or concrete apron or platform for the water to fall on or a small pool of water can be retained to be used as a stilling basin. The water falling into the stilling basin will dissipate its energy there.

There are some rather complex calculations which should be carried out in designing a large structure with a drop of 5 or more meters which you can safely disregard on the small structures you will be building. Just be sure that the apron extends out far enough so that the water flowing over the weir of your structure will land on the apron and not overshoot it. Constructing a small sill or upturn at the extreme edge of the apron will increase its ability to still the flowing water. This sill should be at least 10 to 15 cm. high and of about that width.

In building such a structure there are several precautions:-

1. Remove all rubbish, trash and loose soil and stones. Be sure that the structure is based on solid soil or solid rock which will not permit the rapid seeping of water under it.

2. Use enough good quality mortar to assure that the structure will be watertight and not permit water to flow through it. This will encourage tunneling behind or under the structure.

3. After the structure is built, tamp earth solidly behind and around it. There will usually be some settling of the filled soil especially if the fill is large or deep. Tamping will reduce the degree of settling. Settling is objectionable because it opens up a crack behind the structure for the water to run or seep down into and start channeling.

4. A little grass sod planted at the juncture of the earth and the masonry will generally prevent this cracking trouble although on soils with high colloidal content like clay, it is a problem.

5. Some maintenance will be necessary on any structure. It is not possible to build any structure, no matter how good, and then forget about it without getting into trouble over it. This maintenance is as important as good design and construction.

You will not be called upon to calculate the flow capacity of large structures. If you are, you had better call on an engineer to do it for you. But many of the small structures which you will be building can be calculated by using the table which is supplied (see page 115).

The head or height of the water is measured from the crest of the weir to the surface of the water above the place where it starts to dip toward the weir. This will be greater than the depth of the water as it passes over the weir. The left-hand column indicates the head of the water in meters. The right-hand column indicates the quantity of water in cubic meters per second, that will flow over a weir 1 meter wide at the various heads as shown.

Example:—If the surface of the water at 0.5 meters upstream from the weir is 10 cm. higher than the weir and the weir is 1 m. long, the quantity of water will be 0.063 M^3/sec.

If you calculate the peak flow at the site of a structure to be 0.08 M^3/sec. you could plan for a head of 20 cm. over a 50 cm. weir or a 15 cm. head over a weir ($\frac{0.080}{0.109}$ M or 73 cm. rounded off to) 75 cm. If for any reason you didn't want a head greater than 10 cm. the width of the weir would have to be $\frac{0.080}{0.063}$ M or 1.27 M in width.

The wider weir notch with the lower head is safer because it spreads the energy created by the falling water, over a wider area. However the wider weir notch is more expensive construction because it requires more materials.

When constructing a series of overfall structures in a watercourse, always start at the bottom. That is just the opposite of constructing terraces. With them you start at the top of the slope. To make the entire series of structures safe, you must either find or establish a stable grade and place the lower structure so that its apron is at this stable grade. This will insure that the water flowing from the apron will not undermine the structure and cause it to fail.

You should try to avoid making your structures more than 1 meter in height—from apron to weir. However, this may be exceeded if it is necessary, in order to place the second structure on the most advantageous position. Select a site approximately 1 meter above the apron of the lower structure for the apron of the second structure. This will determine the height of the weir of the lower structure. The grade from the weir of the lower structure to the apron of the next structure above it should be level or not more than 1 percent. If scouring should start to occur as the water leaves the apron of the upper structure, the ponding of the water above the weir of the lower structure will serve as a stilling basin to control it. Locate each succeeding higher structure in this same way, with the one below protecting the one above from undercutting. That is why it is so important to find or to establish a stable grade for the lower structure. If the lower structure washes out, it may cause all of those above it to also fail.

TABLE OF QUANTITIES OF WATER FLOWING OVER 1 METER WEIR AT DIFFERENT HEADS

Head of Water * in meters	Flow of Water ** M^3/sec.
.025	.0072
.05	.022
.10	.063
.15	.109
.20	.166
.25	.234
.30	.308

* Head of water is the difference in elevation between the weir and the water surface above the point where the weir effects it. (At least 5 times the depth of water over the weir.)

** Quantities shown in table are for a weir 1 meter in width. For practical purposes, the flow over longer or shorter weirs will be proportional to their length.

TABLE OF VELOCITIES AND QUANTITIES OF WATER FLOWING IN GRASSED WATERWAYS (Parabolic Section N .04)

Slope Percent	Depth 2.5 cm Width 1 M. A=0.0245 M^2		Depth 5 cm Width 1 M. A=0.05 M^2		Depth 10 cm Width 1 M. A=0.1 M^2		Depth 15 cm Width 1 M. A=0.159 M^2	
%	V M/sec	Q M^3/sec	V M/sec	Q M^3/sec	V M/sec	Q M^3/sec	V M/sec	Q M^3/sec
1	.29	.0072	.31	.0153	.46	.0457	.58	.0862
2	.43	.0107	.46	.0228	.65	.0644	.80	.1188
3	.52	.0129	.58	.0287	.80	.0792	.98	.1452
4	.62	.0154	.68	.0337	.92	.0913	1.17	.1738
5	.68	.0168	.74	.0366	1.04	.1029	1.32	.1964
6	.74	.0184	.80	.0396	1.17	.1160	1.45	.2156
7	.80	.0198	.86	.0426	1.26	.1249	1.58	.2343
8	.85	.0211	.92	.0455	1.39	.1375	1.72	.2563
9	.91	.0226	.98	.0486	1.51	.1496	1.85	.2750
10	.96	.0237	1.04	.0517	1.61	.1595	1.95	.2904
12.5	1.07	.0265	1.17	.0580				
15	1.17	.0289	1.29	.0639				
20	1.29	.0319	1.44	.071				

Waterways

Whenever water falls faster than it is absorbed, a surplus accumulates. Unless there is a reservoir capacity sufficient to hold this surplus until the rainsterm is ended, there will be runoff. Whenever and wherever there is runoff, there is need for a waterway. Remember this—If we don't provide a waterway to handle this surplus water, nature or the law of gravity will make one—and it might not be just where we want it to be. If the water falling on a hillside could be kept spread exactly even, so there were no accumulation into rills or little streams, the damage from the runoff might not be too serious except during the worst typhoon storms.

It is not worth our while to even talk about keeping the runoff distributed in an even sheet. In practice, that just can't be done. If you took the trouble to fine grade an area so that it was exactly a plane with even slope, some difference in soil texture, some piece of trash blown in by the wind, or even mere chance would soon cause runoff to accumulate in some spots. When this accumulation took place, the added depth of the water would increase the velocity and this would increase the erosion so that there would soon be a rill and then a small gully would develop.

The principle of establishing waterways is based on selecting the most desirable and economical locations and providing extra protection against erosion at these places. Next we encourage all or as much of the runoff as possible, to concentrate in these prepared waterways. While we would like to have all of the water absorbed where and as it falls, falling in that during the critical storms, we must prepare to handle the surplus with the least damage and at the least expense.

One of the first problems in waterway construction is WHERE should they be built. There are no hard and fast rules for locating waterways but there are some things that merit consideration. Nothing, or at least very few things, are impossible, if the need is imperative and if sufficient resources are available. However, some things are much more economical and much surer of success than are others.

Water tends to collect in the lowest spots and therefore it is easier to keep it in a waterway that is built in a depression. Sometimes these depressions include such steep slopes or hazardous soil conditions that in order to avoid having to stabilize these conditions it may be desirable to select some other site for the waterway where the slope is less steep or where soil conditions are more favorable. In order to avoid the nuisance of having waterways in the center of fields, it is sometimes desirable to locate them along a field boundary. By doing this it is often possible to have one waterway serve two adjacent fields, may be owned by different farmers. These conditions are the exception and generally, the waterway will be both cheaper and safer if is located in the natural drainage channels.

If not hindered or abated nature may establish a large number of small waterways, one in each depression. You may depend upon it they won't appear under natural conditions unless there is a need for them. But the natural drainage pattern may include so many channels that it would be very expensive to stabilize all of them and too much of the area of the field might be taken out of cultivation. It is the job of the soil conservationist to determine how much runoff there will probably be and to plan sufficient waterways to carry this amount.

Some of the land previously taken up by waterways may be restored to crop production if means are provided for collecting all of the runoff and conducting it to the prepared waterways. We can use contour furrows, hillside ditches, broad based or bench terraces or similar means to collect and conduct the runoff. This is the first and most obvious step in the waterway program. Many farmers have taken this step but have gone no further. That is a shortsighted mistake.

WHEN the waterways should be stabilized depends upon several factors. If they are to be stabilized with grass or other vegetation, it is desirable that this be done at least one year before the full load of runoff water is dumped upon them. This is especially true if the grass sod is developed from seed but is also applicable if sod is transplanted. Several years ago we placed a complete cover of Bermuda grass sod on some waterways in one of the demonstration areas in Ah Kung Tien. That night there was a hard rain and the sod was all washed into a heap at the bottom of the waterway. Then we had to carry it back up and fasten it in place with bamboo pegs. After its roots grew into the firm soil beneath it, it was securely anchored and has withstood all of the storms since that time.

Where stabilization of waterways is to be by masonry structures it is better to construct the terraces first. Then the structures can be accurately placed so they will drop the water from one bench level to the next. If the structures are built first, it may be difficult to get the benches built so they will match the structure levels.

While a great many small waterways would occupy too much land and might be expensive to stabilize, the reverse may also be true. If you get too much water concentrated in one location, especially on steep slopes, the erosion hazard may become very great. Small flows of water can be handled safely, even on pretty steep slopes. But if three or four of these are combined, grass may furnish inadequate protection and structures will be required. Structures are almost always more expensive and are frequently much less convenient when cultivating a field, than are grass waterways.

For these reasons you must weigh the advantages and disadvantages of the several possible protection schemes to determine which is the most economical or otherwise desirable. There will be occasions when it will be more economical to make a grassed waterway down the gentle slope on the "nose" of the hill rather that having to build structures to carry the same amount of water down the steeper slope in the "throat" of the natural drainage channel. If you ever have need to use such a waterway, just be sure that you have made provision for keeping the water in this channel on the nose so that it cannot break away and wander back to the natural watercourse.

Frequently you will find it wise to use a combination of both structures and grassed waterways. As long as the quantity of water and the slope do not produce an erosive velocity, use the cheaper grass. Where the slopes are steep enough or the volume of water collected is great enough to develop an erosive velocity, don't be afraid to use some structures. It may frequently happen that if you take half of the fall in the waterways in the form of structures, that grass will be able to handle the volume of water on the reduced slope. This is safer than all grass and cheaper than all structures. Just be sure that you don't try to save so much money that the whole thing has to be done over.

The volume of water to be carried effects the velocity by the increase in depth or the proportion of the flow that is in contact with the grass lining, the slope factor remaining the same. This extra depth increases the velocity which is what causes the erosion. The depth of the runoff stream can be lessened if it is spread out so that it will not be so deep. Doubling the amount of grass that it creates friction with as it flows, will slow it down. There are practical limits as to how wide a waterway you should recommend. One factor is getting the farmer to agree to give up that much land and another, equally important one, is your ability to keep the flow of water evenly spread over a very wide area. It tends to accumulate because of deposits of trash and in a year or two it may all be flowing much deeper over only a small portion of the designed waterway.

For these reasons, multiple waterways of not too large capacity should always be considered. Usually, if one waterway for a field is not enough, it is possible to place one at either end or they can be widely separated. This will reduce the distance the water must travel from where falls to where it enters the waterway. This will cause less erosion in the row or terrace and will result in less erosion damage if the terrace should be broken by accident. If there is but one place where the slope and soil conditions are favorable, it may be necessary to construct several adjacent waterways, each carrying the runoff from a separate area, to avoid concentrating too much water in one channel and thus creating an erosion hazard.

Like any other drainage system, the outlet or lower end of the waterway is the most critical spot. The volume of water will be greatest here and in some layouts, the velocity may be greatest but this is not always the case. Unless this discharge point is well stabilized the entire waterway may "ravel out" and failure will result.

Even with the best construction and satisfactory establishment there will probably be some minor failures. This is to be expected. The farmers should be warned of the need for maintenance and you must go pass once or twice a year, especially after the first heavy storm of the season, and check on the condition of the waterways. Failure to do this and to call to the attention of the farmers the need for a little bit of maintenance work or repairing here or there, may result in extensive damage later.

Since they are cheaper to construct and maintain, and since the farmers are more accustomed to working with vegetation than with cement, grassed waterways should be used wherever the velocity of the maximum expected flow will permit. It is relatively easy for a farmer with his hoe or shovel to cut a chunk of sod and place it in a hole that is starting to erode in a grassed waterway. But if a structure needs repairs, he has to get sand and cement and tools which are not always handy and then carry water and make a special trip to do this repair work. As a result, maintenance work on structures is usually delayed much longer than maintenance work on grass. In fact if the damage is not too severe and time permits, a spreading type of grass will frequently heal a small break without any assistance.

A waterway can be effective only for that water that gets into it and stays in it. Therefore in designing and constructing waterways always keep them low enough so that the water will flow into them naturally and so that gravity will hold it in them. Now and then you will find where someone has built a waterway higher than the field beside it. This can be done and with careful maintenance it will work successfully, just like some of the irrigation canals. But failure is more likely since it takes more maintenance and that is something to be avoided if at all possible. Farmers in America are notoriously poor maintenance men. Some of them will spend time and money to build things but seem to think that they are too busy to maintain them. This is a false economy as it leads to serious damage and costly rebuilding later on.

If you should build a grass waterway and line it with sod, don't economize on the sod by lining just the flat bottom and letting the sides stay bare. This is another false economy. What will happen is that silt will collect in the sod and the elevation of the flat bottom will be raised whereas the bare sides will erode and become lower. As a result the water may soon be flowing down small gullies on one or both sides of a nice strip of sod which you planned would carry it. I have seen numerous instances of just this happening. A nice grass strip with a lower bare channel on each side of it.

After this has happened, about the only thing you can do to remedy it is to throw up dirt levees on each side of the grass and then protect them with sod. If the situation is too bad, it may become necessary to remove the sod, lower the grade by excavating some of the soil from beneath it and then replace the sod. The second time you build a waterway, don't forget to protect the edges or levees.

Occasionally you may find cases where there is a good waterway that will hold the water that gets into it but for some reason or other the water runs parallel to the waterway without ever entering it. This is a serious fault but one which is easily remedied. All you have to do is build dikes or levees across these outisde channels so the water will be forced into the waterway.

Now and then you will find a place where water flowing from a hillside ditch, a terrace or a bench is just a little lower in elevation than the edge of the waterway at that particular point. Unless some correction is made, a channel will be eroded along side the waterway. In most cases it will be easier to carry this runoff water in a small auxilliary channel along the side of the waterway until the drop in the waterway will permit the water to flow over the side of the waterway and into the proper channel. This is accomplished by making the grade of the auxilliary channel less that the grade of the waterway.

In planning and constructing waterways, your objective should always be to keep the water moving along as uniformly as possible. Sudden falls, sudden truns and objects in the channel tend to cause turbulence or uneven flow. This turbulence amounts to higher velocity in small areas and may result in spot erosion.

This should be avoided. If it can be done without too much labor and expense, the grade of the waterway should be maintained or at least changed as seldom as possible and necessary changes should be made as gradually as it is practical to make them. The same is true about changes in direction. It would be ideal if the waterway could run straight but this will not always be possible. Then the direction must be changed, made the bends broad and even. Objects such as trees, stumps, rocks, etc. which will interrupt the even flow, should be removed of the waterway and should be located to avoid them. While a large rock will not be washed out by the runoff water, it may set up a turbulence which will cause erosion of the sod below it.

In chosing a grass to line a waterway, you will be limited to the species that are available. Never the less there will frequently be a choice between several species. An ideal grass for lining waterways is one that is sod forming rather than a bunch type grass. This means that the soil will be completely covered and that a solid mass of roots will be formed to bind the soil in place. It also means that the grass will without any particular help, heal any small breaks in the sod caused by cattle trampling it when wet, by ruts formed by carts or other implements or by turbulence set up by some debris which has lodged in the grass. A bunch type grass will not spread or at least not rapidly enough to do its own maintenance.

Another desirable characteristic of a waterway grass is that it should not be too coarste or too stiff. The ideal grass would be one that would bend over with the flow of the runoff water and would form a thatch to deflect the current away from the soil underneath. It should act just like the thatched grass roof that you see in the villages. If the grass is too stiff and coarse, it will not bend with the current but will offer so much resistance that the velocity will be greatly reduced and the capacity of the waterway will be reduced correspondingly. Trash may lodge in stiff grass, forming an obstruction which will force the runoff water out of the prepared waterway. This may result in serious erosion parallel to the good waterway.

Very few grasses will thrive in dense shade. Therefore clumps of brush or large weeds may weaken or crowd out the grass which you established, leaving weak places where erosion may start. To prevent this, it is desirable that the grass and weeds in the waterway be mowed once or twice a year. This will encourage a vigorous, uniform sod which is what you want to control the waterflow. It is a mistake to allow a grassed waterway to be used for a cart-road. This will result in killing out the grass in the ruts and gullying will soon result. Building a small masonry drop structure is an expensive but effective way to discourage this practice. Even driven cattle do not like to climb up over a structure 50 cm. high.

Now to summarize the discussion of waterways. Why do we have them? Simply to remove the surplus water with the least damage. If we could cause all of the water to be absorbed where it falls we would not do so. Realizing that some water must flow off, we seek to provide a safe path for it. Choose the flattest, most uniform grade available for the site of the waterway. Avoid concentrating too much water in one channel. Use grass protection unless the velocity is too erosive. Then use structures or a combination or grass and structures. Be sure that the waterways are given elevation and cross section that will make it possible for the water to enter and remain in them. Be particularly careful to protect the lower end of the waterway. Keep the grade and direction as uniform as possible and make any necessary deviations as gradual as possible. Try to use a sod forming grass that will not be so coarse and stiff that it will obstruct the flow and reduce the channel's capacity. And above all see to it that the waterway when once constructed is maintained. No structure, building, machine or waterway can last forever. They all need maintenance.

When are Surveys Necessary?

October 1960

When committees are considering the development of "idle" lands or the stabilization and protection of illegally cultivated public lands, there is a tendency to spend a great amount of time, talk and energy to determine the exact extent and location of the lands in question. In my opinion, this is a waste of time and effort since it does not contribute to the solution of the problem.

If it is agreed that there are SOME "idle" lands or SOME illegally cultivated lands, it should be evident that the problem exists. If it is agreed that there are at least, say, 1,000 hectares to be considered, whether there are 20,000 ha. or 200,000 ha. does not change the problem nor should it alter the approach to the solution. When the program gets down to the stage of actual execution, the amount and location of the lands being considered will have a bearing on the number and location of the field offices needed to execute the program.

It is frequently suggested that before serious consideration is given to the solution of the problem at hand, there must be a survey to determine the extent and location of the lands in question. While probably not intended for that purpose, such a procedure amounts to increasing the needed budget and delaying the start of the program for several years, pending the execution and interpretation of such a survey.

Some types of projects such as drainage, irrigation, or flood control do require consideration of the entire project before any operations should be started. Other types of projects are cumulative in nature and can be done piece at a time without knowing the ultimate cost or extent. Soil conservation projects such as the protection of illegally cultivated lands or the development of "idle" lands are of this type.

The distinction is that you cannot drain or irrigate the upper or lower part of a watershed without taking into account the effect that this operation will have upon the whole. On the other hand, when one hectare of land is bench terraced or revegetated, the results secured upon this field are not dependent upon having all other hectares treated. There are, of course, minor exceptions under which adjacent areas might damage benched land unless the foreign water is controlled.

Because of this difference in the cumulative effects, known areas of "idle" land can be developed individually without waiting to study the cost or the effect of similarly developing other "idle" lands near by or far away. If this one area can be economically developed, it should be done as soon as possible. To delay while an investigation is being made of other areas is not justifiable.

Each sub-project or the development of each tract should be considered on its own merits. Will the total benefits justify the total costs? If so it is economically sound, if not it is unsound. The fact that an estimate discloses that the development of one tract is economically unsound, does not necessarily indicate that the development of other adjacent tracts would also be unsound. Neither does one economically sound development guarantee that all such developments in that vicinity will be sound, economically. Each tract should be treated according to its own physical needs and economically justified on the basis of cost : benefit comparison.

The Land Bureau, the Ministry of Civil Affairs, the Taiwan Forestry Bureau and perhaps other agencies have legal responsibilities for the use and management of lands of different categories. These legal responsibilities must not be overlooked nor infringed upon. However, which agency is legally responsible for the management of a tract of land, in no way effects the physical condition of the land nor the technical problem of treating it properly. Under similar soil and slope conditions a given rainstorm will cause the same amount of damage whether the land is designated as Aboriginie Reservation, National Forest, Hsien public land or privately owned.

Therefore the technical problem is the same, regardless of the agency which has been designated to administer the land. If the problem is the same, the solution should be approximately the same, too. Perhaps the first thing that should be done is to state what should be done to protect and stabilize lands under certain conditions. After the needed treatment is determined and recommended, different means of applying the needed treatment will undoubtedly be devised by the different agencies for the lands under their control. That is to be expected and is perfectly proper.

Maybe if the various committees would try to arrive first at the treatments that are needed and then encourage each administrating agency to suggest and develop its own means of applying the appropriate treatments, less time would be consumed and the actual treatment of the land would be speeded up.

Design for A Small Watershed.

Watershed management is not a separate and distinct science. It is the application of a number of standard soil conservation practices with the particular objective of controlling flooding or siltation within a watershed. Regardless of the size of the watershed, the same principles apply. The details of planning and application will vary with the size of the undertaking.

The first step in making a conservation plan for any area is to find out what the problem is. You will remember that we have mentioned this point before in farm planning. Next, you have to find out what you have to work with. Again you will remember that we have said that you must make an inventory of conditions. This is usually called "making a survey." Making a survey has many implications. Locating and measuring the extent of damages is one phase of a survey. The delineation of physical, social, and economic factors is another. Much or little of the needed information may already have been collected. The data may be only approximate or very exact.

To save time, money, and expense, always find out what data are already available and make use of as much of them as are applicable. These data may be in the form of topographic maps, soil or vegetative cover maps, irrigation or drainage maps, land use or ownership maps, social studies, population or census data, etc. It would be a great embarassment to any government bureau if it were known how much time had been spent in resurveying for data that was already available in their own files, not to mention that available for the asking in the files of other government bureaus. A little thought and inquiry before starting a survey may save you a lot of time and effort. Try to do things the easy way by using what is already available.

Collecting a lot of unneeded data or collecting it in greater detail than is needed can be the cause of wasting much time and money in making surveys. Unless you are going to actually use the data, don't waste the time and money required to collect it. A great deal of time can be spent measuring the exact area of each subwatershed. Then when this laboriously collected exact data is used, it is multiplied by an "estimated percentage" of the runoff of an "anticipated intensity" of rainfall. In the end you have an approximate figure regardless of the exactitude of the a real measurements. You can make hundreds of measurements of the slope of a watershed and average them arithmetically, arriving at an average slope which is accurate to the third decimal place. However, for our purposes two or three or not more than ten actual measurements, averaged mentally, will usually suffice.

The greater the area of the watershed and the more detailed the plan that is to be made, the greater the need for elaborate data. For a large watershed, accurate reproductions of topographic maps are desirable. For a small watershed of only a few hectares, you can frequently stand on a hill where you can see the entire area and make a sketch map that will be adequate. If so, this will save a lot of time. When you can see all of the actual watershed from one point there is less need for accurate mapping. A map is merely a paper image. When you can see the actual watershed you don't need to depend on the study of a paper image. Regardless of how it is obtained, it is necessary that the planners get a visual picture of the problems.

Any watershed is composed of subwatersheds which, in turn are composed of sub-sub-watersheds. Surface treatments usually start with the smallest sub-watersheds while structural treatments of the stream usually start with the major or combined watersheds. Thus we plan reforestation or terracing of the sub-watersheds to reduce the runoff from them but we build retention dams, training dikes, etc. on the lower reaches of the stream after many subwatersheds have combined to contribute to the flow of a larger stream.

On the watershed map should be delineated the drainage pattern and the location of the damage areas. Physical features which might effect the drainage, such as highways, railroads, irrigation or drainage canals, should also be shown. With all of these factors shown graphically on the map, the solution to the problem will usually become quite evident. There is an old saying that a problem well stated is half solved. That certainly applies to watershed management.

After you have determined what and where the damage is and the source of the water that is causing it (if it is caused by runoff water) you are then ready to plan how to prevent or at least control it. It is seldom possible, and still less often practical, to entirely eliminate erosion or flood damage. We strive to control or limit its destructiveness. The degree of control justified should be determined by considering the extent of the damage and the cost of varying degrees of control.

There is seldom anything that can be done about increasing or decreasing the amount of water falling in a watershed. Frequently something can and should be done to influence how much of it will infiltrate where it falls or how rapidly the runoff portion is removed and concentrated in the streams. In the cultivated areas of the upper watershed, the same practices that are used for flood control and siltation prevention, are also used for water conservation and erosion control in our regular soil conservation farm planning.

Every extra liter of water that can be induced to infiltrate where it falls, reduces the runoff and the flood potential of the watershed by that much. It also adds that much to the subsoil moisture supply upon which the crops depend and which is also the source of well and spring waters. From the standpoint of the individual cultivator, he wants to prevent the removal of the surface soil from his fields, as that is what produces his crops. By retaining the surface soil he conserves and accumulates organic matter and plant nutrients. From the standpoint of watershed management, the primary interest is in retaining the soil in place to prevent the sedimentation of canals, reservoirs and paddy fields in the lower part of the basin.

In both cases, the practice that serves one purpose also serves the other. These is no divergence or conflict of interest. If the price of a commodity is raised, the producer benefits at the expense of the consumer. If it is lowered, the consumer benefits at the expense of the producer. But in applying sound soil conservation practices both the cultivator and the watershed benefit.

After inducing as much water as possible to infiltrate into the soil, it is sometimes desirable to temporarily retain some of the runoff in the upper part of the watershed until the channels in the lower part are emptied so they can carry it without causing floods. To relieve damages caused by swampy conditions it is sometimes desirable to increase the speed with which surplus water is removed. Thus the nature and location of the damages governs the kind of treatment.

Because of the steep slopes which are prevalent in Taiwan and because of the torrential rains which can reasonable be expected each year, it will seldom be either possible or feasible to retain all of the water that starts to runoff. However, we should always be on the lookout for sites where some of the runoff can be temporarily detained. We should calculate the quantity of water that can be expected to runoff from each watershed and sub-watershed per second, per hour, and per day. With this data available you can quickly calculate how many hours peak flow could be stored at a given site by a dam of specified height, even before going to the trouble of calculating the cost of the structure. Only if it appears that such a structure would give relief to the lower reaches of the stream, should we go to the trouble of calculating the cost of such a dam. If the cost : benefit ratio seems to make such a project economically feasible, you can go on with the design of the structure.

Since the water from the retention dam must be released into the stream, the logical question is, how fast can it be released without doing appreciable damage? In order to answer that question we must know the safe capacity of the channel below the stream and how much of this capacity will be used by local runoff for the period following the torrential rainstorm. The escaping water from the retention dam should not overload this stream channel. The capacity of the escape culvert should be larger than the normal flow of the dammed stream but no larger than the unused capacity of the channel below.

Any hydraulic structure in a stream should have an emergency spillway to handle the overflow and, in case it rains harder or longer than you calculated, save the structure from overtopping and possible failure. The greater the investment in the dam, the greater the need for protecting it from washing out.

In any event, it is desirable to induce as much of the rainfall as possible, to infiltrate where and as it falls. In addition to helping the cultivator of that field, it will reduce the size and cost of the lower structures needed to control that portion which must run off. As you already know, mulches and sod covers encourage more rapid infiltration. Level benches hold the water in place for a longer time and thus permit more of it to enter the soil instead of running off.

These practices also prolong the runoff period and thus reduce the peak flow following a hard rain as even that water which is not absorbed by the soil is delayed in running off. This smaller peak flow permits smaller, cheaper structures and lessens the damage from floods.

In our discussion of RUNOFF WATER we discussed how to calculate the total and peak flows from an area. For storage, either permanent or temporary, we are interested in the daily runoff. For the construction of channels and the weirs of structures we are interested primarily in the peak flows.

Whenever it is economically possible to choose, we should keep the runoff water moving as slowly as possible. This will cause less erosion in the channel and will cause less damage to the structures. We must remember that the quantity of water flowing thru a channel is the product of the cross section by the velocity. If we merely slow down the velocity by any means, the cross section will have to be increased proportionally in order to carry the same amount of water.

The growing of bamboos, willows or even stiff stalked sugar cane in the flood plane of a stream, slow down the velocity when the flood waters are forced out of the regular channel. This means that in order to carry the flood flow, the stream will have to rise to even greater depths than if the retarding vegetation were not there. This may have been one of the contributing factors responsible for the extreme spread of the flood flow during the floods of 7 August 1959.

A watershed management plan should include provisions (1) for the encouragement of infiltration, (2) for the temporary retention of some of the runoff, (3) for channels adequate to remove the peak flow and (4) for the maintenance of such channels free from obstructions. The balance between these various phases of the plan requires that the costs of each segment of the plan be balanced against the costs of establishing and maintaining that treatment.

Design and Construction of Check Dams

Before considering the location, design, or construction of any structure, we should thoroly analyze the problem that we are trying to solve. What is the trouble? How is it hurting the farm? What is the cause of it? What are the alternative methods of remedying it? In considering check dams particularly, we should be clear about what we expect them to accomplish, not just general terms like "protection" or "conservation," but specific details of how these are to be accomplished,

Check dams have many objectives. In Taiwan they are most frequently built for the purpose of stopping the movement of stones down the bed of flooding streams. They may also be used to stop the degrading of a valley floor. They may be used to temporarily stabilize a grade until planted vegetation can become established. Check dams built for this purpose are frequently made of brush or other material which will rot away after the vegetation is established.

When a valley floor is degrading, or eroding away, it leaves steep, perpendicular banks which erode or slump in, removing the toe of the adjacent steep valley slopes. This removal of the toe of the slope sets the stage for land slides. If the present slopes are stabilized, they may remain so if the degrading of the stream bed can be prevented.

Concrete or masonry check dams will frequently serve this purpose. These check dams are not designed to catch or hold material coming down the stream. They are designed only to maintain the present grade. There may be some degradation between the check dams but at the dam sites, the elevation of the stream bed is stabilized. If this is the problem to be solved, check dams may be the answer.

These seems to be a great deal of misunderstanding regarding the use of check dams to stop the movement of stones down a stream. When a check dam is built with the weir above the level of the stream bed, rocks will lodge behind it until the check dam is filled to capacity. When this will occur depends upon many factors. Obviously, the depth and capacity of the check dam is important. So is the quantity of debris that comes down the stream each flood. We should really estimate the useful life of a check dam in terms of the number of floods rather than in terms of years, altho the number of floods per year can be estimated.

The slope of the stream channel is flattened at the dam site and immediately above it. This slows down the velocity of the stream IN THIS AREA. If a series of check dams are constructed so close together that these low velocity areas meet, the velocity of the stream is reduced. However, in the undisturbed channel (1) above the top check dam and (2) below the last check dam, the velocity is not altered.

After the check dams are filled, they do not increase or decrease the amount of water in the stream. All the water that enters must leave and in approximately the same period of time. The velocity of a stream flow is determined by the (1) slope of the channel (2) the friction between the water and the channel and (3) the hydraulic radius, or the relation between the wetted perimeter and the cross section of the channel. Since none of these factors are changed below the check dam, the velocity will remain the same.

Since the velocity of the stream is checked in the basin of the check dam, sediments will be deposited there. The clay, silt, fine sand, and depending on the velocity, gravel and smaller stones may be carried over the dam but the larger rocks will be retained. After the check dam has been filled to the level of the weir, the coarser sediments will start depositing above the water line where the current is first checked by the accumulating debris. Materials will continue to collect on a grade of increasing slope until approximately the original grade has been reestablished.

The collection of sediments in the stream bed raises the level. At higher elevations most channels are wider. Spreading the same amount of water over a wider area makes it shallower and consequently it will run slower AT AND IMMEDIATELY ABOVE THE CHECK DAM SITE.

After the check dam has been filled and the debris has again established the original grade, the check dam no longer stops the movement of stones down the stream. An exception to this is the fact that by raising the elevation of the surface of the rock fill, it becomes wider and the flow of water, if evenly distributed, would be shallower and slower. However, the water is seldom uniformly distributed.

During the period while the check dam is functioning to retain stones, the full flow of the water (minus the stones) continues to flow down the old channel below the check dam. In practically all cases there is a large store of rocks of various sizes which have been deposited in the old stream channel, below as well as above the site of the check dam. It is usually the accumulation of these rocks that leads to the construction of the check dam.

Check dams offer no protection against water damages during floods because the same amount of water pours out in the same time. Even tho for a year or so, no rocks may be passing over the dam, the rock free water flowing down the old channel will, in time of flood, attain enough velocity to pick up and carry along with it, the rocks which had previously been deposited in the channel before the dam was bulit. The same flood intensity that placed them there in the first place will be able to move them on down the stream to be deposited in the villages or fields that the check dam is supposed to protect. Consequently the rock damage at the mouth of a wild creek may be just as great after a check dam has been built 600 ot 800 meters above.

If the check dam is built immediately above the village or other site to be protected, the stream has little or no opportunity to pick up rocks after passing over the check dam. Unfortunately, the most economical sites for check dam construction are usually upstream where the valley walls are higher and closer together.

Check dams should be substantially built to withstand the pounding of rock laden flood waters. If a check dam fails after accumulating a store of debris behind it, all of this material along with the normal load of the flooding stream may be spewed onto the area which was supposed to be protected. The failure of a large check dam and the sluicing of a large quantity of stored material thru the breach may easily result in greater damage than would have occurred if the check dam had never been constructed. This very thing occured on Tung Shan Creek, Changhwa Hsien, in the flood of 7 August 1959.

The ratio between the cost of a practice and the benefits expected to be derived from it should be considered carefully before any soil conservation practice is undertaken. This is particularly true in regard to the construction of check dams for the purpose of arresting the movement of rocks down the stream. In considering a proposal to build such a check dam, close scrutiny should be given to (1) the comparatively short useful life before the check dam will be filled with debris (2) the lack of protection from water damage (3) the fact that rock deposit damage may occur in spite of the dam unless the dam is located close to the protected area and (4) the danger of increased damage in case the dam should fail.

Because of the high expense of construction, the short life and the lack of assured complete protection, all alternative control measures should be carefully studied before the construction of check dams is undertaken.

In some cases a large part of the debris carried by flood flows is picked up as the result of bank cutting by the stream. This source of debris can be eliminated or reduce by deflecting the current of the stream away from these eroding areas which usually occur on bends. Tree or bamboo plantings will seldom be sufficient to protect vertical banks from erosion by the stream. Spur dikes or stone walls usually are needed for this purpose. If properly designed and constructed, these structures should have a comparatively long life.

When and where there seems to be no alternative but to build check dams, they should be located as close as possible to the area to be protected. This will prevent the water flowing over the dam from picking up another load of rock before reaching the protection zone. Where human life is not at stake, it may sometimes be more economical to just endure the flood damages rather than spend the money necessary to furnish adequate protection for a short while.

If the situation requires the construction of a large check dam, it would be wise for you to have it designed and built by someone with engineering training. You should undertake only the smallest ones. The Soil Conservation Division of the proposed Mountain Agricultural Resources Development Bureau, is expected to have some engineers on its staff. If they are not available to you when and where needed, you might consult the local representative of the Provincial Water Conservancy Bureau for technical guidance and help.

For the small check dams that you may be called upon to design and build there are several points that it would be well to keep in mind. First, the purpose of the check dam and the difference between such a dam and one that is designed to hold water. The water retention dam must be made as leak-proof as possible. Its foundations should be deep, with cutoff walls to prevent water from seeping under it. Its construction should be watertight to prevent seepage thru it. Such a dam should be located where the danger of siltation will be the leas.

On the other hand, a check dam need not be watertight and need not have a water tight foundation. In fact the check dam should so built and so managed that it will be empty of water when the stream starts flowing. Check dams are usually built in places where sedimentation is a severe problem.

Both kinds of dams have certain factors in common, both should have a weir notch of sufficient capacity to handle the maximum flows. Both should have an apron or a stilling basin to dissipate the energy of the falling water and so prevent erosion which might undercut the structure and cause failure. Altho cutoff walls and a tight seal with the bank are not essential for check dams like they are for water retention dams, in neither type must the water be allowed to flow around the ends of the dam.

You need to know the peak flow of the stream in order to design the weir notch. In Taiwan you will need to use a different formula than would be used in lands where typhoons do not occur. An estimated runoff of 100 mm. per hour should be a safe figure. For long narrow watersheds this can be reduced somewhat. However the cheapest insurance for the life of your check dam is to make the weir notch bigger that you think will ever be needed. In addition, the top of the wing walls should not be made level but should SLOPE toward the weir notch from each side.

By making the ends of the wing walls higher than the center, if there should be a flood greater than you calculated, after the weir notch flowed full, the next water would start flowing over the walls at the center, next to the weir. As the height of the overflow increased, the overflow would widen but it would be some time before it reached the ends of the walls and started flowing around the ends of the structure, where it could erode the bank material.

The big flood of August 7, 1959 left several perfectly sound check dams with level topped walls standing out in the middle of the stream. When the flood flow exceeds the capacity of their weir notch, the excess started to flow over the structure, including the wingwalls, at a uniform depth, The main structures and the wingwalls were well built and suffered no damage from this overflow. But the water flowing around the ends, over the unprotected soil, soon eroded the bank so that the stream was soon running AROUND the structure instead of over it. Wingwalls high on the outer ends would have directed this excess flow over the center of the structure where less, if any, damage would have been done.

In picking a site for a check dam, as in locating a storage dam, look for a site where the shortest possible structure will have the greatest storage capacity for rocks or for water. An ideal site is one at a narrow place in the valley with high, solid banks upstream from which there is a comparatively wide area with a flatter gradient. A short, comparatively cheap structure here will raise the water level and back up water which will spread over a wider area, increasing the capacity of the reservoir. While rocks do not spread out as uniformly as water does, never the less, the wider storage area will retain more rocks than a narrow one and the wider area of quiet water will reduce the velocity at that place. This will cause the deposition of more material of smaller size than would be deposited in a narrower channel where the velocity would be greater.

Dams constructed of large stones tend to be more durable that those made of small rocks. In any event, those portions of the structure over which the flood waters will flow should be secured in place with strong cement mortar. If the wing walls are far enough above the high water level to insure that the current will not flow over them, they may be of hand placed, head sized rocks. This will reduce the construction cost.

When materials from the stream bed are to be used for the construction of a dam of any type, they should be taken from above the dam site rather than from below it. This will increase the capacity of the dam by the volume of the materials used.

Altho a check dam need not be of watertight construction, care should be taken that rubbish is cleared away and that sharp banks of the gully are sloped sufficiently so that water will not start channelling or tunnelling which might cause failure.

There are three important elevations in connection with any dam. First, the height of the weir notch which will determine the height of water retained. The second is the height of the wingwalls. This determines the freeboard or height of water when the weir notch is flowing at full capacity. The higher these elevations, the greater the capacity of the dam.

The third important elevation is that of the lip of the apron or stilling basin. This should be as low as it is feasible to make it. If it is too high, there will be a tendency for the water flowing over it to pick up energy in falling and to start erosion which might undermine the apron and eventually the structure. Altho it requires expensive excavation, it is frequently desirable to set the apron or floor of the stilling basin deep enough so that the water leaving the lip will be at or below the elevation of the surface of the channel at that point.

A stilling basin or an apron should have a transverse sill or obstruction across it to check the velocity of the water as it leaves the structures, causing the water to dissipate its energy by jumping up rather than dashing against the soil.

Stream Bank Erosion Control

Streambank erosion is a geologic process that is constantly sifting and sorting the material in the alluvial fill in the stream valleys. The removal of forest cover, overgrazing and cultivation incident to the opening of lands greatly accelerates the erosion in streams because of the increased frequency and volume of runoff. Sedimentation due to upstream erosion, channel blocks, and restrictions such as bridges, diversion dams, and snags, cause the stream meandering that further aggravates bank erosion. Most of the bank erosion is caused during flood stages of the stream and as it is subsiding. It is the continued high rate of flow, rather than the peak flow which causes most of the damage.

In many places streambank erosion is destroying productive valley lands or endangering highways, railroads, bridges or buildings. This sort of situation should be handled by experienced professional engineers. It takes more budget and more experience than you will have in the Soil Conservation Field Office. However it is worth while that we discuss with you some of the principles involved. You should be able to recognize the problem and perhaps handle some of the smaller streambank erosion problems that lie entirely within one farmer's land.

It is well to remember that these streams built the valley lands by depositing there the material carried down from upstream. These streams were in the valleys long before man started farming there and we can expect that they will always be there.

The meandering of a stream is nature's way of controlling the velocity. When a stream starts flowing so fast that it starts to scour or erode, it will start cutting on one bank and soon put kink in the stream channel. Eventually this will make the stream longer. reduce the gradient and so, slow down the velocity until it becomes stable. Remember this, that any time you lengthen the travel distance between two points of different elevation, you are at the same time reducing the gradient. And if you shorten this distance, the gradient is increased.

In times of high water these meandering channels hold back the runoff water and cause it to flood the crops in the valley fields. Farmers don't like this and try to avoid it when they can.

One of the most common ambitions of valley farmers is to straighten out the stream channels so the flood waters will drain away quickly and cause less crop damage. It is usually possible to straighten stream channels, if you are able and willing to spend enough money on them. But when you to straighten them, the channel is shortened and the gradient and velocity are increased. This is true without exception.

When you straighten a stream channel and increase its gradient, the increased velocity soon starts it to scouring and meandering again. It starts trying to do again what nature had already done, that is, create a stable gradient in the stream channel.

I am familiar with many of the details of a project for straightening the Little Nemaha River in southeastern Nebraska. This small stream used to meander over a rich valley. There were usually two or three floods each year which damaged or destroyed the corn crop. The farmers banded themselves together into a drainage district, levied taxes against their land, sold bonds and had a drainage channel dredged through that rich bottom. This ditch was about 2 to 3 meters deep, 6 to 7 meters wide and 30 kilometers long.

When the next floods came, their new river channel carried the flood waters away quickly and they suffered a minimum amount of crop damage. The farmers were greatly pleased. They imagined that they had thwarted nature.

After a few years they noticed that their new channel was getting deeper. This was becuase the steeper gradient and higher velocity caused the stream to erode away the soil in the bottom of the channel. But the dirt was carried away and their crops were not flooded so they didn't care much about the channel depth. After a few more years the banks started eroding, first on this side and then on the other. Trash floating down stream in a flood lodged at one point and deflected the current to the other bank. Soon the stream was starting to meander again. However, this is not all of the story.

As the result of the increased velocity, the bottom was scoured out and the banks eroded away. The stream began to get both deeper and wider. Highway and railroad bridges that had always been adequate in the past, were washed out. They had to be replaced with longer bridges set on deeper foundations.

Millions of cubic meters of soil which were eroded from this new channel were deposited in silt bars in the Missouri River, interferring with navigation. The state highway department and the railroad engineers could not keep bridges across the little Nemaha any more. The river engineers couldn't keep a navigation channel open.

Damage suits were filed in the courts against this drainage district which had straightened the channel of the Little Nemaha and started all of this trouble. They were sued for the cost of keeping the Missouri River channel open for navigation. They were sued for the cost of constructing channel stabilizing structures at each bridge site on their stream.

Water from their own fields which had once flowed harmlessly over a low bank into the old meandering, flooding channel, now fell over banks 10 to 15 meters high and cut immense gullies across this good land that the new channel was to protect.

This is a true story which dramatically illustrates the danger of undertaking to alter natures ways without understanding all of the pertinent details. Competent engineers had advised them against this stream straightening and had predicted just what would happen. But the farmers, thinking only about draining their own little fields, ignored the advice and went ahead with the project.

Now the damage cannot be undone. If all of those farms that were drained were sold, their price would not pay for the damages that have accrued. These farmers "grabbed a bear by the tail and thy can't let loose."

I have taken the time to recite the details of this incident which occurred half way around the earth, just to impress upon you the danger of undertaking stream straightening without having competent technical advice. The public at large has a right to be protected from the thoughtless, selfish actions of a few people, who, for the sake of a small benefit to themselves, would risk putting the public to great danger and expense.

The stabilization of stream channels to prevent further erosion seldom presents the same dangers as stream straightening. Maintaining the present condition and preventing deterioration is a permissible activity. But on larger streams, even this should be undertaken only by trained engineers.

There are two general classes of streambank protection, namely (1) those which retard or slow down the current along the bank and thus cause the deposition of silt or erosional debris and (2) those that protect the bank directly by a covering that will resist erosion.

Jetties or spur dikes of wooden piling, masonry, concrete or other stable structures are examples of the first type of protection. They slow down the velocity next to the bank and cause silt deposits there. These jetties may be designed to deflect the current away from the streambank, or they may be placed parallel to the bank and designed to reduce the velocity all along the edge so that erosion will be halted.

Riprap, brush mats, and concrete or

masonry linings are examples of protecting the bank directly with a covering. The type of protection for a given site will be determined by the nature of the site, and the availability of different types of materials and equipment.

Vegetation should play an important part in the control of streambank erosion. It may be used alone on small streams or, it may be used in conjunction with mechanical measures.

There are two principal problems in using vegetation alone for streambank stabilization. One is getting a stand of vegetation established before a flood washes it out. The other is to stabilize that section of the streambank below the normal water surface so that the vegetation will not be undercut by the high velocity during a flood. This might cause the vegetation and all to slough into the stream. Vegetation is used most satisfactorily above the waterline on properly sloped banks and on the flood plain adjacent to the banks, to retard velocity there. Vegetation should always be used back of revetments and jetties in the area where siltation will occur. It should also be used on slopes protected by brush mats.

All banks should be sloped if the use of vegetation is planned. This will afford a better site for planting trees and shrubs. Excavated material should preferrably be piled on the bank and levelled and seeded rather than being dumped into the stream. If that is done, most of it will merely be carried down stream to form silt bars and cause additional bank erosion at a new place. Keeping the channel free of trees, snags or any other large objects which might deflect the current, will greatly reduce the possibility of bank erosion during floods.

In placing jetties or spur dikes, consideration should be given to the increased velocity which will be created by thus narrowing the stream channel. Sand or gravel stream bottoms actually become fluid and move down stream with the current during flood flow. Since the material moved down stream is replaced by material carried down from above, the elevation of the bottom remains practically the same before and after the flood. Piling or masonry structures placed in a sandy or gravelly stream bed should be set as deep as the expected flood flow so that they will not be undermined by the movement of the channel bottom materials.

The undercutting and erosion of steep banks on the outside of a stream bend is a very common problem in Taiwan. The stream usually flows with maximum velocity on the outside of the curve and undercuts the bank there. Sooner or later the bank will cave in and the caved material will be swept away by the current. The process is then repeated and eventually a perpendicular bank is created.

The slower current on the inside of the curve will frequently lead to the deposition of silt bars there. When these silt bars become vegetated they serve to further deflect the current so that the bend is still further accentuated.

Because of the steepness of the slope and the volume of the material, it is seldom feasible to slope and revegetate these steep bank. Even if they were sloped and revegetated above the normal water line, the swift current flowing against the outside of the bend would soon undercut the vegetation and the entire process would be repeated.

The proper protective treatment for such sites is to deflect the current away from these critical areas by jetties or spur dikes. If piling can be driven, they might suffice or masonry walls could be built. Either type of jetty will have to be deeply set or the high velocity will undercut them and cause failure. In conjunction with these deflecting works, it may sometimes be feasible to cut a channel through the silt deposits which have been built up on the inside of the curve. The combination of the deflecting jetty and the channel may cause the stream to return to its original location.

Whenever a hydraulic structure is placed on the bank of a stream, consideration should be given to what effects may be produced on the opposite bank by the newly deflected current. The damage at the new site may be worse than that which you seek to remedy.

Riprapping with man size stones is an effective means of bank erosion control. If there are plenty of large stones in the stream channel, such as are frequently found in Taiwan, the principal expense is labor in placing them. In order for riprapping to be successful and permanent, it must be started below the lowest point of stream scour. Otherwise it will be undercut and the embankment will fail. Riprap should be placed on a slope not steeper the 1.5:1. A layer of gravel 15 cm. thick under the riprap makes it more stable, especially when it is placed on filled dirt.

On larger streams wire "sausages" filled with rocks are often used to prevent bank cutting. If you should run into a situation which required such treatment, refer it to the reconstruction chief who can take the matter up with PWCB. Those jobs are too big for you, in the SCFOs to undertake.

A combination treatment consisting of large rock riprap up to a point slightly above the normal waterline and this supplemented by vegetative protection of the sloped bank above this point might be the most satisfactory and economical bank protection of the second classification direct covering.

A study should be made at each eroding site to determine why erosion is taking place there, which of several means of protection will be the most effective and economical and, the possible effects of the proposed remedial works on other downstream locations.

Soil Conservation by Composting

What do you think of when I say the word "compost"?

Some people use it to mean the storage of manures. The term is best used to mean the digesting of carbohydrates in organic matter by the action of fungii and bacteria.

You can compost almost any kind of organic matter. Grass. Leaves. Straw. Twigs. Sawdust. Wood chips. Feathers. Leather scrap. Meat or fish scrap. Kitchen garbage. Manure. Even paper and bamboo can be composted if you have enough time. Composting makes biological rather than chemical changes in the material.

It is accomplished by treating organic matter with certain fungii and bacteria. Then keep temperature and moisture conditions favorable. The micro-organisms devour the cellulose and other carbohydrates. This makes them more soluble so they are carried into the soil. There they improve the soil structure and increase the soil micro-organisms. The minerals in the material are made more available for plant use.

You usually make compost heaps about 4 feet wide and 4 to 5 feet high. The length depends on the space you have and the amount of material to be composted. If possible, choose a site that is well drained and close to a source of water. Otherwise you may have to carry water to the pile.

You spread a layer of organic matter about 6 inches thick. On this you spread one half to one inch of manure. Use fresh manure if you can get it. It contains more active bacteria. On this you spread a thin layer of wood ashes, ground limestone or fresh earth. These will take up any acids that are formed. Now spread on another 6 inch layer of organic matter and repeat until the heap is 4 to 5 feet high. Making the pile too high or tramping it will pack it too much. This keeps out the air which is needed for the action of the micro-organisms. As the pile is being built, add water if necessary to keep the material moist, but not soggy wet.

Get air into the center of the pile. This may be done in several ways. You can make loose bundles of straw or stalks of plants and set them upright. Then build the compost heap around them. Air can then enter the center of the pile thru this porous duct. Some people merely jab vertical holes in the pile with an iron bar or a sharp stake. Keeping the pile as loose and fluffy as possible, also helps to aerate the material.

If well wet down and inoculated, the compost pile should start to heat within about three days. Temperatures may reach 150-160°F. This is enough heat to kill many weed seeds, insects, and some plant disease spores. If the pile gets too dry you may have to sprinkle more water on it. Don't over do this. If water starts to run out at the base of the pile, it is too wet and bacterial action will be slowed down.

In about three weeks the material in the pile should be turned the first time. There are two purposes in this turning. First, to aerate the material. Second, to place the material that was on the top and outside of the first pile, in the center of the rebuilt pile. Then all of the material will be composted uniformly. Start at one end of the pile and move the material over 4 or 5 feet. Place the raw material on the bottom or in the center of the new pile. Work through the old pile, building a new pile of about the same size. By this time the material will start shrinking as the cellulose is digested.

After a second three weeks period, the material should be turned a second time. The volume will be much less this time. It is not necessary to aerate it this time as the future action will not require so much oxygen. In rainy seasons it may be necessary to make a grass roof to prevent leaching by the rain that is taken in. If proper air and moisture conditions have been maintained, there will be no disagreeable odors from the compost heap.

The time required for the complete process varies with the type of organic matter being treated. Most materials will be ready for use within 3 to 4 months. Fresh green materials will be ready sooner, especially if there is some nitrogenous material included.

Composting can also be done in the fields. Crop residues and green manures crops can be cut or chopped into the surface soil and allowed to remain there until this process is accomplished. This should not be confused with plowing under green manure in which practice most of the air is excluded.

In sheet composting, as this process is called, the micro-organisms are already present in the soil. Moisture will be supplied either by the soil or by rainfall. Being mixed in only the surface soil, air will be present as needed.

Sheet composting does not produce as uniform a product as heap composting. It requires less labor than is needed for building a pile and turning it twice. Sheet composting takes more time. In Taiwan, where you frequently grow several crops each year, this would be a disadvantage. When you need to use the land for planting another crop immediately after harvesting, you will probably prefer the compost pile rather than sheet composting.

The use of compost is a common practice in Taiwan. In the plains areas almost all vegetation not used for fuel or for animal fodder is composted. Here, there is a scarcity of material for making compost. In the foothills and in the mountainous areas there is usually plenty of vegetation which can be used for this purpose. It is in these areas that compost is needed worst to lessen soil erosion.

The use of compost increases crop yields. It provides plant nutrients. It also improves the soil structure, permits better aeration, drainage and moisture retention. Soil well supplied with organic matter, such as compost will not erode readily.

Where raw materials are available, composting fits well into the farming program. No outlay of cash is needed for any imported or transported materials or equipment. Hand labor, such as you have locally, is the principal requirement.

Composting, like bench terracing, is an accepted practice in Taiwan. You will not need to convince the farmers of its desirability. You may be able to demonstrate better and more efficient ways of accomplishing the desired end.

Soil and Water Runoff Plots*

July 14, 1956

The purpose of establishing runoff plots is to get *comparative* measurements of the losses of soil and of water due to different ways of managing the different plots. The most important consideration is that all plots be treated exactly alike except for the one factor on which you wish to get measurements. The exact slope of the plots is not important except that it should be uniform and should be fairly representative of the whole area under consideration.

The site which was staked out meets these requirements being uniformly 16% slope and silty clay loam soil typical of the area.

Since sugar cane requires more than a single year for maturity, runoff plots on sugar cane should include both the first and second year conditions by having duplicate plots. While you do not recommend up and down the slope planting, there is still a lot of cane planted that way. Therefore one plot should be planted up and down for the purpose of comparing soil and water losses with other methods of planting.

The most commonly recommended method is to plant the cane in contour rows and to pull the soil up into ridges which will hold the water that falls. One plot should be planted in this manner.

Another more permanent and more expensive method is to construct level benches or benches sloping slightly toward the hill and planting the cane on these flat areas. One pair of plots should be planted in this manner. Since so many pineapples are planted in a square pattern, one plot should follow this method. Another should have the pineapples close spaced on contour ridges. Another flat planted in close spaced contour lines with mulching added and a fourth plot should be benched to permit 4 rows per bench.

Ordinarily, the length of the plots should be determined by the formula for the V. I. of terraces ($\frac{S+6}{10}$ = V.I. in meters). I suggest you make your plots 15 meters long. The area of the plots should be large enough to permit application of the cultural methods used yet not so large as to require unduly large measurement tanks or too much labor in servicing them. Calculations are greatly simplified if the plot is some simple fraction of a hectare. Plots 15 $M \times 33.3$ M would contain 50 M^2 or $\frac{1}{200}$ ha. and would be wide enough to apply the treatments.

If the measurement tanks are divided into A and B tanks with a 4:1 divisor between them, the expense of construction and handling can be reduced. Tank A if 2 M deep, 2M wide and 1 M long would hold 4 M^3 of runoff. This would equal 80 mm. of runoff from the 50 M^2 of each plot.

Tank B 2 M wide by 1 M long by 1.5 M deep would hold 3 M^3 but with the 4:1 divisor this would be the equal of 12 M^3 or the runoff of 240 mm. from each plot. Thus the two tanks would hold 320 mm. of runoff. Since the maximum recorded 24 hr. rainfall is 328 mm. this should be adequate provided the tanks are measured and drained after each rain.

In order to prevent surface water from running onto or off of the plots, each plot should be protected by a wall, probably of brick, on the upper edge and at each side. These walls should extend at least 30 cm below the surface and 15 cm above it.

On the plots which are to be benched the walls would have to be deeper and higher

* Memorandoum to Mr. M.C Liao, Taitung Sugar Mill, TSC

because of the excavations and fills. Diversion ditches of ample capacity should protect the plots from water from above.

At the lower edge of each plot there should be a gutter or collecting trough to catch the soil and water that run off. This should be led thru an open drain to tank A. The gutter and drain may be of any kind of material but I suggest brick, masonry or concrete. The gutters should be as long as the plots are wide, about 30 cm. wide and 20 cm. deep and plastered smooth with a little slope toward the drain in the center. The drain should also be 30 cm. wide and 20 cm. deep and slope from the gutter to tank A.

The tanks should be located far enough down the slope so the water will drain from the gutter into tank A. A longer drain trough means less excavation for the tanks. A concrete platform or base 15 cm. thick and 2.25 x 2.37 M should be poured using heavy woven wire for reinforcing material. After this concrete is well set, having been kept moistened for 10 days, the tanks can be built by laying up brick walls (10 cm thick) in fairly rich mortar. The rough brick walls should be built far enough apart to allow 1 cm. for a finish plaster coat which must be applied accurately to make the finished tanks exactly 1 M. x 2 M. inside dimensions.

You should be there with a 1 M and a 2 M gauging stick when this plastering is done for it is not enough that it be a good looking job. It must be accurate or you cannot measure quantities accurately.

Detailed drawings of the gutters, drain and tanks are attached. After the tanks are constructed I will give you more detailed notes on the construction and placement of the divisors and on the operation of the tanks.

Your first steps should be to construct the head walls and separating walls between the plots, the diversion ditches above them and to get the benches constructed.

Manual for the Operation of Runoff Plot Tanks*

Comparative soil and water losses due to differences in management are determined by measuring the soil and water which runoff from experimental plots which are given various treatments. While the plots contain a certain fraction of a hectare, multiplying the soil and water losses from the plot by the plot size factor will not necessarily give the exact loss per hectare for larger areas. However, the comparative soil and water losses on two plots of the same length, breadth and slope will be proportionally the same as from larger areas under these same treatments.

All of the soil and water lost from each plot flows into tank A. If the runoff is sufficient to cause tank A to over flow, the excess is passed thru a divisor (1:2; 1:4; 1:8; or 1:16 as needed) which retains an aliquot portion in tank B and the remainder is wasted.

The length multiplied by the width by the depth of each tank gives the cubic contents. The contents of tank B must be multiplied by the divisor factor to calculate the true volume of the over flow from tank A.

After a rain storm is over, measure and record on the proper form the depth of the water in tank A (item 2) and in tank B (item 5). The water can now be drained from the tanks. Care must be taken not to remove with the drain water, the sediment which has collected in tank A. This can be avoided by decanting the clear water thru the double elbowed drain pipe. By lowering this pipe gradually, draining will take place from the surface, leaving the undisturbed sediments as sludge in the bottom of tank A.

After as much clear water as possible has been drained from the top of tank A, the remaining sludge will be dipped into containers, weighed and sampled. Any water tight container can be used but kerosene tins with one end cut out are very convenient in size and shape. Each container should be numbered for identification and its empty weight recorded. Each container of sludge will be weighed (item 8) and the weight of the empty container (item 9) subtracted to get the net wet weight of the sludge (item 10). Since it is the weight of the dry sediment that is desired, moisture percentage determinations must be made. It will not be possible to get uniform moisture content when more than one container of sludge is taken from a single tank. Therefore, it will be necessary to make moisture determination of each container of sludge.

Numbered aluminum sample cans with tight lids with matched numbers are desirable but ordinary porcelain cups with covers can be used satisfactorily.

The details of the sampling procedure are:

1. Number the cans (or cups) and lids for identification.
2. Weigh and record the empty weight of each can and lid. (items 12, 18, 24.)
3. Stir the sludge in the container which is being sampled until the consistency of the sludge is as uniform as possible.
4. Dip out triplicate samples, place each in a sample can and cover to avoid evaporation or spillage.
5. Weigh the can and the wet sample. (items 11, 17, 23.)
6. Dry the samples by placing them, with covers off, in a warm, but not hot, place until the sludge in air dry.
7. Weigh each can and dry sample. (items 14, 20, 26.)
8. Deduct the weight of the empty can. (items 12, 18, 24.)
9. The remainder is the weight of the dry sample. (items 18, 21, 27.)

A set of prescription balances weighing by .01 gram to 100 grams are recommended

* For Yuchi tea runoff plots

for weighing the moisture samples.

A platform scale weighing in grams to 50. kg is recommanded for weighing the large sludge containers.

10. The net weight of the dry sample divided by the net wet weight×100 is the percent of moisture. (16, 22, 28)
11. If the moiature determinations for the 3 samples from a container vary not more than 5%, use the average of the 3 determinations. (item 29)

    If one varies more than 5% from the other two, average the two close determinations.

    If none are within 5%, repeat the determination procedure until they are.
12. Apply this moisture percent (item 29) to the weight of the wet sludge in the container to get the dry weight of the sediment in it. (item 30)
13. If more than one container was used for the sludge from a tank, add the weights of the dry sediments in each container to get the dry weight of the sediment in the tank.

    After the water has been drained from tanks A and B and the sludge removed, the tanks should be immediately prepared for another rain storm.

Record of Runoff and Sediment of Runoff Plots

Date of Record

(1) Rainfall recorded by gauge last time plots were drained ____________

Plots No.		1	2	3	4	5	6	7
Tank A								
(2) Actual depth water	M							
(3) Net Depth (2)-(1)	M							
(4) Volume (3)×1.69	M^3							
Tank B								
(5) Actual depth water	M							
(6) Net Depth (5)-(1)	M							
(7) Volume (6)×1.69	M^3							
Sediment—Tank A								
(8) Gross wet weight	gm							
(9) Container weight	gm							
(10) Net wet weight (8)-(9)	gm							
Sediment moisture sample X								
(11) Gross wet weight	gm							
(12) Container weight	gm							
(13) Net wet weight (11)-(12)	gm							
(14) Gross dry weight	gm							
(15) Net dry weight (14)-(12)	gm							
(16) Percent dry weight (15)/(13)	%							
Sediment moisture sample Y								
(17) Gross wet weight	gm							
(18) Container weight	gm							
(19) Net wet weight (17)-(18)	gm							
(20) Gross dry weight	gm							
(21) Net dry weight (20)-(18)	gm							
(22) Percent dry weight (21)/(19)	%							
Sediment moisture sample Z								
(23) Gross wet weight	gm							
(24) Container weight	gm							
(25) Net wet weight (23)-(24)	gm							
(26) Gross dry weight	gm							
(27) Net dry weight (26)-(24)	gm							
(28) Percent dry weight (27)/(25)	%							
(29) Average dry weight $\frac{(16)+(22)+(28)}{3}$	%							
(30) Dry sediment weight (10)×(29)	gm							
(31) Soil loss per ha. (30)×10000/80=(30)×(125)	gm							
(32) Runoff per plot (7)×4+(4)	M^3							
(33) Runoff per ha. (32)×10000/80=(30)×(125)	gm							

Tank measurments by ____________

Moisture sample by ____________

Calculations by ____________

Approved ____________

Soil Conservation in Irrigation*

Oct. 14-15, 1957

Other speakers will discuss the important matters of storing water, water supplies, transportation of water, water return, drainage and other hydraulic and engineering aspects of irrigation.

I will try to confine my remarks to those aspects which have to do with soil conservation.

Definition

First what is soil conservation? It has been defined as "wise use"—"use without waste" or more lengthily "proper land use, protecting the land against all forms of deterioration, rebuilding eroded and depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income, all at the same time".

In studying irrigation you will be interested from the stand point of soil conservation in:—

1. Preventing soil erosion.
2. Preventing leaching destruction or maintaining fertility.
3. Preventing destruction of soil structure.

Let us consider these points one at a time.

Soil Erosion Control

The control of erosion is generally recognized as one of the important phases of soil conservation. In fact, in the minds of some, it is mistakenly thought of as *being* all of soil conservation.

Before we take up the discussion of soil erosion and how to control it, let us consider some of the characteristics of soil erosion.

Soil erosion, reduced to the simplest terms, is simply the movement of soil particles from one location to another. This movement may be by wind, by water or by gravity. It may proceed at a slow or a rapid rate. It may be detrimental or occasionally beneficial. But erosion is still the movement of soil particles from one place to another.

There are two conditions that must prevail before soil erosion can take place. First; the soil particle must be detached from its present attachment or anchorage. Second; it must be transported.

If either of these things can be prevented from taking place, there can be no soil erosion. The whole erosion control program is based on either preventing the soil particles from becoming detached or on preventing them from being transported after detachment.

For a homely illustration; you send a boy to the garden to bring some sweet potatoes to the house. What two things must he do? He must (1) dig the potatoes and then (2) carry them in, mustn't he? If he has no digging tools or if the ground is too hard, he can't dig the potatoes, he can't detach them from their present anchorage. Consequently you get no potatoes in the kitchen. Or supposing that he is able to dig them or finds them already dug but has no basket to carry them in, or that there is an impassable fence or there is a tiger on the path. You still will get no potatoes in the kitchen because, although they are detached, it is not possible to transport them. From this simple illustration you can see that if either the detachment or transportation is interferred with, you get no sweet potatoes.

In just the same way, whenever the detachment of the soil particles can be prevented by any means whatsoever, or when ever the transportation of them can be prevented by any means—there can be no

* For PWCB training class

soil erosion. It is just that simple.

With these abstract principles established, let us see how we can proceed concretely to prevent either the detachment or transportation of the soil particles from taking place.

Preventing Detachment

There are numerous factors which determine the detachment of soil particles. Some of these are:

1. The cementing material that holds them in place.
2. The force of the wind or water that strikes them.
3. The kind and amount of tillage that has been done.
4. The binding effects of plant roots.
5. The sheltering effect of any organic matter which covers the soil.

If you had clods of soil of various textures, you would find that there is a marked difference in the case with which soil particles are detached as you handle them. A clod of sandy soil must be handled very carefully or it will crumble in your hand. This is particularly true if the organic matter content is low.

On the other extreme, clods of clay soils tend to be quite hard and will stand rougher handling. They may even be hard to break when you try to do so. Not only the size of the particles but the difference in the cementing or binding material makes the difference.

The large particles of sand usually have a very weak binding agent. If humus is present, it serves to hold the soil together but pure sand has practically no cohesiveness. It is referred to as being incoherent in structure. Very fine colloidal particles of clay bind the particles of a clay soil together and, wet or dry, they tend to cling closely together so that it is difficult to detach them from the soil mass. These are the extremes. Other soils fall between.

Drops of rain may exert a tremendous force as they strike the surface of the soil. This force is dependent on the size of the raindrops and the height from which they fall. Their velocity may be increased, too, by the force of the wind during a storm.

Raindrops 1mm. in diameter fall at the rate of 4 meters or practically 13 feet per second, regardless of the height from which they fall. Drops 5 mm. in diameter fall at the rate of about 5 meters or 16 feet per second when falling from the height of 1.5 meters, or at the speed of 9 meters or about 30 feet per second when falling from great heights.

It has been calculated that a 2 inch rain falling at the speed of 20 miles per hour would exert enough energy to lift the surface 7 inches of soil to a height of 1 meter. A mild drizzling rain exerts very little force and does not detach the soil particles. If you have ever faced a hard beating rain you must realize how much force it exerts and you can imagine how it beats the soil particles loose from their moorings.

If there is a cover of growing vegetation or a litter of organic matter on the surface of the soil, this serves as a shock absorber and receives the impact of the force of the raindrops, letting the accumulated water trickle down to the soil with practically no force at all. Hence, rain falling on vegetation, whether dead or alive, has very little effect in detaching the soil particles.

Soil particles can also be detached by cultivating when the soil is too dry, so that the soil becomes practically a powder with each particle detached and ready to be transported.

Our contemplation of the nature and characteristics of detachment will have been rather futile unless we can discover some way in which we can control this destructive process.

By maintaining a protective cover on the ground surface, the effect of the raindrops is minimized. By maintaining the organic matter content of the soil, it can be made more cohesive so that it will resist detachment.

Controlling Transportation of Particles

Many factors are involved in the case with which soil particles are transported, but the principal ones are;

1. The velocity of the transporting agent, wind or water.
2. The size of the soil particles.

Have you ever watched a stream of water running over sand or gravel? You will see that the larger gravels stay perfectly still, the smaller ones will roll occasionally where the current is especially swift but the sand and smaller particles will roll along all of the time. The same comparison exists between the particles of sand, silt and clay. Water has to be moving pretty fast to carry sand. On the other hand after clay has once become detached and is gotten into suspension, it will stay in suspension for hours or days. When a pond is stirred up and becomes all red with the lateritic clay such as you have here, how long does it take for it to become clear again? But sand will settle out just as soon as the current slows down a little. That is why you get sandbars right out in the moving water in the river channel. Something caused the current to slow down at that particular point and it immediately dropped its load of sand. The smaller silt particles are carried on down stream until they hit still water like the ocean. There they settle out to form a delta like that at Rangoon or Calcutta only the clay and the colloidal matter is carried out to sea. When you are flying over the mouth of a big river you can see all of these things, the sandbars where the current starts to slow down, the silt beds which make up the delta and the muddy smear extending out into the ocean. All of these things come about because of the difference in the size of the particles that are being transported.

There is very little that you can do about controlling the size of the soil particles but frequently it is possible to do several things about controlling the velocity of the water that carries them.

Paddy Irrigation

In a rice paddy where there is a body of standing water with only a small stream flowing in and the same amount (less evaporation and percolation) flowing out, the velocity of flow across the soil will be so slow that there will be practically no soil movement. The only place there would be any would be a small area where the entering stream might cause some soil movement.

Most of the irrigation water in Taiwan is applied to paddy. This is so different from the irrigation of other crops that it must be discussed separately. In paddy production farmers purposely destroy the structure of the soil by plowing and harrowing it repeatedly when wet. This greatly reduces the permeability and so reduces the amount of water required to keep the rice plants covered to the optimum depth.

Irrigation of Crops Planted in Rows

In other irrigated crops attention must be given (1) to drainage to avoid this waterlogged condition and (2) to the maintenance of a condition of aggregation which permits aeration and better percolation of water.

When crops like sugarcane or vegetables are irrigated by running water between the rows occasionally, in contrast to it standing permanently on the paddy, there is more chance of erosion taking place. We must watch the velocity of the water in row irrigation or we may cause erosion. Even though the soil may not be washed out of the field, removing the surface soil from one end of the row is detrimental.

Before we start figuring how to control velocities, let us talk for a while about some of the principles that govern the action of fluids.

What makes water or any other fluid flow? It is the movement from high pressure areas to lower pressure areas. Usually gravity is the force that supplies the pressure, it always is when the water is in open streams or containers. Fluid contained in a tight vessel does not flow after the surface stabilizes at level. All of the low places in the vessel are filled and there are no peaks on the surface.

Now, if we take away a portion of the containing vessel like cutting away a piece of the dam to a pond, the water next to that hole can move to a lower level outside, and it does this at once. When this water has moved out to a lower level, the water next to it can move down some and so the entire body of water starts to move toward the lower level, by flowing through the opening we have made, all because gravity pulls the water to a lower level when there are no obstructions.

The speed at which water travels when it flows is called the velocity. This is represented by the letter V in all formulae which we will use. It is usually measured in feet or meters per second. If water is flowing at the rate of 2 feet per second, V=2 s.f. This velocity is not related to the quantity of water in the stream, only the speed of flow.

Slope and "Head" Determine Velocity

What are the things which cause the velocity in row irrigation?

One obvious thing would be the slope of the field from the inlet to the outlet. Unless we make level bench terraces, there isn't much we can do about the slope of a field. However we can do something about the direction in which we run the rows. We can lay out the rows on the contour, with no slope, or we can lay them out at the maximum slope of the land. Or we can lay them out at any intermediate slope.

Another factor that helps to determine the velocity is the "head" or depth of water turned into the entrance end of the row. This is actually factor in the slope, for when accurately determined, slope is measured from the *surface* of the water at two points, not from the bottom of the ditch at two points.

Thus you might have a perfectly level row or furrow prepared and by turning in a head of 20 cm. of water, cause the water to flow so rapidly that severe erosion would result. In the same row or furrow, a head of 2 or 3 cm. would result in only a very low velocity which would detach or transport but little soil.

Since water from one row does not cross over into other rows, each row is a separate problem and the number of rows being irrigated at one time has no effect on the velocity except as it effects the "head" of water introduced into each.

Percolation

When water is poured into one end of a row, some of it immediately starts to infiltrate into the soil. This continues as long as there is free water on the surface. How fast the water infiltrates or how much enters the soil per minute depends for the most part on the texture and structure of the soil. Loose sandy soils or soils with distinct, durable aggregates or soil crumbs, take water more rapidly. Heavy, compact soils with low permeability take water slowest. Dry soils naturally take in water faster than saturated soils but a continuous rate of percolation is soon reached.

Whatever the rate of percolation for a given soil, the longer the water stands on it the more water is taken in and the deeper the soil is wetted. If a big "head" of water is turned into a row it will quickly flow the length of the row so that percolation will start on the entire row at almost the same time and the depth of wetting will be approximately the same throughout the row. The smaller the "head" used, the longer it will take the water to reach the outlet end of the row. This means that the inlet end will be wet longer and percolation will be deeper than at the outlet end.

We have, then, two opposing considerations. We want to use as large a "head" as possible to wet both ends of the row alike and get the same depth of penetration. On the other hand we want to use as small a "head" as necessary to keep down the velocity and avoid soil erosion in the row. We must compromise these two factors, giving on one what we take on the other.

You can tell by observation whether the velocity caused by a certain "head" is causing erosion. If the erosion appears to be serious, you must reduce the head until erosion is not obvious. Now, with this largest permissible "head", observe how long it takes for water to reach the lower end of the row. At the time the water reaches the end of the row, determine how deeply it has penetrated at the inlet end.

This can be done quickly and easily by using a plain iron rod probe of $^3/_8''$ to $^1/_2''$ diameter bent 90° to form a handle. Merely shove it into the wetted soil. It will push in easily until it strikes the dry soil. When dry soil is encountered, mark the surface line on the probe, pull it out, and measure the depth of penetration.

Length and Direction of Rows

If you want the soil to be wetted to a depth of 1 meter at the lower end of the row, you can expect that at the upper end it will be wetted to about 1 meter plus the depth measured on the probe when the water first reached the low end. Unless water is ponded in the lower end, the upper end will usually receive the most water because it starts percolating there first.

If with a given soil, a given slope of row and a given head of water, there is no serious erosion and not too much extra percolation at the upper end, your application of water is satisfactory.

If the depth of penetration at the upper end of the row is too great, this can be remedied by cutting the row length into 2 or more pieces, by running irrigation feeder ditches across the field and irrigating the short rows from them. Before planting the next crop, may be the water can be carried across the field faster by laying out the rows so there will be more slope to them.

Why do we not want the water to penetrate too deep? One reason is the extra water that is used and wasted beneath the root zone of the plants. The other is that this water passing down will leach out some of the plant nutrients which will be lost below the root zone. In sandy soils or those of low fertility, this may be a serious matter.

Irrigation in a humid climate like Taiwan is quite different than in truly arid areas. Some crops can be grown without irrigation. However there are frequent periods when the lack of available moisture limits crop production. Irrigation here is pointed toward overcoming these periods of deficiency.

All areas in Taiwan are subject to the intense rainfalls that accompany typhoons. Any field construction or layout must always be designed with these down pours in mind. If we construct our irrigation furrows or crop rows on the contour on a sloping fields, we may control the head of irrigation water to make them work just right and they will seem very satisfactory. Then, when a typhoon hits and 400 mm. of water is dumped on our field in 24 hours, they may not be able to take or hold all of it.

If one row cannot hold all of the water that falls in the area it covers, the water will break over at the lowest point and immediately start to wash away the retaining soil at that point. When this happens, the row into which the excess is poured then also becomes overloaded and it breaks into the 3rd row. This continues clear across the slope, each break becoming more and more severe and the erosion increasing with the larger volume of water.

If the field is level or nearly so, the amount of water moving will not be great and its velocity will be slow, so little damage will be done. The steeper and the larger the field, the greater the hazard.

If the field has an appreciable slope, this hazard can be reduced by laying out the rows with enough gradient to cause them to drain off slowly, but fast enough to prevent over topping and the concentration of large amounts of runoff water thru the broken ridges.

On the other hand, if we lay out the rows quite steep and depend on using a very small "head" in irrigation to keep down erosion, this may be satisfactory as long as we can control the "head". But during the typhoons we cannot control the head and serious erosion may be the result.

Here again we must work out a compromise between what we need for controlled irrigation and what will be safe in heavy rains.

Border Irrigation

Border irrigation is the flooding of areas somewhat like rice paddies except that there is a slight grade from end to end. The water is introduced at the upper end and allowed to flow slowly down the border. Any excess is removed by the pickup ditch at the lower end.

The width of border will be determined by (1) the labor required to make it level from side to side (2) by the head of water to be used and (3) by the practicality of keeping the water spread over the entire border from top to bottom. Unless you use a very large head on a slight gradient, 10 meters is about the maximum width of border.

The length of border and its grade are determined by the same factors that determine length and slope of the rows.

Drainage

In irrigation, it is just as important to remove surplus water as to apply water when it is needed. If the soil is sandy or permeable, there will be little danger of the soil becoming waterlogged.

Heavy soils may present more of a drainage problem. For this reason, rows laid out on the exact contour or rows with closed ends where water will stand and not drain away on the surface, should be avoided on heavy soils.

Regardless of how carefully you may watch the application of irrigation water, you will not always be able to apply just enough and not too much. To attempt to do so would be like trying to drive a car without brakes, hoping to turn off the gas just in time to make the car coast just to where you want it to stop.

We can apply approximately enough gas to get us where we want to go and then use the brakes to give final control. In the same way we can apply approximately enough water to irrigate the field but depend on surface drainage to remove the small surplus in low spots.

You will note that in several instances we have pointed out that you must weigh the advantages and disadvantages of this approach then do the same for another approach and finally select the most workable compromise for *that* situation. It would be much easier if we could just give you a rule book which you could apply blindly, but this will not produce the desired results.

Efficiency of Irrigation

Where the supply of irrigation water is limited in relation to the land available for irrigation—and this is usually the case—every precaution should be taken to make the irrigation program as efficient as possible. This must include prevention of water waste (1) through runoff, (2) through too deep percolation, and (3) through evaporation as well as efficient use of labor in irrigation.

A given soil will absorb the water only so fast. If water is applied faster than this rate, it cannot penetrate but must pond up and runoff. Whenever you see irrigation water running across the highway, it is an indication that some one is applying water faster than the field can use it. This is a waste of precious resource as well as a threat of soil erosion.

Applying too much water at one time causes part of it to penetrate beyond the depth of the crop roots. When this happens that much water is wasted as far as this crop is concerned and in addition some of the plant nutrients are carried down beyond the reach of the roots.

If too little water is applied at one time, applications must be made more often. The greatest loss by evaporation occurs at the time of application. Therefore frequent, small applications are less efficient than fewer, deeper irrigations.

It is essential therefore to determine for the crop being grown how deeply the soil should be wet, and then govern the application of water accordingly to achieve most efficiency in its use.

Land Levelling

Even distribution throughout the field at the desired rate and prevention of loss from runoff can be improved by land levelling or smoothing. We seldom want any but a paddy field to be exactly level. What we want for row crop irrigation is a gradual, uniform slope with all hummocks and ponding areas removed. If the soil is deep, this is a simple problem of cutting off the high spots and using the cut soil to fill the low areas. Heavier soils frequently have a more or less impermeable zone below the plow depth. If the surface soil above this zone is removed in the levelling process, this area will be definitely less productive than before. This will necessitate the use of green manure crops or the application of manures, compost or other organic matter to eventually correct the condition.

It is frequently more economical to divide large fields of irregular topography into smaller fields, each of which can be smoothed out with much less labor and less soil disturbance than would be required to smooth the entire field.

This smoothing represents an investment of considerable labor or money but makes possible savings of labor at each irrigation and also more efficient use of water and higher crop yields.

Soil Texture-Permeability

Not all soils can be irrigated efficiently. Medium textured to slightly heavy soils are best for irrigation. Very light sandy soils take water readily but their holding capacity is low and they require frequent irrigation. This increases the labor required, increases the loss from evaporation or too deep penetraiton and from lecahing.

Very heavy clay soils have a high water holding capacity but absorb water slowly and hold it so tenaciously that plants have difficulty in getting enough during hot dry weather, even though the soils contain water. The slow infiltration rate of these heavy soils increases the difficulty of applying water. Unless the head is carefully controlled much loss from runoff may occur. Unless the slopes are quite uniform, water may run too quickly from the steep places and collect in ponds in low places.

The soil texture affects not only the rate of percolation but the pattern of penetration. In sandy soils the water penetrates so quickly and easily and the water retention characteristics are such that it passes downward by gravity much more rapidly than it moves laterally by capillary action. Therefore, on these soils water carrying with it some leached plant nutrients, will escape below the root zone before the area between wide rows is wetted.

In heavier soils the rate of percolation is slower and the water is held more tightly by the soil. Therefore it moves downward by gravity more slowly, allowing more time for lateral movement near the surface before loss below the root zone occurs.

The application of this fact is to make the irrigation rows closer together on sandy soils to permit complete lateral wetting before leaching takes place. Conversely, on heavy soils the rows can be wide apart or in extreme cases, irrigation furrows may be placed between every second row.

The addition of organic matter to either sandy or clay soils, improves their structure for irrigation and for crop production. Common ranges of available moisture-holding capacities for soils of different textures are:

	Inches of water per foot of soil
Very coarse textures—very coarse sands	0.40-0.75
Coarse textures—coarse sands, fine sands, and loamy sands	0.75-1.00
Moderately coarse textures—sandy loams and fine sandy loams	1.00-1.50

Medium textures—very fine sandy loams, loams, and silt loams 1.50-2.30

Moderately fine textures—clay loams, silty clay loams, and sandy clay loams..............................1.75-2.50

Fine textures—sandy clays, silty clays, and clays 1.60-2.50

Peats and mucks..........................2.00-3.00

Ditch Structures

Water flowing in unlined irrigation ditches may cause a great deal of erosion. The amount of this erosion will depend upon the texture of the soil and upon the velocity of the flowing water. Unless the ditch is lined, there is not much that can be done about the erosibility of the soil. Erosibility is quality of being susceptible to erosion. Control of erosion must usually be obtained by regulating the velocity of the water. The simplest method of controlling velocity is by regulating the slope of the ditch.

Whenever, in order to carry water from one point to another point, the ditch becomes so steep that the water runs fast enough to cause erosion or scouring in the ditch, we must reduce the grade in the ditch.

This usually calls for the use of several drops or checks in the ditch. These structures allow the water to fall vertically onto a protected apron.

By taking this much of the vertical distance between the two end points, the slope or gradient of the ditch is reduced by that amount and the velocity of the water flowing over the unprotected earth is reduced.

These drop or check structures may be very simple or elaborate, depending on the height of the fall and the volume of water. The essential parts are:

1. A weir which determines the elevation of the upper section of the ditch.
2. Wing walls and cutoff walls which force the water to flow over the weir rather than under or around it.
3. An apron with appropriate wings to dissipate the energy of the falling water and prevent scouring.

They may be constructed of concrete, masonry or wood according to plans which are available through PWCB.

The use of these structures where needed is very important to the control of erosion.

The irrigation supply ditches should be designed to maintain the same velocity throughout. If water carrying sediments is slowed down appreciably, siltation can be expected. This means either a job of ditch cleaning or impeded flow. Velocity in the ditch can also be attained by using a bigger cross section "A" area. $Q=V\times A$. V can be reduced by half, if A doubles and not effect the Q. Usually this will also require gentler slope unless the ditch is made wider and shallower.

However this requires more land space and is harder to maintain. Usually it is better to just put in checks or drop structures to control the grade. But regardless of the grade or the Q, it is the V that causes erosion.

Effect of Turbid Irrigation Water

The amount of sediments suspended in the irrigation water, especially the colloids, is an important factor in determining the rate of infiltration. Soils with desirable structure have many small passages, called pores, between the sand grains or soil crumbs called aggregates. Soil aeration and the more rapid infiltration of water takes place through these pores.

If the entrance to these pores is clogged by fine sediments, they no longer can serve as passageways for air or water. The deposition of colloids or fine silts by turbid irrigation waters may actually improve the texture and structure of loose sandy soils which are more or less incoherent or structureless by supplying cementing material to cause the sandy particles to cling together.

Heavier soils may be damaged by the deposition of colloids which cause the soil to swell when wet and to shrink or contract when dry. This permits excessive evaporation when the soil is cracked. When wet, a soil high in colloids tends, unless well aggregated, to become plastic and impermeable to air or water. Soils high in colloids are frequently very hard when dry and are difficult to plow or break down for good seed beds.

Therefore, the turbidity of the water applied can materially effect the texture, structure and permeability of an irrigated field.

There are several aspects of irrigation which, while they are not concerned with soil erosion, are directly concerned with the economical production of the highest yields of crops. That is another phase of soil conservation as defined above.

While water is essential to plant growth and is the principal concern of the irrigator, water alone will not insure high crop yields. Soil fertility is also an essential factor. Unless the required plant nutrients are present and available, the very best irrigation is futile. The fertility of the soil is of course, not your responsibility, but unless there is teamwork, and someone does attend to that matter, your work however well done, cannot be effective.

In order to be most effective, water must be applied at the time it is needed. If water is withheld until the soil is parched and the crop plants have begun to wilt, irreparable damage will have been done and the yield will be depressed regardless of heavy irrigation at a later date.

Other factors such as the control of insects and diseases, selection of good seed of the best variety, cultivation and weed control, unless properly cared for can cancel out your good work. Therefore, for selfish reasons of making your irrigation project a success, it is to your advantage to assist all of the other agricultural programs in performing their functions.

Irrigation, like soil conservation, is but a single plank in a sound agricultural program. If any of the planks are weak or missing, the agricultural program is weak or inadequate, in spite of one or more other strong planks.

Constructing a Fresno Scraper

One eighth inch soft iron plate has proven to be satisfactory for the body of these scrapers. Lighter weight metal does not have sufficient structural strength and thicker material adds weight and expense without making the scraper more serviceable.

The scraper consists of a bottom or floor plate, 2 end plates, two runners of $^3/_4$ inch pipe, a stub handle of 2 inch pipe, a brace of $^1/_2$ inch pipe and two bails of $^3/_8$ inch iron rod connected with a ring of $^1/_2$ inch iron.

Each of the end plates is made from a rectangular sheet 12×19″. Locate a point 9 inches above the bottom edge and 9 inches ahead of the rear edge. From this point mark a quarter circle tangent to the rear edge and to the bottom edge. Trim the end plate to this line. From the upper front corner, mark off 5 inches along the front edge and 5 inches along the top edge. This triangle may be cut off to reduce weight and to make the scraper easier to use.

Drill a $^1/_2$″ hole (A) 8″ from the front edge and 3″ from the bottom edge. If the runners are to the attached by bolts, mark and drill $^3/_8$″ holes as follows:-(B) 1″ from front edge and 4″ from bottom edge, (C) 1″ from top edge and 6″ from rear edge, (D) 8″ from top edge and 1″ from the curved rear edge. If the runners are to be welded on, these points (BCD) should be marked only.

The floor plate is made from a piece of $^1/_8$″ plate 24″×26″. A cutting edge of $^1/_4$″×2″ steel 24″ long with a bevelled edge forged along the lower front corner is welded to the front edge of the floor plate with a butt weld, so that the bottom of each will be in line and the difference in thickness will be on the top.

At the rear edge of the floor plate, $^1/_2$″ from the edge and 1″ on each side of the center line mark points (E). If the stub handle is to be bolted on, drill $^3/_8$″ holes at (E). Bend a 1″ flange along the rear edge (including points E) at right angles. This will stiffen the top of the floor plate where the stub handle is attached. From a point 3″ from the angle of the flange, bend the floor plate to a 9″ radius so it will fit the end plates. Have the flange toward the inside of the bend. Attach the end plates to the floor plate with a corner weld. If the cutting edge protrudes a little beyond the end plates, it will do no harm.

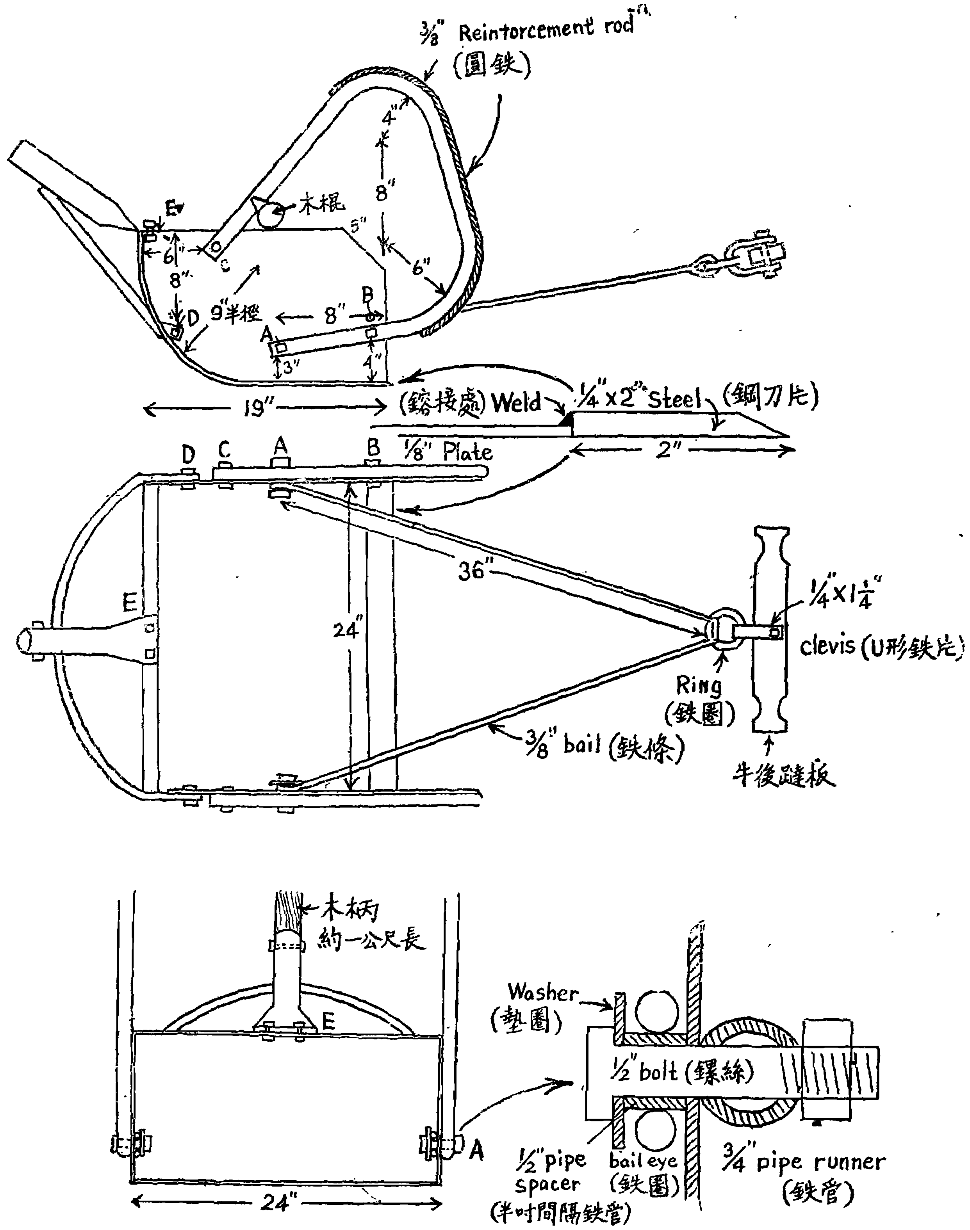
The stub handle is made of a piece of 2″ iron pipe 12″ long. Heat and flatten this for 1″ on one end. Bend this flattened part to about 30° from the axis of the pipe. If it is to be bolted on, drill two $^3/_8$″ holes to match (E) on the flange of the floor plate. For the stub handle brace, bend a piece of $^1/_2$″ pipe into a bow as shown in the drawings and flatten the ends. Weld this to the stub handle as shown and if the brace is to be bolted to the scraper, drill $^3/_8$″ holes to match (D).

The runners are of $^3/_4$″ iron pipe about 63″ long. Drill a $^1/_2$″ hole (A) 1″ from the end. If the runners are to be bolted on, drill a $^3/_8$″ hole to match (B) and a $^3/_8$″ hole 1″ from the other end (C). As shown in the drawings, bend the runners around circles with 6″ and 4″ radii with the centers of the circles 8″ apart. Whether the runners are bolted or welded, always insert a $^1/_2$″ bolt in (A) first as this is the point of attaching the bails and must line up.

It is somewaht quicker and cheaper to weld on the runners and the stub handle and brace than to bolt them on. However, attaching them with bolts is of some convenience if it is ever necessary to replace or repair these parts.

The bailes are of $^3/_8$″ iron rod with 1″ welded eyes in each end with the center of

24 INCH FRESNO SCRAPER 二十四吋鉄糞箕



the eyes 36″ center to center. Make a welded ring about 3″ or 4″ in diameter of 1/2″ iron rod and attach the two bails thru this ring. Bolt A is 1/2″ × 2 1/2″. On this place a large, heavy washer. Next slip on a 1/2″ long piece of 1/2″ pipe for a spacer. Place this thru the eye of the bail and then thru holes (A) in the end plate and runner and tighten the nut securely. This will make a secure attachment of the bail but leave it free to move up and down.

Make an evener of solid wood about 1″ × 3″ and 20″ to 24″ long. If a short evener is used, the ropes are apt to rub the skin off of the animals legs during the frequent turning operations. Drill a 1/2″ hole near the front edge of the evener and in the center, lengthwise. Attach the evener to the ring on the bails with a U shaped clevis of 1/4″ × 1 1/4″ strap iron and a 1/2″ × 2″ bolt. After being placed, the threads of this bolt should be tightly battered to prevent the nut from losing off.

Take a 1″ × 2″ wooden bar or a 2″ bamboo about 30″ long and wire it in place in front of the runners on top of the end plates. The purpose of this bar is to rest on the bails when the scraper is dumped, and so prevent the scraper from falling forward on the cattle.

Make a wooden or strong bamboo handle about 4 feet long, that will fit into the stub handle. It is convenient to have a piece of rope about 6 feet long tied to the upper end of this handle.

Step By Step Instructions For Making A Fresno Scraper

Using 1/8″ soft iron plate make:—
1 piece 24″ × 26″—floor plate
2 piece 12″ × 19″—end plates
2 bails of 1/2″ rod-weld 1″ eyes in each end 36″ c/c
1 piece 2″ pipe 12″ long heat and flatten 3″ on one end and bend this flat end 30°
2 runners of 3/4″ pipe each 48″ long
Drill a 1/2″ hole 1″ from one end
Starting 8″ from hole, bend on 6″ radius 80°
Then 6″ straight pipe
Then bend on 4″ radius 80°
Then remainder of runner straight (about 16″)
End plates-12″ × 19″
Clip 5″ × 5″ triangles from one corner
From opposite corner clip off at 9″ radius
Bore 1/2″ hole 8″ from front and 3″ from bottom
Floor plate 24″ × 26″
Make sharp 90° bend 1″ from rear end
On front edge (24″) weld a 1/4″ × 2″ cutting edge of steel, sharpened as shown
Bend the floor plate to fit the end plates
Weld them together to make the bucket of the scraper
Assembling bails and runners
Have a 3″—4″ ring of 1/2″ rod welded thru the eyes of the bales (one end only)
Take two 1/2″ × 2 1/2″ machine bolts
Place on them large, heavy 1/2″ washers
Next place on each a 3/4″ long piece of 1/2″ pipe
Place the eye of the bail over the piece of pipe
Insert the bolt thru the hole in the end plate from the inside
Place the 1/2″ hole in the end of the runner on the bolt and place nut and tighten
The other end of the runner can be welded on
Assembling the handle
Weld or bolt the flat end of the 2″ pipe to the center of the 1″ bend on the floor plate
Having originally been bent up—it will now be bent forward
Weld or bolt handle braces of 1/2″ pipe (or iron straps) from bucket to handle leaving the 2″ pipe open to receive a wooden handle about 3′6″ to 4′ long
Making the evener
Take a piece of strong wood 1″ × 4″ × 16″ to 24″
Shape notches near each end to tie the harness ropes to
Bore a 1/2″ hole in the center of this piece
Make a clevis of a 1/4″ × 2″ iron strap 14″ long with 1/2″ holes bored 1″ from each end and bent in a U over the evener wood (1″)
Place this clevis thru the 4″ ring connecting the end of the bails
Bolt the clevis with a 1/2″ × 2″ bolt and batter the threads to prevent losing nut.

Using a Fresno Scraper

A Fresno scraper, so named because they were first made in the Town of Fresno, California, is a good implement to use for moving loose dirt for distances of 10 to 100 meters. Dirt to be moved less than 5 meters can be moved more efficiently with shovels, than with baskets and hoes. Dirt to be moved farther than 100 meters had better be loaded in carts as the wheels reduce the amount of pull necessary for a given load of dirt.

Fresnos are not suitable for constructing benches of 3 meters wide or narrower because it is too difficult to turn the animals around on such narrow benches. Neither are Fresnos suitable in soils with many large, head sized rocks. They will interfere with loading the scrapers. Soil that is wet and plastic will stick in the Fresno and will not dump out, thus reducing their efficiency. Outside of these excepted conditions the Fresno saves time and labor in handling loose dirt. Except in very loose, sandy soils, the soil should be loosened with a plow before attempting to use the Fresno.

Fresno scrapers may be made in different sizes but we have found that the 24 inch cutting edge with 19 inch depth is about as large as the ordinary farm cattle are able and willing to pull all day long. Very strong cattle can pull a 30 inch scraper but if they are made this size, the smaller cattle on the next job will not be able to pull them all day.

In using a Fresno scraper, hitch the animal to it and let him pull the empty scraper around on the level for a little while to get used to the sound and appearance of the scraper following them. Some cattle get frightened at something attached to them and want to run. In using the scraper, never load it so heavily that you "stick" the animal. Just before it gets too heavy for him to pull, push down on the handle and thus lighten the load. That gives him confidence that if he keeps pulling, it will come and he won't be stuck. If you run the scraper too deep in hard soil so the animal can't pull it, he gets discouraged as well as sometime sore necked. For days after that he will quit pulling before he has to remember the time that he was really stuck.

For starting to load the scraper, try to select an area free of grass, weeds, or crop residues. Trash like this will fold over the cutting edge of the scraper and make it pull much harder and it will also interfere with loading. Raise the handle of the scraper so that the rear of the floor of the scraper will be about 10 cm higher than the cutting edge. This slope will make the scraper cut into the soil. In loading, the object is to get the first soil being loaded to move as far back in the bucket of the scraper as possible. If it is allowed to pile up on the cutting edge, the remaining soil can not be loaded and the result is a partial load which is inefficient. If the soil starts to pile up and does not slide back into the bucket, pump the handle up and down rapidly as the animal is pulling. This not only makes the Fresno pull easier but causes the soil to tumble backward into the bucket, leaving more room up front for more soil to enter.

After the bucket is loaded, release the handle and let the scraper slide along flat on its bottom. Holding down on the handle causes the scraper to tilt backward and shove loose soil ahead of it, making it pull harder, which we don't want. When the soil is not loading well and the haul is rather long, it will pay to have a shovel handy and throw several shovelfuls of soil on top, to really fill the bucket. Unless this is done, only a small load will be carried.

The efficiency of using a Fresno scraper depends largely upon getting the bucket well filled each trip and in keeping the Fresno in motion without delays. It takes little, if any, longer to make a trip with a full scraper than to make one when only half full. Stopping the cattle to make short turns or for any other reason also slows down the job. All cattle move very slowly and turning is one of the slowest things that they do. Therefore if we can plan our work to eliminate as much of the turning as possible, we will get more dirt moved per hour or per day.

If you can arrange your loading and dumping areas so that you (1) can either make a wide circle with no sharp turns or (2) can load and carry both directions from the loading or unloading point, this will eliminate stopping to turn. In the later case you make more or less of a figure "8" with a turn at each end but none in the middle.

In building terraces with a Fresno, set three lines of stakes. One to mark the upper edge of the area to be cut, one to mark the no-cut-no-fill line between the cut area and the fill area, and the third to mark the lower edge of the area to be filled. Loosen the soil in the cut area by plowing as deeply as you can. If there is much trash, weeds, grass, etc. on this area, you will save time by raking this material off with a spike toothed harrow to prevent it from catching over the cutting edge of the Fresno and interferring with its operation.

Start loading the scraper at the high edge. Just as soon as the scraper is filled, swing the animal at once and dump along the lower line of stakes. Always cut from the high points and fill first at the lowest points. By filling here and driving the animals and scrapers across the fill repeatedly as the work progresses, the fill will be compacted, little by little as the soil is put in place. This is very important for, if a deep fill is made without compacting it as it is being placed, it is next to impossible to ever compact this fill.

Starting the cut at the high point means that you will not have to work over any step-offs as the work progresses. In making cuts by hand labor methods, it is customary to start cutting and filling at the no-cut-no-fill line, each operation spreading from this point. This is convenient for hand excavation but it is seldom possible to get the fills compacted when the soil is dumped from a basket at the top of the fill and allowed to roll down and come to rest on the slope of the fill. As a consequence, many hand made fills settle badly and this is frequently the cause of land slips or bench failures.

In dumping the Fresno scraper, raise the handle to a vertical position so that the scraper rides on the runners and the dirt slides forward out of the bucket. If you wish to spread the dirt in a thin, even layer, raise the handle only part way and by this means control the depth of the layer of dirt laid down. Spreading the dirt in this layers helps to insure better compaction of the fill.

The empty Fresno may be allowed to ride back to the loading area on the runners or it may be left to ride on its bottom. In either case it is not necessary to stop the scraper to change positions if you take one simple precaution. When changing from the runners to the flat position, make the change in one quick, decisive motion. If you try to bring the handle down slowly, the scraper will start to cut into the earth but at too steep an angle so that it may get to jumping around. By throwing the handle down with one mighty slam this will not happen and the animal will not be disturbed by the jerking of the scraper.

Another advantage of starting the fills at the bottom and the cuts at the top is that, if because of the irregularity of the slope you have miscalculated the exact position of the no-cut-no-fill line, you can proceed with your cutting and filling until a bench with the desired reverse slope is achieved with no wasted effort of having to cut away the top of the fill to replace earth that was cut too deeply.

Except on very broad terraces, it will require less turning if you will load and dump while the scraper is moving paprallel to the edge of the terrace. By doing this you can load and dump right up to the edge of the bench without having to move the scraper by hand. This also prevents the cattle from knocking down the edge of the fill in turning, as they would if they approached it at right angles.

Several time checks have indicated that after a man and buffalo become accustomed to using the Fresno, one man and a buffalo will move as much dirt in a day as 4 men working with hoes and baskets.

Procedure for Constructing a V drag.

1. Take a block of solid wood 3″×4″×10″ (7.6×10×25cm.) and rip it diagonally. This will make two wedge shaped blocks A and B 3″×4″×5″×10″.

2. For a keel, use a board 2cm. or 7/8″ thick, 10 inches or 25cm. wide and about 10 or 12′ long-the exact length is not particular. To this nail block A with the 5″ side next to the keel—D. Saw off the point of D in line with the slope of A to make a continuous slope for attaching the blade plate E.

3. The blade plate E is also 2×25cm. and 93cm. long. Hold E against A and D and mark the angle and saw E to fit as shown in the sketch, leave the other end of E squarc.

4. Make brace board G of 2×20cm. wood and 52cm. long.

5. Nail block B to G as shown in the sketch after sawing off 5cm. of B.

6. Take a 4″×4″×8″ block C and cut a 2″×2″ groove out of one corner to make a seat for a 2″ pipe handle to be inserted later on (see diagram). Also bore two 3/8″ holes 1 1/2″ from each end thru the flange of the block on none side and 2″ from the ends of the block on the other flange as shown in sketch. These two sets of holes must not meet or the bolts will not enter at the same time.

7. Hold C in place on G as shown in the sketch and mark the location of the two bolt holes. Bore 3/8″ holes and bolt C to G with two 5″×3/8″ bolts and washers.

8. With A and D nailed together and B and G nailed together hold them in place and mark the correct location for the two bolt holes in C on keel D. Bore this holes and bolt C to D with two 3/8″×5″ bolts with washers. In bolting C on to D and onto G, place the heads of the bolts as shown in the sketch.

9. Nail blade board E to A and B but do not place nails in the center as holes will be drilled there for bolts.

10. Prepare the iron blade of 1/8″ soft iron plate, 1 meter long and 28cm. wide, make a semicircular cut out 7cm. deep on one end (see sketch). On the centerline of the blade bore 5/8″ holes centered 13cm. from the cut out end and 7cm. from the square end.

11. By pounding between two supports, shape the iron blade until the center is at least 5cm. below a line from one edge to the other (see sketch).

12. Hold the iron blade on blade board E and, with the cut out end just even with the end of the blade board over A, mark the location of the two holes in the blade. Remove the blade and bore 1/2″ holes thru E and A and D and thru E and B and G.

13. If these holes are bored at the correct angle, 1/2″ bolts 5″ long can be used to bolt the blade in place. Put the heads of the bolts thru the blade and leave the back ends free to slip on the end links of a chain 2 meters long. 3/8″ welded link chain is recommended but the links should be long enough to fit easily over the bolts. Then place washers and tighten nuts.

14. Make two wedge shaped sticks by 2″×2″ boards 1 meter long. When shaped to fit snugly, drive then in tight and nail them to support the edges of the iron blade.

15. Make the standing board of a piece of 1×8″ wood about 5 feet long. Hold it

in place above G and D and mark the angles. Saw to fit..

16. The four cleats H can be made of 2″× 2″× 12″ blocks. Nail these cleats in place on G and D, leaving room between them to receive the standing board I. Then nail I in place.

17. Take a piece of 3/4″ iron pipe about 4′ long for a handle to control the angle of the V drag. Drive a heavy spike thru D and into C in the middle to prevent the iron pipe handle from going more than half way thru.

18. For the evener, choose a piece of strong wood 1″× 4″× 24″. Bore a 1/2″ hole in the middle lengthwise but only 1″ from one edge. Make notches near each end to keep the rope harness from slipping off.

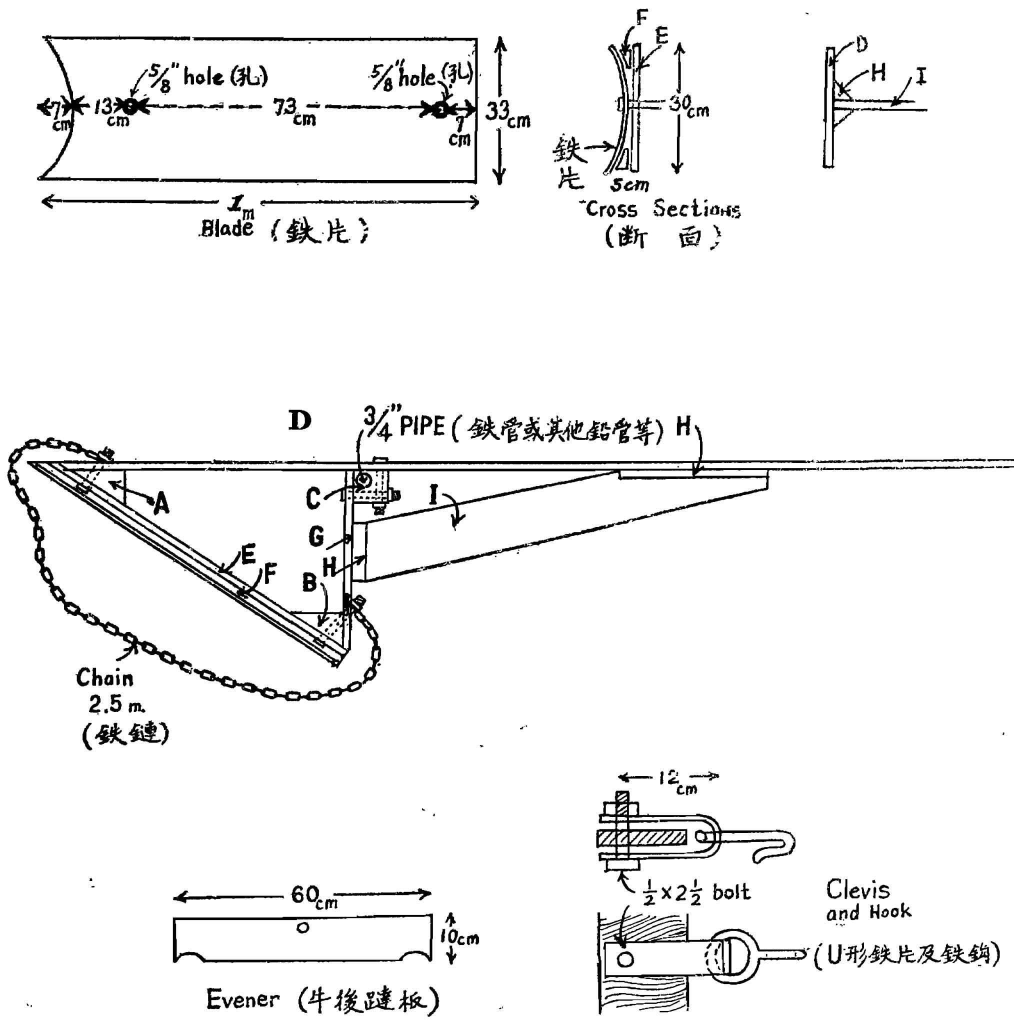
19. Make a clevis of 1 1/2″× 1/4″ strap iron 12″ long. Drill 1/2″ holes 1 inch from each end. Then bend in a U shape with.

20. Make a hook with a 3″ round "eye" and the hook perpendicular to the eye. Use 1/2″ rod for this hook and make the hook narrow enough so that the links of the chain will slip into it easily but cannot slide from link to link.

21. Place the hook in the clevis with the hook down. Place the evener in the clevis with the 3″ side to the rear of clevis. Bolt in place with a 1/2″ bolt with the nut up. Then batter the threads so the nut will not lose off.

22. Place the iron pipe handle in the hole built to receive it. Hook the hook into the bridle chain so that the pull forward will be about in the center of the blade. Care and observation in placing this hook in the proper line of the bridle chain will make it much easier to guide and control the V drag.

SKETCH OF V DRAG CONSTRUCTION V形拖板構造圖



Using a V Drag

The V drag is an efficient implement for moving loose dirt for a short distance sideways. It is not meant for cutting hard solid soil. To try to use it for this purpose will lead to disappointment. Neither is it suitable for moving dirt laterally for a long distance. Therefore, its use should be confined to the construction of narrow benches, not more than 3 meters wide.

The V drag is a miniature blade grader. Its concave blade is set at an angle to make the loose dirt roll as the drag is pulled forward. If the power is hitched to the point of the drag, the side draft will be equally distributed between the blade and the long keel or landside, the length of which tends to stabilize the position of the blade at a greater angle, thus moving the dirt in the direction of the blade.

The blade can be further stabilized by hitching the power by a chain "harness" attached to the point and to the heel of the blade. By hooking the evener to different links on the chain, the hitch can be varied to fit the soil conditions. For normal operation, the power should be hitched directly in front of the center of the blade. If the tail of the keel tends to swing toward the blade side, shift the hitch nearer to the point end of the harness. If the tail of the keel tends to swing toward the land side, shift the hitch toward the heel end of the bridle. A little study and attention to the placement of the hitch will make the drag operate much more satisfactorily.

The length of the V drag itself plus the distance from the point to the shoulders of the animal pulling it, make the rig so long that it is difficult to keep it exactly in the furrow when working around sharp bends. In such cases, instead of the animal following the furrow as he will try to do, it is necessary to drive him straight ahead until the point of the drag reaches the bend in the furrow and then swing the animal so that he is always pulling tangent to the curve in the furrow. Since this is practically impossible to do on steep lands where the V drag will usually be used, the use of the V drag around sharp bends is not satisfactory.

Neither is the V drag efficient for the construction of very short benches, because of the time and effort required to unhook the animal and turn the drag around at each end of the furrow. Other limitations on the use of the V drag are the presence of many large stones or a wet sticky soil condition which will cause the soil to adhere to the blade. If the soil is loose enough and slips on the blade, the curve of the blade will give it a rolling action which makes the drag pull much easier. But if the soil sticks to the blade and will not slip, it merely pushes the soil and so pulls much heavier and does a poorer job.

For your first trial with a V drag, select a location free of stones and with benches at least 50 meters long and reasonably straight. Set a line of stakes at 5 meter intervals on the contour or at the desired grade, along the upper cut line of the top bench. Plow a furrow along this line of stakes. On steep slopes it is difficult to drive cattle exactly on a stake line. Therefore, it may be desirable to mark this line by hand, using a hoe and chopping the soil and pulling it down the slope. With the line marked in this way, it will be much easier to plow along this furrow and loosen the soil. It may be necessary to plow several times in the same furrow to loosen the soil deeply enough.

After some soil has been loosened, use the V drag to move it out of the furrow and down the slope. Place the V drag in the furrow with the keel along the upper side and the blade on the down hill side.

Drive the cattle in the furrow and keep the drag about level by pushing or pulling sideways on the pipe handle. You may need to stand on the drag to make it cut deeper. Adjust the weight on the drag to what the animal can pull without too much effort. Also adjust the hitch to various links on the chain, if needed, to hold the drag at the proper angle, with the keel parallel to the furrow.

Upon reaching the opposite end of the furrow, unhook the animal from the drag and lead him out of the way. Lift the tail end of the drag and, using the point end as a pivot, swing the drag around, down hill, until it points in the opposite direction. Place it, with the blade down hill, in the furrow and hook the animal to the same link as before.

Loosen more dirt by plowing several times in the solid soil uncovered by the first trip of the drag. Repeat the use of the drag. After several repetitions, you will have started a narrow, level bench and will have thrown the loose dirt down hill, keeping the keel of the drag against the upper side of the furrow.

After you have moved a ridge of loose dirt as far as you can with the keel against the furrow, tie a piece of stout rope about 3 meters long to the chain harness where it attaches to the heel of the blade. Place the drag so that the point of the blade is just inside this loose ridge and the blade lies across it. Drive the animal on the ridge instead of in the smooth, hard path where he will want to walk. When the drag starts forward it will tend to slip toward the furrow as the blade encounters the ridge of dirt. Counteract this by having a man walk along beside it and hold the drag on the ridge of dirt by pulling on the rope. Since the dirt is loose and can fall down the slope, it will not be too hard to hold it. But without the help of the rope, it is very difficult to move dirt sideways unless the keel is against the upper side of the furrow.

Proceed, not by plowing at the inside of the furrow, but at the down hill side of the solid dirt which is left exposed. Use the V drag to move this dirt still farther down the slope. Then loosen the rest of the solid soil and use the drag against the upper edge of the furrow to move this last soil over. Repeat this operation, insofar as is possible, keeping the bench shaped so that the loose soil can be pushed down hill rather than up or even across the bench on the level.

After the bench is about as wide as is desired, check the work with a level to be sure of two points. First, that the bench is of the desired grade from end to end and, Second, that it has the desired reverse slope. Before finishing with the drag, it is desirable to trim the upper edge of the furrow with a hoe to leave a smooth, clean surface. This loose dirt can then be moved across the bench with the V drag.

During the course of construction, take advantage of every opportunity to pack the dirt in the fill as it is being placed, by having the men and animals tramp upon it as they go back and forth. Trampling the top of a deep fill will not compact the bottom of it and an excessive amount of settling can be expected. In checking the reverse grade, allowance should be made for the settling that will be proportional to the height of the fill.

After one bench has been completed, with a level, set another line of stakes, just below the filled dirt of the upper terrace. Then proceed as before. If benches are to be built more than 3 meters wide, or if dirt is to be moved longitudinally along the bench, consider the use of a Fresno scraper.

Inaugural Speech of the Soil Conservation Training Center

The purpose of an education is not to avoid having to work. It is to enable one to accomplish more when he does work, to do more or do it better.

The carpenter who learns a skill with his saw, his plane, his hammer and chisel is, in that sense, educated. But his skill is of no value to himself or to the community unless he uses it. Neither is mere willingness to work of much productive value unless it is coupled with trained ability or educated skills. It takes a combination of the two to be effective.

Only the individual can control the willingness to work. It may be prompted by national patriotism, by a humanitarian motive of service to fellow men, or by the less altruistic but still very real motive of wanting to get ahead in the world. No one can supply that willingness nor affect it except by calling the need to your attention.

The education, the skill in doing things, can be supplied by training. The purpose of constructing and maintaining this training center, is to provide a place where this training for service to your nation, to your community and to your family, can be given efficiently and under pleasant surroundings and with the best equipment.

To those who desire to serve better, JCRR are pleased to assist PDAF in providing these facilities for training. These facilities, like the carpenter's tools, are of value only to the extent that they are used. We hope that they will be used frequently and effectively and that the recipients of the training given, will use their acquired knowledge and skills whole heartedly.

If they do this, this training center will have been worth while.

Soil Conservation Philosophy

The earth—or the soil—is the basis of our existence. Plants, animals and man, all depend upon the soil to live. Everything that man needs, except air and water, comes from the soil directly, or indirectly thru plants and lower animals.

Nature treats the earth kindly, she gradually smooths out the steep places and covers the soil with a protective coat of vegetation. Eventually, a state of balance is established between the constructive and the destructive forces.

There always has been, and there always will be, some movement of soil from the high places to the lower places. That is how the broad plane on the west coast of Taiwan was formed, by material brought down from the mountains. That accounts for the fertile valleys of the rivers throughout the world. But we must make a distinction between this geologic erosion and the accelerated erosion which man has caused.

Civilized man upsets the balance which nature has established. He has burned and overcut the forests without replanting them. He has burned and overgrazed the pasture lands. He has destroyed the vegetative cover by plowing and cultivating to grow the grain and fiber crops of civilization.

Conservation philosophy is that it is not wrong to use these natural resources—it is their abuse that endangers man's future prosperity and comfort.

We do not—and probably never will—know all that there is to be learned about soil conservation. But we do know some things that have been proven to be helpful in controlling soil erosion. These practices should have been in use many years ago. Some of them have been used for a long time but too sparingly. It is time that we put them into more general use. Conserving soil resources is a matter of degree. It is not like an electric light, full on or entirely off. It is more like the sunlight, with all gradations from mid-night to full sun at noontime.

History records many instances in which the neglect or abuse of the soil has resulted in the destruction or decay of a civilization. Dr. Walter C. Lowdermilk, who spent many years studying and teaching soil conservation at the Nanking University, refers to this as the "Graveyard of Empires". He says in part:

Agriculture had its beginning at least 7000 years ago and developed in two great centers—the fertile alluvial plains of the Tigris-Euphrates in Mesopotamia and in the Nile Valley. In these fertile soils in an arid climate, with the aid of irrigation, man was first able to produce more than enough food for his immediate needs. This released some workers for a division of labor which led to what we call civilization.

In the days of Babylon, great stone-lined canals brought irrigation and domestic water to these plains. Civilization flourished as long as the combination of soil and water was intelligently managed. Militarily powerful but scientifically ignorant peoples would invade this rich area, killing or enslaving those who knew how to manage the soil and water. As a result, silt would fill the canals, water would fail and poverty would result.

At least eleven great empires have risen and fallen in this land during 7000 years, The barbaric armies came and conquered. In the ignorance, arrogance, and greed which is characteristic of conquerors, they destroyed the soil and water resources which were the basis of the wealth which they desired. Without this wealth, they too, soon weakened and disappeared.

The cedars were cut from the hills of

Lebannon. The camels and goats of the Arabs destroyed the grasses of the pasture lands. The topsoils blew or were washed away, exposing raw subsoil and bedrock. With the soil resources depleted as they are today, it is a difficult and costly job to reclaim this land. But if these resources had been conserved, there is every reason to believe that prosperity would have continued.

At the zenith of this civilization there were between 17 and 25 million prosperous people living in this land. Today there are less than 4 million poor miserable people there.

At about the same time the Egyptians learned to plant wheat and barley in the rich silt deposits left by the annual floods of the Nile river. These enriching floods have continued regardless of the political complexion of the successive conquerors. As a result, the Nile valley has remained suitable for cropping for over 6000 years.

In the Bible, Palestine is described as being a "Land flowing with milk and honey" in the time of Moses some 3000 years ago. Today the red soils, like what you have here in Taiwan, are washed and blown from the hillsides, leaving bedrock exposed. The soils lodged in the valleys and are still being cultivated but are being cut thru with gullies due to the uncontrolled runoff from the barren hills above. Syria, Lebannon, and Northern Africa, which was the granary of the Roman Empire, all present the same picture.

You are more familiar than I am with the Yellow River—Huang Ho—often called China's Sorrow. This river has built up an alluvial fan 40 to 50 feet above the surrounding plain and it takes constant attention and effort to keep the river from breaking out of its elevated course.

The loessial hills in the western upland are the source of all of the brown or yellow silt suspended in this river. Unless and until these hills are stabilized, the silt load will continue. This represents a loss of soil at the source and at the same time a hazard and an expense on the plains.

This same sort of problem exists in all cultivated lands. Naturally, it has progressed to more distressing proportions in the lands that have been cultivated for the longest time. However, there are some lands in northern Europe which have been under cultivation for over 1000 years and which are steadily increasing in productivity.

In the short time, less than 200 years, that the lands of the United States have been cultivated, serious erosion has taken place. Within the past 25 years this problem has been recognized and something is being done to combat it.

Taiwanese farmers have long recognized the damages from gullies and from loss of surface soil. Some of them have done something about it. Many more should start to do something and their methods need improvement, to make them more effective, more permanent, and more economical. That is the function of the soil conservation program in Taiwan.

Chinese farmers, the individualists, are accustomed to being regulated in many of the things they do. In contrast, the American farmers resist having anyone tell them what they should do or how they should do it. This makes it much easier for you to guide their efforts in soil conservation here than it was for us in the States.

The philosophy that "this is my land and I can do with it as I please and it is of no concern to anybody else" is slowly giving way to the recognition that man is only the temporary steward of the land. In the long run, he is responsible to coming generations for the preservation of the land on which they will have to make their living.

If a farmer is careless and lets his house burn down, it is true that he suffers loss, but he can build a new house. His children, too can build new houses for themselves. But if he allows the land to be destroyed by erosion, from then on he and his children must try to support themselves on ruined, deteriorated land.

Before philosophizing further about soil conservation, let us define the term. Conservation means wise use or use without waste. Dr. Robert M. Salter, former Chief of the Soil Conservation Service, U. S. Department of Agriculture gave this definition of soil conservation:—"Soil conservation is proper land use, protecting the land against all forms of soil deterioration, rebuilding eroded and depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income; all at the same time".

The slogan or motto of the Soil Conservation Service has been, use every acre in accordance with its capabilities and treat every acre according to its needs for protection and improvement.

The conservation of forests does not mean to quit cutting trees, leaving them to rot and fall down. It means cutting and utilizing mature trees as they are needed, under a sustained yield system of management. Likewise forest conservation implies protection from damage by fire, grazing animals, insects and disease and the maintenance of the forest stand by natural or artificial reforestation to assure a continuing supply of timber.

In the same way, soil conservation does not mean to quit using the soil so as to preserve it for posterity. It means to use it wisely, without destroying it or lowering its productivity.

Soil conservation is not a substitute for good seed of the proper variety, nor for good seedbed preparation, nor for fertilization, nor for disease or insect control, nor for timely operations, nor for wise marketing or financing arrangements. Soil conservation is not a panacea for all of the ills of agriculture and it will not take the place of any of these other phases of a sound agricultural program. It is but one of the many planks needed to make a sound platform or program. Any platform or program with weak or missing planks is insecure and dangerous to the users.

It is both silly and futile to argue which of the legs on a stool is the most important. Take away any of them and the stool will topple when used. Soil conservation will not take the place of any other plank in the platform and none of the others will take the place of soil conservation. Each is needed and each should be adequate.

Soil conservation, or the wise use of land, is itself made up of several different parts or phases. The most spectacular one and the one that is frequently considered to be all of soil conservation, is erosion control. Other phases of soil conservation are land use, the maintenance of soil fertility and soil structure, water management—irrigation and drainage—where needed. Since a great deal of your effort will be toward controlling erosion let us study it a little bit.

Soil erosion is merely the transportation of soil particles from one place to another, regardless of what may be the cause of this movement. It might be by wind, by water, or by gravity. There are two requirements before soil erosion can take place. FIRST. The soil particles must be detached, or broken loose from where they have been attached. Until this is done, they cannot be moved. SECOND. The soil particles must be transported. Even if they are detached, there will be no soil erosion unless the particles are moved from one place to another. If either or both of these processes can be prevented, there will be no soil erosion. It is just that simple. The erosion control program, then, is aimed at preventing one or the other of these processes.

How do the soil particles become detached? There are many ways but by far the most common is that the falling rain drops strike on bare soil with enough force to detach the particles. Rain, especially when large drops are driven by the wind, possesses a destructive power that is surprising. A 2 inch rain falling at the rate of 20 miles per hour strikes the soil with enough force to raise a 7 inch layer to a height of 3 feet. Of course you don't get a 2 inch sheet of water all at once, but the power is there just the same.

The soil particles can also be detached by plowing, harrowing, or other cultivation. In preparing a seedbed, many fields are so thoroughly pulverized that the soil particles are all loose and ready to be blown away by the wind or washed away by the rainwater. This puts the soil in a detached condition, just waiting for something to carry it away.

Nature has a way of protecting the soil from the force of the falling raindrops. She covers it with vegetation, either forests or grass. They furnish a canopy which receives the force of the falling rain and lets the water trickle slowly and gently down to the soil. Then, especially if a litter of leaves or dead grass has been allowed to accumulate, the water cannot detach the soil particles and there is no soil erosion. But when civilized man comes on the scene, he is not content to live on the grass and trees that nature uses to protect the soil. He wants to cut the trees for fuel and lumber and to plow the grass land to grow grains, vegetables and fiber crops.

When man thus upsets the equilibrium that has been established by nature, a new balance has to be arrived at. In too many cases, this has not been recognized or has been neglected. When we remove the protection that nature has provided, we must provide a substitute or make other compensations or a destructive process is set in motion.

Sometimes we can provide growing crops or a mulch of vegetative material to protect the soil from the pounding and detachment by the rain. There is little detachment caused by rain in a mature crop of sugar cane where the leaves form almost a complete canopy. However, there is no canopy to furnish protection during the first season after the sugar cane is planted. Interplanting the sugar cane with sweet potatoes or peanuts gives a partial ground cover which furnishes some protection against detachment.

In producing cultivated crops, a partial protection can, at best, be provided only a part of the time and there must be periods of several months when the soil surface will be practically bare and unprotected. During these periods our only protection against erosion must be thru preventing the transportation of soil particles which are detached by cultivation or by the beating of the raindrops.

Rice paddies are an excellent example of controlling erosion by preventing the transportation of the soil. In the preparation for planting rice, the soil particles are intentionally detached when the land is plowed and harrowed in a wet condition. As nearly as possible, the structure of the soil is entirely destroyed and it is made into a thin slush with each particle loose and easily eroded. But the important thing is that, while these soil particles are all loose and would be easily transported, the water stands still and is not in motion. Therefore, the detached soil is not carried away and there is no soil erosion in the paddy field.

So, in spite of the detachment which results from the plowing and harrowing of the wet soil and of the detachment caused by rain falling on the bare soil; by controlling the transportation, the erosion of the soil is prevented. It really makes little difference, so far as controlling erosion is concerned, whether we prevent the detachment or the transportation of the soil. Preventing either one will control soil erosion.

Up to this point we have talked in rather abstract terms about the principles underlying the control of erosion because it is most necessary that you understand the principles involved before you attempt to master the details of applying these principles.

Much as we would like to keep the soil all covered with forests or grass from the conservationists standpoint, we know that it cannot be done and at the same time feed all of the people on Taiwan. Much as we would like to have all of the cultivated land made into level benches, we must realize that such a program will require a lot of labor and cannot be accomplished in one or two years. Therefore, we must consider what can be done in the meantime, before the bench terraces are constructed.

Most of the fields for which irrigation

water is available have already been bench terraced or will soon be. There have been some bench terraces constructed for dry farming and there should be many more as time and resources are available.

While we recognize that every sloping field cannot be benched at once, even though it should be eventually, there are some things that can be done at once. These are the simple things that you can take the lead in promoting among the farmers with whom you work. Fortunately, most of these things to be done at once are of such a nature that they can be done with a minimum of equipment or technical training.

Until such time as a farmer is able to construct bench terraces, he need not set idly by and watch his topsoil wash away during each hard rain storm. If he cannot afford to make big broad benches that are level, he can make each row a narrow but level bench which will accomplish some of the same effects as a wider bench terrace.

You have seen large bamboos split in half and used as water troughs for chickens or hogs. As long as these troughs are kept level they hold the water well. But what happens if you raise one end and put a brick under it? If empty at the time, the capacity is greatly reduced. If full at the time, the excess is spilled all over the surface of the soil. Each furrow in a cultivated field reacts in the same way. If level, it holds water. If sloping, it spills it.

Without requiring any more time or any new or special tools, the farmer can make his furrows level on sloping land and thus make a number of small reservoirs which will hold the water like small rice paddies. Remember that if he can hold the water where it falls that, like a rice paddy, the level or contour furrow will prevent the transportation of the detached soil particles.

This is a simple soil conservation practice which requires principally that the farmer understand what it can accomplish in protecting his soil from erosion. The ideal would be to have each furrow level and big enough to catch and hold all of the water that fell in it. It does not take a large furrow to hold all of a small rain and these rains do not do much damage anyway. It is the big rainstorms or the typhoons that cause the damage and they are the ones that are hardest to control with contour furrows.

Before we proceed to discuss these contour furrows any further, let us pause to consider the subject of infiltration of the process of the rainwater being absorbed by the soil. This is a very important subject when we are considering runoff and erosion. Infiltration is simply the absorbing of the water by the soil. Different soils vary in the amount of water they will absorb and the rate at which they will accept it. This rate of infiltration is very important since it determines how much water runs off in any given rainstorm.

When water falls to the earth, what happens to it?

Some of it is caught on the vegetation and will evaporate directly from the vegetation or from the soil. Another fraction of the total will be absorbed by the soil. Some of this will be stored for the use of plants. Some of it will percolate deeper to the underground water table and supply the wells and springs of the community.

Whenever water falls faster than the surface of the soil will absorb it, the excess accumulates as surface water and, unless the soil is perfectly level, it will runoff. It is this runoff portion that is responsible for water erosion. Therefore, anything that can be done to increase the amount of water which enters the soil will to that extant, reduce the amount that runs off. That is why it is so important to keep the surface in a condition that will enable it to absorb the water most rapidly.

There are several factors which determine the rate of infiltration of a soil. The most important is the texture of the soil or the amounts of sand, silt and clay which it contains. There isn't much that you or the farmer can do about this in an economical way. If it is sandy by nature, it will remain that way and if it is a clay soil you can't change that either. Another factor is the structure of the soil or its being broken up into small grains separated by air holes called soil pores, like the pores in your skin. The presence of large numbers of pores of large size enables a soil to take in water more rapidly. There are several things that a farmer can do to increase the pores in a soil. The first of these is to maintain or increase the amount of organic matter in the soil. This may be done by applying manures or compost, by spreading straw or other crop residues or growing green manure crops and plowing them under. The by-products of the decay of vegetative material serve as a cementing substance to bind the smaller soil particles into larger granules or aggregates which act much like grains of sand and maintain soil pores between them.

The farmer can also help the structure of a soil by not plowing or cultivating it when it is too wet or too dry. Working a soil when it is too wet, as paddy fields are worked, causes the granules to be dissolved and results in a hard dense soil which will permit water to move thru it only very slowly. Pulverizing a soil by cultivating it when too dry, destroys the granules by reducing them to dust. When rain falls on a dusty soil, the first water causes the surface to be sealed over. Later water has difficulty in penetrating this sealed surface, even tho the soil below that is dry.

There are then, some things which you can assist the farmer to do to increase the rate of infiltration and so, reduce the amount of runoff water which causes soil erosion. There are, to increase the amount of organic matter in the soil and to cultivate in such a manner as to maintain or improve its granular structure. These practices require no special tools, no cash expenditures and no subsidy.

Another thing that the farmer can do sometimes, is to keep a mulch of straw, cane leaves or other residues on the surface of the bare soil to intercept the rain and prevent detachment by raindrops or transportation by strong winds.

But after a farmer has done everything that is practically feasible to encourage rapid infiltration, there will be some severe rainstorms during which the water will fall faster than the soil can absorb it. When this happens we must depend on preventing erosion by preventing the transportation of the soil by the runoff water which accumulates. Now let us return to the consideration of contour furrows.

How much water or how big a rain contour furrows will control depends essentially on two things. One is the rate of infiltration for that soil and surface condition and the other is the rate of precipitation or the intensity of the rainstorm. Obviously, if the soil will absorb water at the rate of 1 inch per hour and the rain falls at the rate of only $^1/_2$ inch per hour, all of the water will be absorbed and none will runoff. But if the rain falls at the rate of 1 $^1/_2$ inches per hour, surplus water will accumulate at the rate of $^1/_2$ inch per hour. If the furrows we mentioned will store 1 inch of water and the rain continues for two hours, the furrows will hold the excess. If the rain then stops for an hour or two, the impounded water may all be absorbed and the storage capacity of the furrows will again be available for the next shower. But if the rain continues after the furrows are filled to capacity, then what will happen? They will overflow just like a bucket under a faucet. They can hold only so much and any amount in excess of this simply runs over.

In Taiwan where we can normally expect several typhoons per year, we can expect that at such times the contour furrows will be filled and overflow. The fact that the furrows are adequate for most of the rains during the season does not provide protection during the hard rains when it is most needed. On fairly level sandy soils with high infiltration rates, the farmers may be able to build large furrows which will hold even typhoons. Some contour furrows in sugar cane built by the Taiwan Sugar Corporation at their Che-lu-chien plantation in 1955, took the typhoons of 1955 and 1956 without damage.

However, a heavier soil with slower infiltration or on a steeper slope would probably have failed. Because of the heavier soil, the water would have been absorbed more slowly. Beause of the steeper slope, a furrow of the same size would have less capacity. Consider what would happen to the bamboo trough if it were tipped sideways, even tho the two ends of the trough were kept level. A wooden stairway is essentially a series of troughs, side by side. But when set so that the stair treads are level, they will retain no water. If you should take the stairway loose from the building and lay it so the stair rails were level, then each trough could be filled to capacity. But, as you return the stairs from this position to normal position the water holding capacity would be gradually reduced. Contour furrows on steep land have less and less water storage capacity as the slope of the land increases.

Therefore on steep slopes, we must not count on contour furrows storing all of the excess water during heavy rain storms. So what shall we advise the farmer to do under such conditions? If we can't hold all of the excess water, we had better plan to get rid of it as harmlessly as possible before it overtops the furrows and cause severe damage.

It is the speed of the water that causes it to carry the soil particles. Water moving very slowly carries practically no sediment. The more rapidly the water flows, the larger the particles it will carry and the more soil it will transport. Therefore we should strive to make any runoff water move as slowly as possible. There are several things which the farmer can do to accomplish this but they are not as simple as what he had to do to increase the rate of infiltration.

What are the factors that determine the speed or velocity of flowing water? Essentially there are two things. Increasing the slope of the water channel increases the velocity. Increasing the friction between the water and the lining of the channel reduces the velocity. When water falls on a smooth, sloping field, the excess or runoff water starts to flow directly down the slope, following the steepest course possible since that will let it run the most rapidly. If the farmer makes contour furrows, the runoff water will simply fill them during a hard storm and then continue its course down the hill, causing erosion as it goes.

But if the farmer will make his furrows with a slight grade toward one end, the first water that accumulates in the furrow will start to move slowly toward the lower end. Then, while the runoff water is collecting in the furrow, the first water to collect there is being removed slowly, making room or more water to be collected there. If the size of the furrow is balanced with the area drained and these are considered in determining the gradient of the furrow, the runoff can be removed before enough water accumulates to overtop the furrow and cause serious erosion. That is the principle of the modified or graded contour. It is not a true contour but is merely an approximation with a uniform grade in one direction.

Many Taiwan farmers have used this principle in growing sweet potatoes or sugar cane on steep fields. Some of them have been partially successful in using it. Unfortunately, some of them have made the rows slope too steeply at the discharge end so that the water gets to flowing too fast and causes erosion in the bottom of the furrow. Of course, this is better than to have it run directly down the slope but there is still some erosion which could easily be prevented by not making the rows slope so steeply at the end.

Another limitation to modified contour rows is the length. The longer the row, the more water will be accumulated. If long enough, the water may get deep enough to break over the ridge and so cause erosion by concentrating the flow of two or more furrows in one. Most Taiwanese farmers have recognized this since they usually make their rows quite short on these steep slopes, frequently draining them at both ends. This too, is a good practice.

There is another precaution which should be taken, that is to protect the waterway or area of discharge, from erosion. This is the point that is seldom considered. You will notice when driving thru the country that most farmers have simply carried the water so far and then just turned it loose to run where it willed—and that was straight down the slope. As a result, the water running down the slope has cut gullies and carried away large quantities of soil. The results are gullies which collect more and more water and get progressively deeper. In such cases, the good done by the contour rows is largely offset by the damage done in the eroding waterways. This could be avoided by placing grass in the bottoms of these waterways. This would slow down the water and even cause the deposition of some silt in them.

While the slope of the water channel is the most obvious factor in determining the velocity of running water, the friction of the water against the channel lining is also important. You know that you can run much faster on a smooth path than you can thru a jungle of brush and vines. Water, too, can and will run much faster on a smooth, paved chute than on a dense grass sod—with the slope the same. The grass, weeds, or even rough protruding rocks, create friction which holds the water back and makes it run more slowly.

The depth of the stream of water in a channel also determines the velocity. But this is merely a restatement of the factor of friction.

If you can imagine water 1 inch deep running thru a grass sod which is also 1 inch high, you will realize that the water will move rather slowly. Now, if the amount of water is increased to a depth of 2 inches, the total flow will be more than doubled. This is why. The bottom inch will still continue to flow at about the same speed and so will carry about the same amount of water per minute. But the upper inch will be flowing, not thru grass but on a smooth cushion of water. Consequently, the friction will be much less and the velocity will be greater and the quantity will be increased proportionately.

Therefore, in addition to the slope of the furrow or waterway channel, the velocity of runoff water can be regulated by lining the channel with vegetation to increase the friction and by making the channel wide enough so that the water will flow in a shallow stream, most of which will be in friction with the channel lining. These are not such difficult things to do. The principal requirement being that the operator understand the principles involved and what he is striving to accomplish.

We have outlined to you, here, the broad principles of soil conservation and especially the control of soil erosion. Your instructors for the remainder of the course will teach you the details of a great many arts and sciences which are the component parts of the soil conservation program. Study each one carefully. Each phase of the work has its proper place in the whole and is important, just like the parts of a machine.

Every part of an automobile is not in use every minute. You may need the self-starter only once or twice each day when making long trips. Other days when driving around town, you may use it every 10 minutes.

You may use the brakes once an hour or every minute in heavy traffic. Regardless of how often you need to use any part, you realize that it must be kept in condition to work when needed.

Now it will be the same way with some phases of your training in soil conservation. Some of the skills you learn will be used every day. Others will be used only very seldom. That does not imply that those seldom used are not important.

You may go for weeks without using the jack or lug wrench on a car. But when you have a flat tire, it is important that you have these tools and that they work well.

You may not build a great many masonry structures, but when the situation demands that you do, you must be prepared to build a good structure.

So don't neglect to master each of these various skills. Each has a place.

While each instructor is teaching you the details of his speciality, try to see how that fits in with all of the other specialties to make up the whole program.

A man on the job who is a specialist in one phase but can't coordinate his speciality to make it fit into the whole job is as big a handicap to the organization as the man who knows the overall program but hasn't yet mastered the details of the various skills which are necessary to put the program into operation.

I once saw an advertisement of a hardware shop back in the States. It read "When you need hardware *bad*, you need it *good*". The same is true for soil conservationists, when a farmer needs one bad, he needs a good one.

The purpose of this course is to help you prepare yourselves to be *good* soil conservationists.

You have often read and heard that the soil of Taiwan is one of its most valuable resources. With the limited area of cultivated land and increasing population, that will be even more important as the years go by. Very little more land can be developed on Taiwan, so you must save what you now have.

When an invading army conquers the native people, they can with considerable effort, drive the invaders out and repossess their land. For 50 years the Japanese held Taiwan but now you have it again.

But when land is lost to erosion, sometimes it can be taken back but it is seldom worth the effort and when you do reoccupy it, its productive value has been largely destroyed.

It is much cheaper, easier, and on the whole more effective to prevent destruction by erosion rather than to depend upon reclamation after the land has been destroyed.

Some of you have probably served a term in the armed forces of your nation. The rest of you undoubtedly will do so. This is an important and necessary phase of your national existence. It is thrilling and spectacular to put on an uniform and march behind the flag in massed formations with bands playing and crowds cheering.

But unless the farmers produce the food, the armed forces can't be very effective. And unless the farmers are helped to conserve their soil, they can't continue to produce food for the nation. So this job of soil conservation, while not so spectacular, is fundamental to the prosperity and stability of the nation.

Think of this, then, as a training school not just to help you get and hold a government job—but as the means of equipping you with the knowledge and skill with which you can help to defend and perpetuate your country.

Soil conservation is an important job. Thomas Jefferson once wrote "He who control the most gullies is the greatest patriot." You can be patriots before and after you serve your time in the armed forces. This course is designed to help you to be greater patriots.

Soil Conservation Information and Education

The basis of all news writing is to tell the Why, the How, the Where, the When and the Who of the subject.

Why is there need for a soil conservation information and education program?

The soil conservation program, especially after the demonstration phase is passed, depends upon the active and intelligent participation of the many individual farmers. Before people will act they very properly want to know what is expected of them. What are or will their neighbors be doing? How will it all effect them?

Therefore, since we want the farmers to participate, we must supply the answers to these and other questions, even before they are asked. That is WHY there is need for an information and education program in soil conservation as in all other agricultural programs.

HOW is the information and education program to be carried out?

There are no one or two ways for doing this satisfactorily. Appropriate use should be made of any and every means of communication. One of the most effective ways of presenting ideas to farmers is by demonstrations. They will probably understand and believe what they see even though they may be confused or skeptical about what is told them. That is why we try to start the soil conservation work in a new community by setting up demonstrations on the various appropriate practices. Sometimes a single practice or skill is demonstrated. At other times a demonstration will consist of several interdependent steps or processes. But demonstration is a fundamental approach to convincing farmers of the value and practicality of soil conservation.

Some things do not lend themselves to demonstration but must be told to the farmers. This telling can be done individually or in groups. Telling each individual farmer each thing is undoubtedly the most effective means of communication. The number of farmers is great and the number of technicians is and always will be small. So, it is often necessary to increase the effectiveness of the technician by telling the farmers in groups. This may be in meetings or field tours or any other places that you can meet the farmers.

Such meetings or tours should be held under the sponsorship of the regularly established extension agencies even though you, who are strictly conservationists, actually conduct the meeting and put on the program. Let us never be justly accused of trying to run a show all of our own for we are, or should be, just part of the entire agricultural team. Unless the time and place of our soil conservation tours and meetings are cleared on the extension calendar, they could and might run into another meeting on another subject at the same time and place. That would be embarassing to both parties and the farmers would find out that you didn't know all that you should.

Whenever you advertise a meeting and invite people to spend their time attending, you at the same time accept the responsibility for having something worth while to present to them. For one or two meetings you might get by with an impromptu program but they will soon tire of coming unless they "get their money's worth". If they feel that what you presented was worth while, they will be apt to come back the next time you call a meeting. And it will be necessary to have a series of meetings to put over the whole soil conservation program.

In the first place, when you call the first meeting, the entire program will probably not have been developed. And even if it were, very few of the farmer would be able to take in the whole program at one meeting. You should figure out a series of steps by which you intend to present the entire program, just as a primary school teacher makes plans for how he or she is going to present various steps in the study of mathematics.

If you expect to have 25 farmers attend a meeting for 2 hours that is 50 hours of attention that you are asking for. What are you willing to pay for this much attention in terms of preparation? Isn't it worth rehearsing your program, word for word, several times so that you can make the most of your opportunity when the farmers come out?

Whether you are conducting a demonstration, a field tour or a meeting, you owe it to your public to see it that all of the tools, charts, maps, and other equipment are on hand at the right time and in readiness to serve their part on the program. Nothing is quite so disconcerting as to find, in the middle of a demonstration, that some essential tool has not been brought along or has been broken since the last time you used it, or that you have the map of the wrong farm or hsien. Preparation can avoid errors like those.

Newspapers and radio programs reach many more people than ever attend your field tours or meetings but the effect is still more dilute. It is seldom possible to actually instruct a farmer how to perform any soil conservation practice by newspaper articles. However, they do have a big place in the overall information program as interest and good will builders. By means of well written local stories you can often convince a farmer that such and such a practice is a good thing and *CREATE WITHIN HIM A DESIRE* to participate in that part of the program.

The use of posters, especially those with pictures in color, is an effective means of getting a message across. That should be particularly true here in Taiwan where people are accustomed to congregating at the public bulletin boards to read the newspapers and official announcements. Since there will be no one there with the poster to further explain it nor to answer questions, it is necessary that such posters be prepared in such a way that their meaning is perfectly clear and not subject to double interpretation.

The use of projected slides along with lectures makes your message much more vivid. This, of course, is not the equal of a field demonstration but can often be used before field demonstrations are available in a community. You will not be able to reach as many people with slides as with posters but the contacts should be far more effective.

Having printed leaflets to pass out at meetings or field tours serves to fix the subject matter more definitely in their minds. They also serve as references at a later date. However, these handouts should be kept fairly simple and deal with only one or two subjects such as how to perform or establish certain practices. Many paged bulletins of a philosophical nature have been wasted at such meetings.

Have in mind the abilities and the limitations of each kind of information outlet. Each can be used for a certain purpose and a well rounded, effective program can be built. This requires a conscious effort toward a definite goal rather than an occasional spurt in just any old direction when the central office gets after you to publicise your work.

WHERE you will conduct an information program depends somewhat on the nature and extent of the program under consideration. General stories of the need and importance of soil conservation, flood control or the evils of soil erosion are appropriate for newspapers and radio programs but not too effective at local meetings. First build up interest by generalized stories and by success stories telling how a certain farmer did a certain thing at a certain place and achieved certain desirable results. Then you are ready for meetings and tours and demonstrations to show how certain practices can be applied and to actually teach the farmers how to do them.

Just remember who it is you are writing for or speaking to. How to build a bench terrace is a poor subject for a national newspaper release and farmers won't come many times to hear you generalize on the needs for soil conservation over the whole island. They want something that they can put their teeth into and chew on. Tell them how to do what the newspaper articles have convinced them they should be doing. There isn't much use advertising a farmers meeting in Yilan in the Kaohsiung paper nor vice versa.

WHEN should information be released? Have you ever sat down after supper to read the paper and found that there was a notice of a meeting, a football game or a movie that night that you had been wanting to attend? Take care to get your publicity out in plenty of time. Of course a generalized article does not have a deadline like the notice of a meeting or a field tour but there is still an element of timeliness about all publicity.

A well conducted soil conservation program contemplates that at certain times of the year the interest will be on planting trees. At other times, it will be on building terraces or drainage ditches. Working schedules greatly increase the efficiency of any group and publicity schedules have the same effect. Make up a calendar and schedule of when you should release stories about each phase of the program. The stories themselves can be prepared well in advance and then proofread just as they are released. Then you aren't up against a dead line with nothing written to meet it.

A publicity schedule like this isn't something that can be prepared in Taipei and sent out to all soil conservation projects for their guidance. It must be made to fit the needs of each locality and then followed or revised if need be. Preparing a schedule and then getting out the material to fulfill it is work, but it is productive work. There will be many rainy days when you will sit in your offices and have no specific work to do. Then is WHEN you can prepare for the releases which seem to come right in the midst of a busy work schedule out in the field.

WHO is this information and education program pointed toward? Some releases of a general nature are aimed and everybody, to give them the idea of the importance of soil conservation and to build up public interest and popular support. Both are necessary if your budget is to be maintained or increased when needed. Other releases are for a local group and are concerned with local affairs. A mammoth public meeting with lots of red banners and prominent speakers should be set up for school children, townspeople and the farmers as well. But when you want to teach eight or ten farmers how to do something on their own farms, dispense with the banners and crowds. Don't try to have too many people there if you want to teach them.

In addition to rehearsing the program for a demonstration or meeting so everyone will know what they are supposed to do, it is well worth while to rehearse what they are supposed not to do. Remember that the real or central purpose of the meeting is to get some certain ideas across to those who attend. Anything that will add to the effectiveness should be emphasized. Anything that will detract or result in confusion or distraction should be suppressed.

Good intentions are not enough. The program has to be carefully worked out and then adhered to or distractions can arise. Many well planned demonstrations have been ruined or at least hampered because someone wanted so badly to help that he started talking to some of the people there and drew their attention away from the program itself. This being Free China as it is, you won't be able to control the talking of the farmers who come to the meeting but you can at least control the "yakitiyak" of the people who are on the payroll. Working together and by refusing to get drawn into discussions while the program is in progress, you can discourage a lot of cross talk.

For conducting demonstrations, the old four step method hasn't yet been beaten. First, you tell the learner about what he should know and how the job is done. Second, you show him how to do the job or demonstrate to him. Third, you have him participate by doing a bit of the job himself, under careful supervision. Then, lastly, after he *APPEARS TO HAVE LEARNED THE JOB, HAVE HIM* teach it to someone else. If he can do that, you can be sure that he knows it correctly. It will build up his self confidence and "face" immeasurably. If he has done it once with you, he can do it something that everyone will be talking about, he will not be backward about showing the neighbors that he is "on the ball".

Interviewing People

An interview is different from a chance meeting. It should have a definite purpose. That purpose is to get or to give some information. Frequently you will want to do both.

You who are receiving training here will be doing the soil conservation work in your home localities. It will be up to you to PLAN IN ADVANCE of each interview just exactly what information should be obtained from, or imparted to, each farmer contacted.

You will be less likely to miss some vital subject if you make a written list of the subjects you intend to discuss and in the order they should be brought up. Leave room on your list to write down the answers and then check off the questions as they are completed.

If you do not make a written list, you may miss some important point and you will probably not bring up your points in the most effective order. Leading smoothly from one point to the next in a logical sequence will strengthen your case by good presentation.

Although it is not necessary, it is a good habit to start out by making some statements of fact that the farmer already knows and agrees with. For instance "The soil is the source of your wealth and the basis of your livelihood. The better the soil, the better your living. Therefore it is to YOUR interest to keep the soil in the best shape." This may not increase his knowledge but it will, or should, get him in the attitude of agreeing with what you are telling him—believing in what you say.

Lead gradually from these facts with which he already agrees, to some related subject that he doesn't know about. Having agreed with you in the first subjects, he will more likely agree with you now, than had you started immediately talking about the unknown.

If, from talking with him previously, you think that he may agree with you on certain points and not agree on some others, start the interview with several of the points on which you expect agreement. Get him in an "agreeing mood". Then bring up one of the mildly controversial points and see how he reacts. Be sure to make clear to him the difference between facts, which are not debatable, and your own ideas or recommendations, which can be argued about.

Emphasize the facts or reasons which call for the practice rather than relying on your position of authority or your superior technical training. Simply stating "because I say so" is a poor reason.

Be positive and confident in your approach. Be sure of your reason. But, if he gets stubborn, don't get into a futile argument with him. Pass on to some other subject which you have reason to believe he will decide correctly. Let him "win this one". It is just human nature that he will feel better after a point or two has been decided in "his way" which, incidentally is also your way.

Now take up some other controversial subject and continue to alternate from the agreed to the disagreed matters. Always try to keep in reserve some points that he will agree with. If you settle all of these points first, you have nothing left to "feed" him when he gets stubborn.

He must be convinced by facts and reason. Merely "highpowering" him and getting him to chop an agreement will not make him a willing and an enthusiastic cooperator. Unless he becomes such, the finest practices you can put on his farm will soon languish from lack of care and maintenance.

Take all of the time necessary to thoroly explain the WHY, the HOW and the WHEN of each practice. If he has trouble understanding one or two points, make a note to review these points with him on the next visit. The program on his farm will be no more secure on his farm than the understanding in his mind. It will last no longer than his enthusiasm. Don't make the mistake of getting so busy moving dirt or doing physical things that you neglect to bring the farmer along mentally with the development of the soil conservation program.

Try to plan your interviews well in advance. Make your notes. Collect the facts you intend to present to him. Assemble the maps and sketches you will need. Get photographs or printed materials and have them attached in order to the notes. It is convenient to have all of the information available about him and his farm, assembled on one or more sheets of paper and identified with his name and location. Keep all of the notes and material related to him and his farm in a folder or envelope and keep them handy. You can never tell when you may get an unexpected chance to interview him. It would be a shame to have to tell him "I'll have to come back and see you next week because I can't remember now what I wanted to see you about".

It is usually better to interview the farmer alone, preferably in the field to be planned. Out there you can point out exactly what you are referring to. There will be less interruption and fewer things to distract his attention than if you see him in some office. If some of your own staff are present, be sure to have it understood that they will not break into the discussion unless, of course, they are asked for information. You cannot control his family nor his neighbors if they are present. But you can insist that the people on your payroll not interrupt or "horn in".

An interview is not just a social visit, held just for the fun of it. It is a business engagement with a definite purpose. It is not considered rude, according to Chinese etiquette, to "butt in" on someone else's conversation or for everyone to talk at the same time. However, to do this is NOT EFFICIENT PROCEDURE. So, for the sake of efficiency, never allow more than one person to be talking at the same time. That also applies to all business meetings and discussions. Getting the farmer out in the field all alone with you, makes it much easier to eliminate this confusion which results from too many people trying to "help" you convince him. This is important.

Use all of the points in salesmanship. Communicate with him. Tell him the facts you feel he needs to know to understand the situation. Also try to get him to communicating with you. He will have some ideas. They may be very good ones. He lives there.

Illustrate your points by comparison to processes or happenings with which he is familiar. Use pictures, sketches, maps, models……. Take him to see a demonstration farm or some neighbors' field where a similar problem has been well solved.

Motivate him. Help him to realize that the purpose of each practice recommended is to help HIM. Explain what the benefits are. How it will help him this year, next year, in the future years. How it holds back water that may increase his yields during drought periods. How it prevents the loss of soil and the attendant lowering of yields. How it prevents the gullies from cutting his fields into many small pieces. To the extent that he can see that the program will be to his advantage, he will go along with you.

Activate him. Get some action started. It is a good habit to try to make a return date for something that will promote the program. If he is not yet convinced, make a date for another interview, to be held after he has had time to think it over. Or take him to see a field where the practice under discussion has been successfully applied. If he is agreeable to the program, make a date to help him START DOING SOMETHING toward getting it applied on his farm.

Many farmers have failed to make any progress in soil conservation simply because they were not started into action when they were all ready to go. The old adage "Strike while the iron is hot" applies to conservation farmers as well as to blacksmiths.

A prospective conservation farmer who has been "warmed up" by careful, systematic preparation but has been allowed to "cool off" due to neglect, will be much harder to warm up a second time. Nothing succeeds like success. It is much easier to keep a cart or a car rolling than to start it rolling again after it has once come to a stop.

Soil conservation is a long time program or a way of living. It is not a quick and easy "one shot" process. For this reason a certain number of follow up or return visits is essential for the purpose of encouraging the recent convert to conservation farming. After he is once thoroughly convinced and has had some experience, he will probably help in spreading the soil conservation idea. He should be encouraged and even requested to do so.

These are some of the reasons why at each interview you have with a new soil conservation farmer, you should arrange for a return date. At that time you can help him actually start his program.

All of this advice and these suggestions refer to how you should plan to schedule and conduct your interviews. There is always the possibility that something will occur which will make you change the plans as they are being executed. That is common to most planning where people are concerned. However, the possibility of having to alter the plan is no justification for not making a plan or for not trying to carry it out.

An army that advances without a plan for battle cannot expect to be very successful. It is true that the actions of the opponent may make you alter the plan to meet the new conditions. Making your plans flexible and not becoming frustrated when change is required is just as essential as making a sound plan in the first place.

Remember, it is the final objective and not the adherence to the details of the plan which counts. The objective of the interview is to impart or to obtain information to help in conservation planning with the farmer. The interview is merely a means of doing this. Having the interviews well planned and smoothly executed makes them a more effective tool in achieving the desired result.

Likewise, the soil conservation plan is a tool to achieve the desired result of conserving and wisely using the soil. It may at times be necessary to change some of the details of the plan first drawn up, due to changes in the physical or economic conditions. But the overall objective will still be the same.

Soil Conservation Salesmanship

There are some basic points in salesmanship that apply to selling any product whether it be food, clothing, machinery, political doctrine, or soil conservation.

KNOW YOUR PRODUCT. You cannot hope to be a good salesman unless you are thoroly familiar with your product. What will it do? How can you get it? How much will it cost? How does it work? You must not only know about your product but sincerely believe in it. A lecture on the evils of strong liquors loses much of its effectiveness if delivered by a notorious drunkard. Unless you sincerely believe in soil conservation or any other subject, you are handicapped in trying to sell it to the public.

KNOW YOUR PROSPECTIVE CUSTOMER. Each person is an individual just as each farm is different. We say to treat each hectare in accordance with its needs and use it in accordance with its capability. The farmers are more important than their farms. You should study each one while you are studying his farm so that you can make just as correct an approach to him as to the technical problems of the land.

What are his particular interests, especially at the time you are interviewing him? What are his needs, technically, financially and otherwise? What are his resources? What does he have to work with? How much can he afford to invest in labor, materials, or change of farming operations?

While two identical fields should have approximately the same treatment, the various ways of achieving the desired ends may vary greatly because of the ability, resources and interests of the two owners. One can understand and will quickly agree to adopt certain practices all at once. He may have the resources in labor and power to do so in a short time. The other farmer may be skeptical as to the need or efficacy of the practices. He may be so poor that he cannot, if he wishes to, make more than a token beginning toward a satisfactory program. If one has a bullock and several strong sons to help and perhaps considerable other land to depend upon for his living, you should suggest a far different program than for the man who has no work animals nor any help except what he pays cash for and who is entirely dependent on that field for all of his living.

It is futile to propose a plan that the farmer is not able to carry out with the resources he has available.

HAVE A PREPARED PLAN OF APPROACH FOR EACH FARMER. Each farmer is different as much as each farm is different. A soil conservation plan that is fine for one farm may not fit another. There is no one best way of approaching farmers to convince them that they need soil conservation practices. Before you make your contact you should have a plan of approach worked out just like a general does when he goes into battle. Don't leave things to chance.

What will you talk about first? What will you say? If you were applying for a job, you would rehearse your speech many times before you met the prospective employer. You would have outlined all of your qualifications, your recommendations, your school record, and any posts that you had held to try to impress the prospective employer that you would be a valuable man in his organization. In presenting soil conservation to the farmer you should follow the same procedure.

One of the best outlines on salesmanship I have seen was based on a chart with CIMA printed in large letters with an amplification of each. *"C" stands for COMMUNICATE.* You have to get your message across so the prospect can understand you. Regardless of how much he might know about the subject a man speaking only English, Spanish or Norwegian would be a poor salesman in Taiwan because the people could not understand what he was talking about. Almost as helpless is the man speaking only Mandarin in a community where the farmers speak only Taiwanese, Haaka, or an aboriginie dialect. Using the approved Mandarin in official transactions is one thing. Trying to "sell" a man who can't understand Mandarin is another matter. Regardless of regulations, it won't work.

In addition to using a common dialect, the attitude in which you approach the prospective customer is important. You are in a much better position to "sell" your product after you have "sold" yourself. As he gets the idea that you are willing and able to help him, he will much more readily accept your suggestions and plans. That is why your attitude is so important. Don't look down on him as a poor, ignorant farmer—much below you in every way. If you are afflicted with such an attitude you will do well to consider that these farmers are some of the people who earn the money and pay the taxes that support you. Furthermore these farmers are independent and intelligent enough that they can and do make their own living and don't crowd up to the pay window every month for a public handout.

A pompous "stuffed shirt" attitude is objectionable in every way. And so is subservient self effacement. Stand up on your feet but don't tread on his. Be sure that you can make the distinction between respect for him and servility. Or between competence on your part and condescension toward him. A happy medium is what you want.

"I" stands for ILLUSTRATE. Was it Confucius or some other Chinese sage that said "One picture is worth a thousand words". Whoever it was that coined the saying, it is certainly correct. Make the man see what you mean, either literally or figuratively. Comparing what you are talking about with something that he knows about is almost always good procedure. Draw a picture or a map, use photos, models or, what is always best, take him to see some other farms where the same sort of problem has been solved satisfactorily. When he understands what you are talking about and how it will work, you can say that you have illustrated the subject to him.

"M" stands for MOTIVATE. He must have a reason for doing the thing you are advocating or he won't be apt to do it. Is there any good reason why he should or should not do a certain thing? If there is, that is the motive. You may give mental assent to the eradication of field bindweed in Kansas, but you aren't really very much concerned. When it comes to eliminating malaria from Taiwan, you are vitally concerned. Protecting the health of your family and yourself is a vital reason for taking action. Then you are motivated.

In selling the idea of soil conservation, you need to explain to the farmer how important it is TO HIM as well as to the nation that the soil and water be conserved. When he grasps the idea, you have motivated him, or given him a reason for taking action.

"A" stands for ACTIVATE. After you have communicated with the farmer and won his confidence. After you have illustrated the point to him until he understands what to do and how to do it. After you have convinced him that it is in his own interest that certain things be done. You still don't have any soil conservation program in operation. Someone or something has to step on the starter, turn the switch.

A gun may be correctly designed, properly loaded and accurately aimed. But the target won't be hit until you pull the trigger. After adequate preparation, something has to happen to start a chain of actions or the project will not be carried out. Activating, then, is that vital and necessary step of getting the farmer started to actually doing the soil conservation practices on his farm. Without this final step, all of the preparation may have been wasted.

These four steps, then, are important. First, communicate with the farmer. Win his confidence so you can exchange ideas. Illustrate your points in the field, with maps or with pictures. Be sure that he understands what you mean. Motivate him by showing him why and how it is to HIS advantage to carry on the plan that you are proposing. And finally, activate him. Get him started to actually doing something to put the program into effect.

If you do these things you can truthfully say that you have really "sold" him on soil conservation.

Why Conduct Demonstrations?

When we mention a demonstration, what do you think about? To me, this does not mean a pretty, park like area where someone has done a lot of useless work just to make it look pretty. My conception of a demonstration is a place or an action in which we show someone how to do something that they did not previously know how to do, or that we show them a new and better way of doing an accepted practice.

It is not necessary to demonstrate to the farmers how to put on their pants or their wooden shoes, unless, of course, you know a way that is better than the way they are now doing it. Why? Because they already know how to do these things. There may be a few communities in Taiwan where the farmers do not know about benches and don't appreciate their value, but most farmers know that benches hold their soil and water and they would like to have their land benched. So, there will be very few places where you will have to show them benches on the basis that they don't know about them. Therefore, just to go out and build a bench does not constitute a demonstration. Because the farmers already know about benches just like they knew about putting on their clothes.

Practically all of the benches in Taiwan, and there are many of them, were built by hand labor, chopping the soil loose with a hoe and scraping it into a basket and dumping it in the filled areas. Most farmers know this method of building benches far better than you or I do, or possibly ever will know it. This is a hard, slow expensive method of doing a good and valuable job. We don't need to demonstrate this to them for they already know more than we know about doing the job this way. So, for us to go out and build a bench with a hoe and a basket isn't a demonstration. It is just doing work. Good work to be true, but not a demonstration.

Unless we can make a better bench than the farmers have been making or can show him how to do it in a better, easier or more economical manner, we have no business spending public money in trying to demonstrate benching to the farmers. Can we show him better methods of doing this good practice of benching? I think that we can. If we can't, we had better do something else.

At one time all burdens were carried on human shoulders. Then someone discovered that animals could be trained to carry them. This led to the domestication of cattle, horses, camels, elephants and other beasts of burden. That was a step forward. Somewhere and sometime man discovered the wheel and found that by making a cart he could carry or transport a given load much easier and quicker, and hence cheaper. Then he hitched his domestic animals to the cart and that made transportation of heavy loads still easier and cheaper. Sugar cane carried to the mill on a man's shoulders would be no better than if carried on a cart, but it would be more expensive to produce sugar in this way.

We use buffalos and bullocks to haul the sugar cane, not because man can't carry it, but because it is cheaper and easier to do it by utilizing the strength of the cattle for this hard work. This same reasoning can also be applied to building terraces or benches. If cattle power can be used to do the hard work of moving the soil, the resulting benches won't be any better that those built by hand but they will be cheaper and easier to build. If we can discover, and then show the farmers, how to use the cattle that they have and, with a few tools which can be made in their village shops, build a good bench with less time and effort, then we have something to demonstrate.

A new way which they don't know, of doing an old job. This then would constitute a real demonstration, showing them something useful that they do not now know.

The same is true about demonstrating waterways. The Taiwan farmers have built many good and lasting waterways by laboriously carrying large stones and lining a ditch or canal with them. These are good and effective waterways. We can't criticize their effectiveness. But why have not more of them been built? The farmers recognize the need. The reason they have not built more is that this method is quite expensive in time and labor. We don't need to demonstrate this type of waterway. They already know more than we do about it.

If we can't show them a better way of controlling their water disposal systems, can we show them a cheaper, easier way to do the same job in an acceptable manner? I think we can in some cases.

The question of using tractors of various sizes with which to conduct a demonstration, comes up frequently. Do you remember what we said about the purpose of a demonstration? It was to show the farmer how to do something in a way that he could do it on his own farm. If you should be working in a community where all or most of the farmers have tractors, demonstrating how to use tractors to do the soil conservation work would be fine. But suppose you rent a tractor and do the job but the farmer has no tractor and can't afford to rent one? How can he follow the example you have set?

If you demonstrate with animal drawn equipment and the farmer has animals, he can buy or borrow a scraper and imitate your demonstrated practice. If you demonstrate with a tractor but he has and can get none, how have you helped him?

On the Chingshui Demonstration Area we did use a little D2 bulldozer and built level bench terraces on about 7 or 8 hectares. That was no doubt, cheaper and certainly faster than doing the same amount of work with animals. We got the benches built well and on time. They have demonstrated that benching the watershed area will eliminate the runoff and so control gully erosion which is being caused by that runoff. To that extent the tractor demonstration was successful. But what of the effect on the farmers of the community?

They don't know that benches can be built with their buffalos. They saw them built with a bulldozer and they have no intention of hooking their animals on to Fresnos. They are just sitting down, waiting for someone to bring the bulldozer back and build more benches on their farms. So, as far as getting the farmers to bench their own farms, the tractor demonstration was a failure.

Consider this whenever you are tempted to bring in something that the farmers don't have or are not able to get.

There will be many fields where you will be called upon to make demonstrations, which are so full of rocks that neither a Fresno scraper nor a V drag will work. For those fields, about the only way to construct benches is by hand labor. But since the farmer already knows how to do this, you have nothing to demonstrate. To just go out and bench a man's field without cost to him, may make him smile broadly and bow deeply to you but it is not doing your job of conducting demonstrations. The point is, that there will be some times and some places where you can not improve upon what the farmer already knows or is doing. In those cases, just go on to the next farm where may be you can show them either a new practice or a new way of applying on old one. Remember you are not a magician pulling tricks out of a top hat. You are just a technician, trained in some of the skills developed by others in the art of soil conservation.

If an engine in excellent condition is brought to the mechanic in a work shop, he can merely look at it to see that there is nothing that he needs to do or can do to improve it. That is no reflection on him that he can't find something wrong for him to fix. We have much more respect for the mechanic who, in this situation merely says "it is all right. You don't need me to do anything to it" than one who attempts to "save face" by making up some imaginary trouble and running up a bill on the owner. There are times, too, when a hopeless wreck of a machine will be brought in for inspection. An honest mechanic will tell you that if it can be repaired at all, the cost will be greater than the value of the machine after repair. Therefore you had better junk it.

You will undoubtedly be taken to view some hopelessly gullied areas and asked to "demonstrate" reclamation process. Many things are possible if you have enough budget but many of these "possible" things are not feasible. Unless there is some important thing like a home, a bridge, etc. threatened, would you spend your own money to reclaim the area? If you will not or would not recommend that the farmer spend his own money to do a certain job, what justification is there for spending your soil conservation budget for doing an unreasonable thing. In conducting demonstrations, we should be demonstrating or showing to the farmers how they can and should be handling similar problems.

You can stop many, tho not all, landslides, by plastering the side of the mountain with concrete, provided you have enough budget. But could, or if he could, the farmer spend his money that same way. If he can not, we have demonstrated an uneconomical practice and should be censured for doing so. Always keep in mind the difference between just doing work, even tho useful, and demonstrating to farmers how they can and should do practices on their own farms. Don't get misled into doing, in the guise of a demonstration, just a big pretty piece of work for the benefit of some scheming farmer. He will, no doubt, be pleased to get the job done free, but he won't respect you for being such a sucker.

Many of the places that you will be asked to spend your budget for demonstrations, then are not demonstrations at all. They are just work projects. For these we should give all of the technical assistance needed. For instance if a farmer wants to bench a stony field. You can't demonstrate the improved practices of the V drag or Fresno because of the rocks but you can and should give him technical assistance in staking out the terraces for him to build by hand labor to be sure that they will have the correct grade and reverse slope. Thus technical assistance for the farmer's work projects may often be appropriate where a demonstration is not possible.

When you are giving technical assistance the farmer will, of course be present to do the work. When you are demonstrating and the farmer is getting the work done for nothing, just to be sure that he sees how you are doing the job, insist that the farmer be present, preferably actually helping with the practice. If he says he is too busy, just pack up your tools and come back when he has time to work with you. If he can't or won't attend, your demonstration will probably not be very effective on him and he won't be able to duplicate it on his other fields.

Choosing a Demonstration Site

Some of the basic principles of demonstrations should be discussed before we start discussing the choice of a demonstration plot.

Demonstrations are one of the most convincing and effective ways of imparting information or skills to other people. They are an educational method in which people learn by seeing and doing rather than by just hearing or reading. The objective of our demonstrations is to show farmers either a new practice or a better way to do an old practice. Unless we accomplish one or both of these objectives, we can't say that we are conducting a demonstration.

It is ridiculous to try to teach a farmer something that he already knows or something that he doesn't need or can't use. Therefore, before undertaking each demonstration, consider these questions:

1. Does this farmer already know what I propose to teach him? If he does know it, there is no need for the demonstration. If he does not know this subject, then consider the next two questions.
2. Does the farmer have any need for the information I propose to give him thru this demonstration? There would be no point in demonstrating the use of a television set because Taiwanese farmers do not have such sets and have no need for this information or skill.
3. Can the farmer make use of the information or skills that I propose to demonstrate? To illustrate, in our first SCFO at Chingshui we demonstrated building bench terraces with a bulldozer. It worked fine and we built nice terraces. The farmers did not know how to do this, at least in this way. They needed the information BUT, they had no bulldozers. Therefore, the so called demonstration was no good as a demonstration, because the farmers could not use what was taught them.

If a SCFO should hire a crew of men to harvest a farmers paddy for him, using his regular old methods, it would save him the expense of hiring the laborers and he would appreciate it and thank you BUT since he did not learn anything that he did not already know, we could hardly justify the expense of the laborers as a demonstration.

There is a big volume of many kinds of essential work to be done in Taiwan and there are agencies whose responsibilities is to do these various jobs. For instance is the responsibility of the Highway Bureau to not only plan but actually do the work of building the highways and bridges. PWCB is to plan and build the reservoirs and irrigation canals. That is fine and proper, but it is not the responsibility of the SCFO to actually DO the soil conservation work. Their job is to (1) demonstrate new practices or new ways of doing old practices and (2) furnish technical direction for farmers to do these practices on their own farms. We should not confuse DOING the work with demonstrating HOW the work should be done.

The farmers are somewhat familiar with most of the soil conservation practices that we recommend, particularly with bench terracing. They have been building benches in Taiwan for more than 300 years. They know the value and advantages of benches. They want them and most of the places where water is available for irrigation, the benches have already been built. They would like to have benches for nonirrigated farming if they felt that the returns would justify the expense. Therefore there is no need to demonstrate the value of benches. They have that information without the SCFO demonstrating it. What they do not have but what they need and can use, is information about how to build these same good benches easier, quicker and cheaper.

Where the soil, slope and other conditions will permit their use, Fresno scrapers and V drags will build good terraces cheaper that equally good terraces can be built by hoe and basket methods. In the past, the farmers have always used this more expensive hand labor method and all of them are familiar with it. Since they already know about this, there is no need to demonstrate to Taiwanese farmers how to build benches with hand labor. But they don't know about the animal drawn machine method. They need this information and they can make use of it since there are draft animals in every community, if not on every farm. This is a subject that justifies demonstration.

Of course there are fields so full of rocks, stumps, or roots that you can not use a machine to save any time or labor. Benches on that kind of fields will have to be made by hand labor, following the methods that the farmers have used for the past 300 years. That kind of bench building does not need demonstrating. It is well known.

If a farmer doesn't have a draft animal or wishes to honor his ancestors by doing things the way that they did it, we should have no objection to the building of extension benches by hand methods, that is DOING the work which is the farmers responsibility. Yours is to demonstrate HOW it can be done better.

It is the responsibility of the SCFO to also furnish technical assistance to all farmers who ask for it, planning the layout, setting the stakes, and checking the elevation of the finished benches. That should be done on extension benches as well as on demonstrations. We should also give full, all-out help to the farmer in stabilizing the waterways whether he builds the benches by hand or by machine.

Now to come to the choosing of a site for a demonstration. There are a number of things that should be considered in choosing one site over other alternate locations. One of the most important considerations is the attitude of the farmer. If he is interested and wants to conduct the demonstration, that is perhaps the most important single factor. If everything else looks good but the farmer holds back or wants you to pay him a lot of money for the priviledge of improving his farm, you will do well to pass by him and try to find some other location.

Since the most effective demonstration is one that works well, it is important that you select a site on which whatever it is that you intend to demonstrate is applicable. Trying to demonstrate a Fresno on a field full of big rocks will disappoint not only the SCFO crew but the farmers as well. If you try something and can't make it work, the farmers will remember that longer than ten successful attempts. So before you undertake a demonstation, be reasonable sure that you can successfully demonstrate that practice there.

A demonstration where many people can see it as they pass by, is much more effective than one hidden far back in the hills where only the farmer that owns the land will ever see it. However, location along the main road should not be given precedence over farmer attitude and suitable soil conditions.

The demonstration site should also be representative of the conditions found generally thruout the community. You should not choose the steepest nor the flattest place but something average.

It would be useless to demonstrate pineapple planting on narrow benches if that was the only farmer in the Hsien that would be planting pineapples, unless it was the purpose of the demonstration to propagandize the increase of pineapple planting in that community.

To summarize the subject of choosing a demonstration site:

1. Determine what the farmers need to know but don't know and plan to demonstrate this in a way that they can use.
2. Find an interested farmer who wants to

cooperate.

3. Be sure that this farmer has a site on which it will be possible to demonstrate the practice decided upon.

4. If more than one such combinations of good farmer and good field are available, choose first, the one where the most people will see it.

5. Be sure that you have made a distinction between demonstrating HOW to do the work or the practice and just DOING the work; however good it may be.

Your staff and your budget will be limited. With as much important work as there is to be done, we can't afford to waste your time or your budget in doing unnecessary work in place of demonstrations.

The item in your SCFO budgets for "Labor and Animal Hire" was put there to permit you to demonstrate new things, not just to do favors to farmers who come asking for them.

You can demonstrate the building of benches just as thoroly on the top two or three in a large field as if you do the entire field for the farmer. The test of your skill as administrators and technicians is whether you can do such a good job on the first few benches that the farmer will take over and, with your guidance, go ahead and complete the field using the methods you demonstrated. If he does, you have reason to feel that it was a successful demonstration. If he does not, something is wrong. Either you picked up a wrong farmer or you failed to convince him that your method was worth following.

Soil Conservation in the United States

During the period from 1620 to 1860, soil erosion became a major problem in many American farms. The New World settlers found that after a few years of farming, the sandy hillsides of New England and the erodible soils of the Southern and Middle Atlantic states were injured by wind and water. Some farms had been abandoned once even before 1800. In the last half of the 18th century some foresighted farmers and philosophers were writing about the dangers of soil erosion and suggesting methods to control it.

At that time and for a century later, plenty of new virgin land could be had for the asking, by anyone who would move westward and clear the land. The general public, except for a few prophets of doom, believed that there would never be a time when there would not be a surplus of good, new land available. The current opinion was that this public land should be exploited for a profit rather than conserved for the future.

The need for a change from the system of continuous, clean cultivated cropping was recognized by a few who wrote and spoke about it but nothing was done. Lands were farmed to the point of no return and they were then abandoned and new lands broken out.

Individual soil conservation practices such as horizontal or contour plowing, deep plowing, hillside furrows which were the forerunners of terraces, improved drainage systems, streambank erosion control and the increased use of organic matter, were recognized and used by isolated farmers. Soil deterioration was also blamed on high taxation, lack of tariffs, tenancy, high interest rates and the need for an Agricultural Board such as England had.

Outside of the very few pioneers mentioned above, nothing was done to combat erosion until the later part of the 19th century. By the beginning of the 20th century contour plowing and terracing were beginning to be practiced in a few communities but usually as single practices. Strip cropping was practiced in some of the Dutch communities in Pennsylvania and Wisconsin.

After the Federal-State cooperative extension program was started in 1914, the extension services, particularly in the southern states, promoted a great deal of terracing. Too often, little or no attention was paid to the outlets and, organic matter and soil fertility were allowed to drop to shameful levels. Everyone deplored the formation of gullies and the flooding and siltation of streams and bottomlands but still little was done about it and what was done was not part of any organized program. Mark Twain, one of the great American humorists wrote that "everyone was talking about the weather but no one was doing anything about it." That applied to soil erosion for the first quarter of the 20th century.

In the Bureau of Chemistry and Soils in the U. S. Department of Agriculture there was a soil surveyor and inspector, H. H. Bennett, who saw the effects of erosion on numerous soils in many states. He led others to study the effects and progress of erosion and became the prophet and evangelist of the soil conservation movement in the United States.

At least three of the established bureaus recognized the problem and each had a partial solution. The Forest Service agreed that there was an erosion problem and recommended the planting of trees as the control measure. The Bureau of Agricultural Engineering recognized the problem and recommended terracing the hillsides and building dams and gully control structures in the gullies. The agronomists also recognized the soil deterioration and recommended lime, manure, fertilizers and the use of better crop rotations as the cure.

As a matter of fact, each of these three approaches had merit and was appropriate under certain specific conditions but none of them alone was adequate, to control all situations. Interbureau rivalries prevented the adoption of any overall program, each bureau pushing their specialty and ignoring the other treatments.

After many years of writing and speaking about the evils of soil erosion, the pleas of H. H. Bennett were heeded and in 1929 congress authorized the U. S. Department of Agriculture of establish a number of Erosion Experiment Stations, scattered throughout the various sections of the United States where erosion was recognized as a menace. Commissioner R. H. Davis of JCRR was in active charge of the establishment of two of these Erosion Experiment Stations at Hays, Kansas and at La Crosse, Wisconsin and so was one of the pioneers in the soil conservation program.

The great depression hit the United States in 1929-32 and started a period of severe unemployment. The Federal Government set up many kinds of work projects to provide partial employment for the unemployed. As a result of the interest generated by the Erosion Experiment Stations, one of the Emergency Work Programs set up in the Department of Interior, which was administering the relief money, was a number of Soil Erosion Demonstration Watersheds. On these demonstration areas the farmers were asked only to give their consent and agree to follow the program recommended. The Federal Government provided the labor, the lime, seeds, fertilizers, tree seedlings, fencing materials and earth moving machinery in order to complete these demonstrations in as short a time as possible.

There was also widespread unemployment among the professional engineers, agronomists and foresters so they were recruited in large numbers and organized into an emergency organization called the Soil Erosion Service. Since they were paid with emergency money this organization was set up in the Department of the Interior. The men who were operating the Erosion Experiment Stations were the best qualified to direct this program so many of them were appointed as project directors. Commissioner Davis was the director of the Number One Demonstration Watershed at Coon Valley, Wisconsin. There were in all more than 50 such demonstration areas set up.

The technical problem varied greatly from state to state and from wet to dry and from north to south. Up to this time there had been no organized procedure for soil conservation. Each project director, with the staff of technicians that he assembled, devised a program to fit the conditions under which he had to work. With such a diversity of technical problems and with personnel coming from so many different backgrounds, it was little wonder that there was little recognizable resemblance between the programs on the various demonstrations.

Where terracing and gully control were applicable and where there was an agressive engineer in charge, that program naturally tended to overemphasize the engineering phases of the total program. Where there was an agressive forester, undue emphasis was give to tree planting. Where an agronomist dominated the planning, too much dependence was placed on soil fertility and rotations to the neglect of needed engineering and forestry.

In order to make the widest use of the best technical skills available in the various staffs and to bring all of the technical programs into some semblance of uniformity—after making allowance for the difference in the technical problems—Regional Offices were set up to direct and administer the program. These Regions embraced on an average about 7 states and, except for one set up out in the "Dust Bowl" in the Great Plains, coincided with State boundaries.

Another by-product of the depression was the organization of the Civilian Conservation Corps which enrolled thousands of unemployed youths and took them off of the streets of the cities and placed them in camps of about 200 boys each. Reserve officers of the Army, Navy and Marine Corps were in administrative charge of these camps to supervise the feeding, clothing, housing, payment and control of the boys. These camps were assigned to do work for numerous state and Federal agencies altho the actual work they did was secondary to the personal development of the enrollees.

Hundreds of these camps were assigned to do soil conservation work. Technical men were recruited to plan and supervise the work program. The camps were located in all of the states where erosion was a serious factor. The Erosion Control Demonstrations had broken the ice and many people now knew about the soil conservation program that was being developed. The demand for soil conservation assistance was growing. It was no longer either necessary or possible for the government to pay all of the costs of applying the soil conservation program to all of the farms that needed it. A cost sharing plan was established under which the CCC camps furnished the labor of the enrollees and some machine work such as Caterpillar tractors and cement mixers, but the farmers furnished the seed, lime, fertilizers and a part of the construction materials and did all of the terracing. This program, altho not so liberal as the original Demonstration Program, was well received and the demand for more soil conservation camps could not be met.

In the late 1930s the worst of the depression was past and the number of boys seeking admission to the CCC camps declined and the number of camps was reduced proportionally. With the supply of CCC help decreasing and demand for soil conservation work increasing, some other approach had to be made. A device by the name of Soil Conservation Districts, was suggested by the U. S. Department of Agriculture and the various State Legislatures passed state enabling legislation under which the local farmers could, wherever and whenever they so desired, organize such districts and elect their own supervisors who would have administrative charge of the soil conservation in that district.

When these district supervisors so request, and practically all of them do, the soil Conservation Service will send technically trained men out to do the technical planning and layout work and will pay their salaries and expenses and provide them with the equipment they need to render this assistance. Many of the Soil Conservation Districts have gone into the business of buying and selling grass seeds and tree seedlings so they will be cheap and easily available to the farmers who need them. They have also operated tractor equipment or made deals with private contractors to do the machine work at the individual farmer's expense.

We see here three distinct stages in the financing of the soil conservation work on private farms. First, the government paid all of the bills, just to introduce and demonstrate a new idea which was the coordinated program—using forestry, engineering, and agronomy all on the same farm in the places and amounts where each fit best. In the CCC camp stage, the government furnished available labor and paid a little of the other expenses, but the farmers assumed about half of the expense. In the Soil Conservation District phase, in which the program is now, the farmers stand practically all of the expense for improving their farms while the Soil Conservation Service of the Federal Government provides principally the technical guidance and the equipment that they need to perform this service.

Recently, after 15 or 20 years experience, the program has been reduced to writing in the form of technical standards which specify the treatments which are recommended for the various conditions encountered. The regional offices have been disbanded and the Soil Conservation Service maintains an office in each state with technical specialists to guide the technical phases of the program.

Another organization, the Agricultural Conservation Program, within the U. S. Department of Agriculture is authorized by Congress to make payments to farmers to share the cost of certain soil conservation practices. The Federal-State Cooperative Extension Service also has a part to play. This is conducting the educational program to create and increase public interest in soil conservation. There are, then, three separate organizations within the U. S. Department of Agriculture which have a part to play in the overall soil conservation progam. The Extension Division to create interest and advertise it, the Soil Conservation Service to assist the farmers in the Soil Conservation Districts to plan and apply the various appropriate practices on the land, and the Agricultural Conservation Program to assist and encourage the farmers with Share-the-cost payments. There is no overlapping of these responsibilities and, where the Personnel are well organized and directed, there is harmonious cooperation.

There is another phase of soil conservation which is not directly connected with this field operations work. That is the research on soil conservation subjects. All agricultural research is conducted by a separate Agricultural Research Service in the U. S. Department of Agriculture, either directly on Federally operated research stations or in cooperation with the various State Experiment Stations. This separation of the research, operations, and extension functions of the various programs has been a step in the direction of more efficiency. A few of the stalwarts of days passed still try to resist this new alignment of responsibilities but the trend is moving irresistably in this direction.

Now all of this recitation of the history of Soil Conservation in the United States has a point in which you should be interested. The study of history may be interesting to some but it is of real value only when it is possible for the present to profit by the mistakes and successes of the past. The Soil Conservation Program of the Republic of China need not follow exactly in the footsteps of that program in the United States but, by observing some of the steps that were taken and the results obtained, it may be possible for you to make faster progress and avoid some mistakes.

The pioneering soil conservationists of the United States had no literature or precedents to which they could refer for guidance. They had to cut and try, developing their organization and methods step by step. You have a distinct advantage over them, for in the past 25 years much has been done and much has been written and is therefore, available to you as a basis upon which to build your program. It was for the purpose of sharing with you some of that experience, that I was sent over here as advisor in Soil Conservation — so that you could profit by our experience and not have to bump your heads on all of the same unseen obstacles.

After 25 years of growth and development, the Soil Conservation Service in the United States has not become a fixed, static organization. It must continue to grow or it will die. No progress is possible without change but, of course, all change is not neccessarily progress. China has made a start, here in Taiwan, toward the development of a Soil Conservation Organization. It is only a start and much more remains to be done in this direction.

You now have 19 Soil Conservation Field Offices in operation. In connection with them you have established a number of demonstration areas on which public funds have been used to pay most of the expense of demonstrating the best practices and the improved means of applying them. The demand for more and more soil conservation assistance is growing steadily. It is apparent that this demand cannot be met by establishing more and more demonstrations, altho in new areas they still have their proper place.

Based on our U. S. experience I would say that after the demand has been created by the demonstrations, this demand should be met by extension methods in which the SCFO supplies the technical know-how and the farmer supplies most of the labor and materials.

Fortunately, you have no big depression which necessitates the establishment and employment of labor comparable to our CCC Camps. Therefore we need not expect to see that phase of the development of the U. S. soil conservation program repeated in Taiwan.

I confidently believe that there will be a time when you will need and will have, organizations similar in nature and purpose to the Soil Conservation District in the United States. But I also question whether you are yet ready for that stage in the development of your program. There are several limitations which, in my opinion, make it inadvisable for you to undertake the organization of these districts at the present time. Fortunately, the passage of time will remove these limitations and you can later proceed with safety.

For one thing, the knowledge about, and demand for, the soil conservation work is not yet sufficiently widespread among the farmers and city dwellers. The natural growth of the program will remedy that.

Dr. Sun Yat-sen emphasized that democracy, as a way of living and thinking, is a state that can be achieved only by education and growth. It does not come over night as the result of a revolution or the issuance of regulations. The organization and operation of a Soil conservation District is an example of democracy in action. It is a stage which requires some skill and exprience. To attempt it before that skill and exprience is obtained, might lead to unhappy results.

A skilled and experienced cyclist can, by paying attention, ride with comparative safety thru heavy traffic. But a small boy just learning to ride might come to grief unless he first practiced riding on the side streets. If he tries the heavy traffic too soon he may permanently damage both himself and his bicycle.

With the attention of the government and its citizens now centered on the reoccupation of the mainland, the government might not permit the organization of additional governmental subdivisions. But if they did permit them, premature organization of Soil Conservation Districts might result in failure due to inexperience. Once Soil Conservation District had failed it would be much more difficult to reorganize them than it would be to wait until a more propitious time to undertake their organization.

Soil Conservation Program and MARDB*

Nov 1, 1961

Before undertaking to discus a subject, it is worth while to define what YOU mean by the words you intend to use. Soil Conservation means many different things to many different people so I'll tell you what I mean. Soil Conservation means the wise use of soil, or using it without waste. Dr. R.M.Salter, former Chief of the U.S. Soil Conservation Service defined it an meaning "Proper land use, protecting the land against all forms of deterioration, rebuilding eroded or depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income, ALL AT THE SAME TIME." The motto of the SCS is to "Use every acre in accordance with its capability and treat every acre according to its need for protection and improvement." That is a large order, hard to carry out.

Soil conservation, important as I believe it is, is not a substitute for the use of good seed of adapted varieties, proper fertilization, pest and disease control, nor for wise marketing practices and financial management. Neither are any of these important programs a substitute for soil conservation. It is futile to argue which of the legs of a stool is the most important. If any one of them is too short OR TOO LONG, the stool won't sit even or be usable. Likewise, the various legs of the agricultural program should be balanced to achieve success, none too long or none too short.

Soil conservation itself is composed of a number of phases such as proper land use, maintenance of soil fertility and soil structure, water management—drainage or irrigation where needed, and erosion control which is frequently considered to be ALL of soil conservation. It is an important phase and is worth studying closer.

Soil erosion is merely the movement of soil particles from one place to another. Before soil erosion can take place two things must happen and if either or both of them can be prevented, there will be no soil erosion. First; the soil particles must be broken loose or detached from where they have been fastened. Second; the detached soil particles must be moved or transported. We have then DETACHMENT and TRANSPORTATION.

Detachment may be from several causes but the most common is falling raindrops. Wind or cultivation may also detach them. Transportation may be by wind or by flowing water. Nature protects the soil with a canopy of trees or a mulch of grass or a litter of dead vegetative matter. These keep the rain or wind from striking the soil and causing detachment. The grass or the mulch prevents flowing water from moving the soil.

In order to produce the food and raw materials for industry, civilization requires the destruction of this vegetative cover ON SOME OF THE LAND. When man destroys nature's equilibrium, a new balance has to be established. Unless attention is given to this, trouble will follow. In establishing this new balance, thought needs to be given to preventing either detachment by maintaining a canopy, or to preventing transportation by flowing water.

Rice paddies are an excellent example of controlling erosion by preventing transportation. Before planting rice, the soil is intentionally detached by plowing and harrowing it into a thin soup—thororly destroying any soil structure. Tho it is detached and unprotected from the rain by any canopy, there is no erosion because the water in the rice paddy is stationary and not flowing.

* Speech at the National Taiwan University

All of the land can hardly be made into rice paddies but it can be handled to reduce, if not eliminate, the flow of water. A furrow plowed level or on the contour makes a narrow, one row level bench or impounding reservoir. If you were to completely cover the floor of this room with troughs such as are used to provide water for hogs or poultry, how many buckets of water would it take to fill them all? If one man had to carry it all, it would take a long time to fill them. If an area of equal size on the side of a hill were covered with similar troughs, set level, an equal amount of water would be held. But if these same troughs were placed sloping up and down the hill, what would happen to the water? Someone standing below the area would get wet. No doubt about it.

Contour furrows hold water in the same way. If they are built level and have no low, or weak spots, they will hold a fairly large rain and not allow it to run off. If wider bench terraces are built and a dike constricted to retain the water on them, even a typhoon rain can be held in place.

When water falls on the land, some of it evaporates directly, more of it percolates into the soil for use by plants and to add to the underground water supply which feeds the wells and springs. The excess above what percolates into the soil must be held or impouded on the surface or it will run off. It is this portion that runs off that causes soil erosion.

The factors that cause runoff are: 1. Amount and intensity or rainfall; 2. Soil texture and to a degree soil structure which controls percolation; 3. Slope; 4. Land use or soil cover and 5. The size of the watershed area. Man cannot control the rainfall nor the soil texture. He can do a little bit about the soil structure and can sometimes control the size of the watershed by dividing the runoff into several channels. Man can also control the soil cover by the land use, but producing food requires that much of the soil be kept bare. That leaves only the slope factor to deal with. By building level bench terraces, the slope factor is eliminated or controlled.

On sloping cultivated fields the excess water runs off and when it does, it frequently carries with it the fertile topsoil and much of the fertilizer and organic matter that has been applied to the field. On level bench terraces the water percolates into the subsoil and the fertility is retained on the field. It isn't mysterious at all, why level benched lands produce higher yields of crops than sloping fields from which both the water and fertility has been lost.

On impermeable soils or with crops that are sensitive to excess water, it is usually necessary to remove some of the excess water to avoid crop damage. When this water is removed it is the velocity that must be controlled for it is the velocity or speed of the flowing water that determines the scouring or erosive effect of the current. Water moving slowly causes little or no erosion and carries little silt. The two principal factors determining the velocity of flowing water are 1. the slope of the water channel and 2. the friction between the water and the channel lining. That water flows faster down a steep slope than on a gentle one is rather obvious. It is also obvious that water flowing thru thick grass is retarded and flows slower than when unobstructed. The practical application of this factor is, that by spreading the water in a thin, broad sheet, more of it comes into contact with the grass lining of a waterway and it runs slower than if the same cross section area of channel were made narrow and deep so that part of the water rode on water instead of on the grass.

The slope of a water channel can often be changed by constructing drop structures at intervals. The loss in elevation at these structures leaves less of the total difference in elevation to be spread over the rest of the channel. This makes the slope of the channel less and consequently slows the velocity of the flowing water.

The need for applying soil conservation is made particularly intense in Taiwan by a combination of three factors, any one of which would be serious by itself.

1. The intensity of rainfall during typhoons. Rains of 100 mm. or 4 inches in one hour can be expected several times each year and storms of 400 mm. or 16 inches in 24 hours occur at some place in Taiwan practically every year, not always in the same place.

2. Erosible soils on very steep slopes. Most of the soils of Taiwan are formed from sandstones, shales and mudstones which disintegrate and erode very easily and, except for the west coastal plain, the slopes are characteristically very steep making the velocity of runoff very fast and erosive.

3. Population pressure which forces many farmers to cultivate very steep lands. More than 10 million people must secure food and raw materials for industry from about 2 million acres or 800,000 hectares in round figures. These so called cultivated lands include some very steep lands that are being damaged severely. Even with the multiple cropping which increases the production on the better lands, the pressure on the land is so intense that the application of soil and water conservation practices is both necessary and difficult.

The erosion problems of Taiwan fall into three main classifications.

1. There is little or no soil erosion in the level rice paddies. The problem there is largely one of fertility and soil management.

2. The Land Use Capability of the high, steep mountain areas is limited to forestry and the forests provide the only feasible erosion control. The forests are managed by the Taiwan Forestry Bureau.

3. Therefore the Soil Conservation Program is applied mainly to the cultivated slopes which lie between these two extremes. This is the area where most of the soil erosion is taking place and is also the area where agriculture is the least efficient in producing food and fiber crops.

Because of the land scarcity and Chinese traditions, the farmers of Taiwan have a very high regard for their land and are anxious to conserve it. For over 300 years they have been building bench terraces for their rice paddies but have been doing this by hand labor which is a hard, slow and expensive method. It has not been necessary to put on a campaign to "sell" them on the merits of bench terraces. They already respect and want them. It has been largely a matter of cost or economics that has prevented the complete benching of the island.

Mechanization may be feasible for large operators like Taiwan Sugar Corporation working on large fields on gentle slopes. But most of Taiwan is steep slopes in small fields cultivated by small farmers with limited resources. For them, mechanization with large equipment is not feasible. Some simple tools that can be made in the local iron work shops and can be drawn by the farmer's own cattle have been developed and introduced. JCRR has supplied hundreds of these which are loaned to the farmers for their use in working on their own lands.

The Land Use Division was set up in the Provincial Department of Agriculture and Forestry in 1954. PRIOR TO that there had been no organization in Taiwan which was responsible for soil conservation work. Altho this Land Use Division was given a fairly adequate budget and was required to make reports on soil conservation, they were not allowed to employ any technicians for planning or carrying out a soil conservation program in the field.

With financial and technical assistance from JCRR, the first Soil Conservation Field Office was set up at Chingshui in 1955 with technicians begged, borrowed, or stolen from various sources. Additional Field Offices were established year by year until each of the 16 hsiens and three of the five Cities now have them. The soil conservation program of these hsien/city SCFOs is entirely voluntary. The technicians encourage and assist those farmers who request assistance, to conserve the soils on their own farms, largely with their own resources. The technicians survey the farm, plan the various practices and assist in laying out benches and waterways. They loan the Fresno scrapers and V drags to the farmers and demonstrate their use. Mechanical structures in the gullies and waterways are essential to the success of the whole program, but since they do not bring in any increased income, the SCFO subsidizes the cement and brick for their construction.

Since the Land Use Division was not allowed any technicians to give technical leadership, each SCFO more or less went its own way. The Provincial Government did finally recognize the need for providing the technical and administrative leadership and in April 1961, established the Mountain Agricultural Resources Development Bureau. This semi-autonomous bureau in PDAF is responsible for not only soil conservation but also the development of agricultural and range resources in the mountainous areas. In addition to the regular offices for personnel, general affairs, controller and secretariat, it has four technical divisions for land, agriculture, livestock, and soil conservation. The functions of the first three of these practically duplicate the functions of existing organizations so there will probably be some competition and overlapping which China can hardly afford.

With the establishment of MARDB, the field offices were divided into two classes. Those with special assignments in limited areas are called Soil Conservation Work Stations. Their work is generally of more public interest and consequently they use more funds and do more of the work directly, to get their programs effected more quickly. There are now work stations on the watersheds of 5 major reservoirs plus one at SunMoon Lake, two on bananas, and one on citronella problems.

No program is more effective than the personnel who apply it. Recognizing this, a Soil Conservation Training Program has been in effect since 1953. A training center was built in 1958 at Tsaotun by JCRR for PDAF. Each year 40 or more men from the hsien or provincial governments or from commercial agricultural agencies, are given a 7 week course of training in soil conservation. Class room lectures by instructors from the univestites or specialists from government agencies, are alternated with field practice on the various phases of soil consrvation so that the trainees will learn by actually doing. A reservoir of trained technicians is being built up. Men can be drawn from this reservoir as needed when and as the program expands.

Beginning in January 1962, the Provincial Government plans to start a big project for the development of the watersheds of the Black and Muddy Rivers in central Taiwan. This will be an immense program which will greatly reduce the future hazards from floods in this area.

Some research plots have been established and are being operated by various experiment stations to measure the soil and water losses from tea, pineapples and sugarcane when these crops are grown by different methods on different slopes.

So with the research, training, and field operations phases of the overall program organized and functioning, the Soil Conservation Program in Taiwan is off to a good start. With a body of trained personnel and an organization to direct them the program should continue to develop to serve the farmers of Taiwan.

Briefing Lecture on Soil Conservation for TA Participants

Sept. 30, 1959

It is seldom possible, or at least not feasible, to entirely eliminate soil erosion. The degree of erosion control varies as does the light from the sun; practically none at midnight but almost full light at noontime on a bright day. Some erosion is continually taking place, even in virgin forests and jungles. We should recognize this but need not become alarmed over it. What we should be alarmed about is the accelerated erosion which results from man's upsetting of the balance which nature had established between the processes of soil formation and soil erosion.

The job of the soil conservationists is remarkably like that of a physician. He is familiar with numerous treatments which have been successfully used to relieve different patients suffering from a host of maladies. Before he can properly select one of these treatments to be applied to a particular patient, he must examine THAT patient. What is wrong with him? What is causing the trouble? What course of treatments should be prescribed? After answering these questions he is ready to treat the patient. Not before.

If statistics indicated that 10 percent of the patients at a hospital should have appendectomies and a patient came in demanding this operation, it would be rather ridiculous for the clerk in charge to say that "We have had 100 patients this month and performed 10 appendectomies, therefore the quota is full and you will have to receive some other treatment. Or if the quota were not fulfilled, to insist that a patient who did not need it, must have his appendix cut just to keep in line with the averages.

It is necessary for the purposes of overall planning and budgeting to consider averages and percentages but in the application of a program each field should receive the treatment indicated by its needs, not by predetermined averages. To insist that for each unit of terraces there must be so many units of waterways and so many masonry structures is distinctly "paper and pencil administration" and that is *not good* administration.

Although each patient needs to be treated to cure his individual infirmities, there are certain diseases and condition which may be so prevalent as to be characteristic of a community. For instance malaria, tuberculosis, or certain parasites may be so common that nearly every patient needs to be treated for that affliction.

The same is true in applying soil conservation practices. In certain areas in the United States, broad based terraces are an almost universal recommendation for sloping cultivated land. Yet in other communities they may not be needed or they may be inadequate.

Broad based terraces are seldom recommended here in Taiwan. Not because of prejudice against them but because they seldom fit the needs of the particular fields for which treatment is being planned. Broad based terraces are not practical on slopes greater than 12 percent. Their use on slopes greater than 8 percent should be discouraged. Aside from the rice paddies, most of the cultivated fields in Taiwan are steeper than 8 percent. That is one good reason why broad based terraces are seldom used.

Another reason for not using broad based terraces is the small size of the fields owned and operated as separate units. Terraces have to follow the contour of the land. This would mean that each terrace must cross numerous separately operated fields. When the different farmers insist on planting sugar cane, sweet potatoes, casava, or peanuts on their plots without regard to what crop their neighbors are planting, it is difficult if not impossible to maintain either the height of the terrace ridge or a clear channel to permit drianage.

In some regions in the United States where the rainfall is well distributed and seldom intense, contour cultivation alone or combined with strip cropping, is adequate protection against the transportation of soil by runoff water. In other areas of equal annual rainfall but there torrential rains of several inches per hour are to be expected, contour cultivation and strip cropping are NOT adequate protection. Here broad based terraces are usually recommended to remove the surplus water as fast as it accumulates.

In Taiwan it is not at all unusual to have 100 mm. or 4 inches of rain fall within one hour. Nearly every year in connection with a typhoon we can expect 400 mm. or 16 inches of rain within 24 hours. This places a severe strain on broad based terraces and their outlets. Except on very gentle slopes and on very permeable soils, the broad based terraces would be overtopped and serious damage might result. Consequently level, bench type terraces are most frequently recommended here in Taiwan. When these bench terraces are built with a reverse slope, that is, a slight slope backward toward the hill, or if they are built level but have a dike along the front edge, they will hold several inches or water at one time. On permeable soils the excess water thus held can percolate into the subsoil before another rain shower is received. On impermeable or slowly permeable soils an outlet must be prepared to remove the surplus water before more is received.

Therefore, while bench terraces supported by waterways where needed, is not the only practice used in the soil conservation program in Taiwan, it is the most frequently applied practice. Bench terracing in more expensive than broad based terracing but is more effective. If the slopes you expect to terrace in your country are less steep or if your rainfall is less torrential in nature, you may not need to go to bench terraces.

It is essential that we remember that, just because a practice is considered best for one locality or one set of conditions, it is not necessarily the best practice for another set of conditions. Reverting to the illustration of the doctor who must study his patient before prescribing a treatment, the soil conservationist must study the field and the soil and the climate before recommending a practice. This field may be the only one in the community requiring a certain practice. If it does, don't hesitate to recommend it even though it is different from all others around there.

Mr. Louis Bromfield, a prominent United States writer on soil conservation subjects once stated that soil conservation was an art rather than a science. He illustrated it this way. Any one can mix a certain quantity of blue pigment and a certain quantity of yellow pigment and the result will always be the same shade of green. It is a science because any one can do it any time and the result is predictable.

In contrast to this science is the art of several painters who, in putting the same scene on canvas, elect to mix different shades of green and apply them in different manners to register their impression of the scene. The results may be equally pleasing, but you may be assured that no two of them will do it alike. That is the distinction Bromfield made between science and art.

We have the exact sciences of mathematics and engineering. Any good technician can and should arrive at the same answer to a problem in mathematics. Soils, agronomy and forestry are not so exact but they are, nevertheless, distinct sciences. Bromfield maintained, and I agree with him, that the blending of all of these sciences to make a program of soil conservation is not a science but an art.

These things are mentioned to you merely as a warning against getting the idea that there is just *ONE* correct solution to a soil conservation problem, and that all other solutions are wrong.

Instead of seeking *THE ONE* solution, we need to go back frequently and ask ourselves "What is wrong? What is the cause of this trouble? How can this situation in *THIS* field best be corrected?" If we do this we may discover several acceptable plans and be able to choose between them. It is so easy to get into the habit of applying a certain practice just because we have done so frequently before. If the problem and the conditions are the same, of course we should use the same solution. We should not try to figure out some new and unique solution just to be different. Neither should be neglect to consider whether the old practice is applicable to THIS field.

An old man I knew was taking a long automobile trip with his family. They noticed that they were following a bright yellow roadster for mile after mile. This yellow car obliging led them thru the unfamiliar streets of a large city and they continued on their marked route. It got to be a habit to watch that yellow car instead of the road signs. Finally the yellow roadster turned off down a country land and the old man turned off after it. When upbraided by his sharp tongued wife for getting off the highway, the only excuse the old man had was "Well, that yellow car turned off and it has been going on our route all day". The point I want to make by this anecdote is that it is all right to follow the community pattern AS LONG AS IT SOLVE THE PROBLEM YOU HAVE. But whenever the yellow cars or the "habit directed practices" cease to lead us toward our objective, we had better do a little independent thinking and not be led away from our route just because of habit.

We can read books and bulletins; we can follow rules of thumb; we can learn formulae and how to apply it but there is no substitute for THINKING ABOUT *THIS* PROBLEM. What is the trouble here? What is the cause of it? Can it best be solved by preventing detachment or preventing transportation? Which of several possible solutions will work best HERE? There are frequently several ways by which a practice can be applied. Which will be most effective or economical HERE?

The first soil conservation demonstration area that I helped to establish here was at Chingshui. I hope that you will stop to see it when you make your tour of Taiwan. The problem there was that large amounts of runoff water collected on nearly level fields on top of an old marine uplift called Tatu mountain. It then came cascading down the steep slope, cutting huge gullies and spewing rocks and silt across the main highway during each typhoon. The Japanese had tried retaining walls but they soon filled up and the rocks jumped over them.

The upland fields were cultivated so we could not prevent detachment. Prevention of transportation seemed to be the right approach. Now the red laterized soils on these uplands are quite permeable and will take water very readily. So, we decided to build level bench terraces with dikes around each bench to retain any rainwater until it was absorbed. This was done and no outlets were provided. About 10 percent of the watershed on one drainage way was in sugar cane or some other crop so that the operators did not want to have it benched then. However, with 90 plus percent of the area bench terraced, the runoff was practically stopped and the gully that had been eating its way up the hill ceased to grow. The farmers were well satisfied with the yields of crops on the benches, even though considerable subsoil was exposed in building the benches. The extra water stored in the subsoil under the benches apparently off-set the disturbance of the subsoil.

From the standpoint of controlling the growth of the gully by eliminating the runoff and from the standpoint of maintaining crop production, the demonstration was a success. But it had one serious fault. It has not resulted in any of the neighboring farmers benching the adjacent fields. If it was otherwise satisfactory, why did not they do this?

When this demonstration was established we were anxious to get it completed as quickly as possible and as cheaply as possible so we did the benching with a small Caterpillar tractor with a dozer blade. This machine did good work and did it much quicker and more cheaply that it could have been done by the customary method of chopping the soil loose with a heavy hoe and carrying it in baskets. What was wrong with what we did? Our mistake was that we used a machine and a method that the farmers could not use. They had no bulldozer and could not get one. Consequently our very effective water disposal and our economical construction operations "was a big failure" as a demonstration to the farmers. Consequently there have been no more benches built in that community. We had hoped that after they saw how effective they were, everyone would bench his farm.

On the next demonstration area which was in Hsinchu Prefecture, we made and used some Fresno scrapers pulled by local draught cattle hired for the demonstration from the neighbors. This method of building benches was not as fast nor as cheap as the bulldozer BUT the farmers saw that benches could be built with cattle instead of by hand labor. They HAD the cattle and we LOANED them the cheap Fresno scrapers and they went to work. Many benches have since been built there.

When the first demonstration area there was completed and the farmers had been paid for their cattle and their labor, one of them said to the technician in charge "If you would loan me that scraper I would like to build some bench terraces on my own farm". Even though this method was slower and more expensive per hectare than the bulldozer, this was a successful demonstration because it encouraged the farmers to duplicate the results while the more efficient bulldozer job did not.

This should not be constructed as a demonstration of machinery or of economical operation. Far from it but for a demonstration to be successful it must be conducted in such a way that the farmers can and will want to imitate the method.

We started the soil conservation work here in Taiwan by having just one Field Office. This was administered directly by the PDAF. Later that year a second Soil Conservation Field Office was set up with PWCB as administering agency, to work on the watershed of the Ah-kung-tien Reservoir. In neither case did the local hsien governments participate in the staffing or the administration of the SCFOs. This was not desirable but, because there were no positions for soil conservationists in the local organization charts and the local officials were not acquainted with the soil conservation program, nothing could be done about it at that time.

In anticipation of building a reservoir in Hsinchu Hsien, PWCB relinquished the administration of the Ah-kung-tien SCFO to the hsien government and moved their two men to start a new SCFO in Hsinchu Hsien. Unfortunately, the only man experienced left at the Ah-kung-tien SCFO, was drafted into the army so the hsien government had all green men and no experience in managing the program. The results that year were far from satisfactory. Since then they have gotten some experience and are now doing a good job.

In Hsinchu hsien, the administration of the SCFO was turned over to the hsien government after one year, and PWCB took its men and started another SCFO in Taipei hsien. Following that time, as other hsiens organized SCFOs they assumed the direction of them from the first. Needless to say, as long as PDAF or PWCB was administering the program the hsien governments made little effort to learn how. Looking back on our experience it appears that we made a mistake in having some technical agency assume the leadership instead of insisting that the local officials carry their responsibility and then giving them enough advice and training so that they could do a proper job of it.

The Soil Conservation program has now expanded until we have 17 SCFOs in operation with another requested to be set up in Yilan hsien. We feel sure that it has been much more satisfactory to have the expansion come as the result of steady growth than to have attempted to start all of these SCFOs at once.

Naturally born calves usually weigh from

50 to 100 pounds. If we were able, by some occult dosage, to alter natures cycle and have the calves dropped weighing 500 lbs., it MIGHT speed up the production of beef cattle. But I am sure that it would be hard on the cows.

When the soil conservation program started in the United States back in 1934-1935, it was customary to collect a crew of engineers, agronomists, foresters, etc. and have them work out a program to fit the local conditions. Then when a new project was to be established under somewhat similar conditions, half of the original crew would be sent to the new job and their places would be taken by new men to be trained by the half who remained on the old project.

We have not attempted to follow that pattern here in Taiwan for several reasons.

Family ties are very strong among the Chinese and they resist the idea of moving away from where their parents, their uncles and cousins are all located. The difficulty of finding a place to live in crowded cities where they have no relatives is also a deterrent. On top of this, the hsien governments prefer to use the men from their own hsien rather than to take experienced men from some other place.

In order to meet this situation, which was very different from that in the United States and therefore required a different solution. PDAF has conducted a soil conservation training schools to which men from the various interested localities can be sent. After this training they return to their home communities and are expected to assist in the program there Prior to 1957 the training consisted of one week of concentrated lectures followed by two weeks of observation tours. This developed a lot on interest but was not adequate training to prepare the men to go out and do the job. Beginning in 1957 the training was expanded to two months of alternate lectures and field work, using instructors from the University, the Agricultural College, experiment stations, and other governmental and industrial specialists.

In 1958 JCRR financed a set of buildings at Tsaotun to be used for a training center. We expect this Soil Conservation Training School to become a regular annual event to supply the technicians needed for the expanding program.

In 1954 a section of Soil Conservation was authorized in the Land Use Division of PDAF. It had 3 or 4 men only and there was no legal section for soil conservation work in the hsiens. Since soil conservation had no legal sanction in the hseins, the only way we have been able to get the work done was to beg, borrow, or steal men from the hsien sections of agriculture, forestry or irrigation. Just this year the Provincial Government has authorized a separate soil conservation administration within PDAF with enough men to provide representatives in each of the SCFOs. With this recognition it is expected that the hsien governments will give even more active support to the SCFOs.

We regret and apologize for the mistakes we have made in the development of this program in Taiwan but we don't have too many regrets for the rate of progress. Because the program had to develop under difficult conditions, a lot of "weak sisters" were kept out. If we had blossomed out as a big, full blown organization all in one year, we would surely have made more mistakes than we did.

May be our experience here, in that respect, can be of some value to you as you undertake to set up a soil conservation program in your country. My suggestion would be that you not try to grow faster than you can train and develop your technical personnel. After all, any program is just as good as the personnel that applies it.

Soil Conservation Briefing for Visitors to Taiwan

July 25, 1960

There are several factors which make soil erosion a constant threat to the agriculture of Taiwan. One such factor is the intensity of the rainfall. During typhoons or tropical hurricanes, it is not unusual for 400 mm. or 16 inches of rain to fall within a 24 hour period. Shorter storms of 100 mm. or 4 inches per hour can be expected several times each year. Since there are as yet, no known methods of controlling the rainfall, these storms must be endured and means taken to lesson the damage from them.

Along the west coast of Taiwan there is a broad plain of nearly level, fertile land. Erosion is not particularly difficult to control in this area. The pressure of 10.5 million people depending upon approximately 2 million acres (825.000 hectares) of cultivated land for their food and some of the raw materials for industry, has forced the farmers out of this plain and up into the steep slopes of the mountains and foot hills.

The Chinese have a reverence for the land which is their most prized possession. They would not knowingly or willingly abuse or destroy it but strive to pass it on the next generation in an improved condition. However, the people must eat and so they have been forced to cultivated steep slopes which, in their present condition are not fit for cultivation. The hazardous pattern of rainfall, when combined with the forced cultivation of the steep sloping land makes it imperative that soil erosion must be controlled is a permanent agricultural production is to be maintained. Man can not do anything about the rainfall but he can do something about the slope of the surface.

For many years local farmers have been building level rice paddies surrounded by dikes to retain the water. Stopping the flow of the water prevents soil erosion. Benching, then, is not a new practice on Taiwan. It has been practiced for at least 300 years. The merits and advanteges of cultivating level benches rather than steep slopes in widely recognized, even for non-irrigated crops.

Where a supply of water makes it possible to grow rice, most of the lands are already bench terraced. But where there is no water available only a few benches have been constructed. The ratio of cost to benefits has been the principal deterring factor which held down the construction of non-irrigated benches. In the past the benches were built entirely by hand methods. The soil was chopped loose with a heavy hoe, raked into bamboo baskets, and the baskets of dirt carried to where the fill was being made. Good benches could be made by this method but it was a slow, hard, expensive method of accomplishing a desirable end.

Beginning in 1954 a Soil Conservation Program was started by the Provincial Department of Agriculture & Forestry. Personnel were given some technical training and stationed in Soil Conservation Field Offices which have now been established in every hsien or county. Nearly every farmer owns draught cattle or can obtain them from his neighbors. The Soil Conservation Field Offices have demonstrated that by using tools made in the local workshops and pulled by the farmers' cattle, benches can be made just as good but much cheaper and easier. Under average conditions one buffalo and a driver can move as much dirt as four laborers working with hoe and baskets.

The Joint Commission on Rural Reconstruction has provided surveying instruments, Fresno scrapers and V drags to be loaned to those farmers who wish to use them. The technicians from the Field Offices will stake out the benches to be sure that they are built level and will then demonstrate how to use the various tools. After that it is the responsibility of each farmer to build the benches on his own farm with technical assistance from the Field Office.

Level benching is not the only practice used in Taiwan but it is the one most frequently employed. Other practices used are protected waterways, gully control, windbreaks, green manures, compost, re-vegetation, reforestation ant drainage.

The soil conservation program on Taiwan does not include many big imposing projects but is made up of a great number of small, individual farm projects. There are hundreds of Fresno scrapers and V dags available for use by the farmers who ask for them and most of them are kept busy in season. The program is growing steadily from year to year as more farmers learn of it and as more personnel are getting the training and experience necessary to assist the conservation minded farmers.

The development of water resources for irrigation and for power generation is one of the important projects of the Taiwan Provincial Government. The number of sites at which reservoirs can be constructed economically is limited and the best use must be made of those available.

With the torrential rainfall pattern and the steep sloping lands, the problem of reservoir siltation is very serious. Unless every possible step is taken to protect the reservoir watersheds from soil erosion. The useful life of the reservoirs will be materially shortened.

The Taiwan Power Company has conducted a definite program of watershed protection and management on the watershed of the recently completed Wusheh Dam. This program includes fire prevention and suppression by means of lookout towers, fire control lanes and fire fighting organizations. The number and the area covered by forest fires in this watershed has been greatly reduced as a result of this program.

As another approach to watershed management, the Power Co. has worked with the aboriginie tribesmen who live in this watershed, assisting them in building level bench terraces as a substitute for cultivating the steep hillsides. It has also conducted training classes in handicrafts so that they could earn their living without causing so much soil erosion. Young men have been trained and provided with jobs down on the plains. As a result of this effort quite a number of families have moved out of the watershed. This means that less land in the watershed will be cultivated by the smaller number of inhabitants.

Formerly cultivated areas have been reforested, new highway fill slopes have been stabilized by vegetation, and masonry "sabo" works have been built to check erosion on landslide areas. No opportunity to lessen siltation has been overlooked and the program is a continuing one which is having a very beneficial effect.

Similar programs are being undertaken on the watersheds of the Shihmen and Tachien dam reservoirs. These programs are in only the beginning stages and have not yet produced the visible results that have been obtained at Wusheh.

Soil Conservation work is also underway on the watersheds of the smaller reservoirs built or under construction at Ah-kung-tien and Tapu. These watersheds are at lower elevations and contain a much larger percentage of cultivated land. Because of the need for agricultural products, many of these lands must remain in cultivation but by bench terracing and the protection of waterways, siltation can be controlled here, also.

Comments Regarding Graduate Studies in Soil Conservation at the Catholic University

September 7, 1961

Every institution that is willing to do so should be encouraged to give instruction and conduct investigations in the various aspects of soil conservation. This applies to both the pure science and the applied science fields. However, some caution should be exercised to avoid wasting their limited resources and opportunities in futile or overlapping undertakings.

Louis Bromfield, a noted United States writer on Soil Conservation, once voiced an opinion that Soil Conservation was an art rather than a science. He used as a homely illustration, the fact that you can mix certain amounts of blue and yellow pigments and always get the same shade of green. Anyone can do this at any time and the results will always be the same. Therefore, according to Mr. Bromfield, this is science.

In contrast, a number of competent artists will view a scene, get their impressions, and each may mix a different shade of green and apply it to the canvas in a different manner to depict the impression he got from the scene. This is not science but art, since no two equally competent artists will produce identical paintings, altho each may be equally acceptable.

Mr. Bromfield's contention, which I endorse, is that engineering, soils, agronomy, biology, forestry, economics, etc. are sciences just like the different colors the artist can mix. But Soil Conservation is the art of choosing the shades of each and the proportions in which they are to be combined to get the most desirable composition. Just as no one artists painting can be said to be correct and all others wrong, no one soil conservationist's plan can be said to be correct to the exclusion of all others.

With this conception of soil conservation in mind it is difficult, if not impossible, to conduct research in soil conservation, as such. What can and should be done, is to give instruction and conduct research in some of the specific or basic sciences which the artist, or the soil conservationist, combines to create or depict his idea of the best or most acceptable plan of conservations for a tract of land.

Therefore, it is my opinion that research and graduate study should be confined to the basic sciences of engineering, soils, agronomy, etc. which are the working tools of the soil conservationist. Just as an art student can be instructed in the science of color mixing, the effects of tints and shades of each color, the mechanical theory of perspective, etc., so can the soil conservationist be taught the basic sciences and their application. But just as the artist must have a vision or receive an inspiration to guide his application of colors, so must the soil conservationist "feel his way" until he conceives of an idea and then expresses this idea with the engineering, soils, and agronomic skills which he has been taught or which he may have developed thru research.

The teaching of the individual skills which are used by the soil conservationist has not progressed very far in the various colleges or universities in Taiwan. Some of the basic sciences are taught in several institutions but not with any particular reference to their application in soil conservation. Undergraduate instruction in these basic sciences can and should be developed more widely. After the students have received training in these basic sciences, then they may be ready for graduate studies in one or more specific fields.

Because of the lack or scarcity of undergraduate training in the basic sciences used in soil conservation, graduate training at this time, may be a little premature. However, the time will come and may be closer than I think, when a number of students will be ready for graduate studies in the sciences related to soil conservation.

In considering graduate studies which would contribute to the training of soil conservationists, I am sure that the availability of qualified instructors will be of far greater importance that the equipment or apparatus to be used in each of the courses. Mark Hopkins, a famous educator, once said that the basic necessity for a college education was "a log with an instructor sitting on one end and a student on the other". We have seen examples of a most elaborate set of equipment failing to produce any worthwhile results because of the lack of adequately prepared or inspired instructors. The reverse may also be true but to a lesser degree, where a well prepared instructor is handicapped by the lack of necessary teaching or research facilities and tools.

The equipment needed will necessarily vary with each course, whether it be graduate or undergraduate. A list of needed equipment cannot be drawn up until the subject to be studied and the way it is to be approached, are determined.

Such items as classrooms, laboratories equipped with sinks, running water, electrical outlets, sources of heat, delicate balances, measuring devices etc. will be needed for any of the physical sciences whether connected with soil conservation or not.

There are some problems that might profitably be studied to get some more exact quantitative answers. We THINK that we already know the TRENDS and the APPROXIMATE values in many of these cases.

Fertility of subsoils exposed in bench terrace construction.

In the construction of bench type level terraces, the surface soil is removed from the excavated area and placed on the filled area. This exposes an area of subsoil. Almost without exception, this exposed subsoil is lower in organic matter content and in available plant nutrients than the surface soil which was removed and placed in the filled area. We THINK that we know that this subsoil area will produce smaller yields of crops, probably of poorer quality, than the undisturbed or the filled areas.

I know of no one who can predict the exact amount of depression of yield or quality for any specific site. This depression would, I am reasonably sure, be a variable quantity dependent on the nature of the original soil, the extent to which the soil had been eroded before the benches were built, the depth of the excavation, the slope of the original soil, the method of placing the cut soil in the fill, and perhaps other factors.

Restoration of fertility on exposed subsoils.

A companion study might well be to determine the treatments, both as to kind and degree, that would be required to bring the excavated areas back to the original level of productivity. This would involve the study of the effects of chemical fertilizers, green manure crops, manure, composts, all in varying kinds and amounts and with different methods of application.

Such studies as these would require a supply of soil sample containers, sampling equipment, drying ovens, greenhouse facilities for growing crops in pots and facilities for extensive travelling to study the various crops in the field on farmer's benches, as well as on specially constructed benches. Chemical soil tests of these samples could be run by the graduate student or they might be done in the regular soil testing laboratory, all depending on the scope of the study that is outlined.

Stabilization of the faces of terraces.

Another study that might yield some

practical results in addition to the pure science aspect, would be the stabilization of the faces of bench terraces by vegetation. Here again, we are REASONABLY SURE that any vegetation growing on the face of the terrace is beneficial in stabilizing it against erosion caused by rainfall. I know of no quantitative measurements.

We would expect to find large variations due to differences in the soil itself, the depth to which it had been excavated, the method of making the fills, the length and slope of the faces, the kind of vegetation used, the density of ground cover, the vigor or growth due to fertility or moisture availability, the aspect of the face in regard to the direction of the usual typhoon rains, and perhaps the elevation above sea level.

This study would require more field work and less greenhouse work than the study of the productivity of the benches themselves.

Comparative efficiency of different methods of constructing benches.

Following some rather crude comparisons, we have come to believe that bench terraces can be built cheaper and faster with animal drawn Fresno scrapers or V drags than when similar benches are built by hand laborers using hoes and baskets. We do not know just how much more efficient or economical the animal drawn tools are on 5% slopes; on15% slopes; or on steeper slopes. What is the comparative efficiency of the different methods of construction on friable sandy soils? or hard clay soils? on the soils intermediate between these two extremes? How does varying moisture content effect the efficiency of each method on the more plastic soil? What is the most efficient procedure for terrace construction on each classification of slope? What is the most efficient method of compacting the soil in the fill?

Obtaining the answers to these and similar questions would involve field work almost exclusively with little laboratory or greenhouse work involved.

Runoff and percolation of rainfall on benches.

Another profitable study would be to determine in the field, the infiltration on benches of different types, on different soils and growing different crops. This study might involve the building, maintenance, and cropping of benches of different sizes on soils differing in permeability and with differing surface slopes and with different kinds of outlet facilities. It would be necessary to study the total runoff in relation to the rainfall, the sediment content of the runoff, the rate and extent of percolation or infiltration and perhaps other aspects that the instructor might suggest.

This study would involve frequent moisture samplings, very exact rainfall measurements including intensity as well as the total precipitation. This would require recording raingauges at each location studied and a supply of moisture sample cans, balances, drying ovens, etc. Such a study might well require that the student live at the site during the rainy season and attend classes only during the dry season.

Some of these problems might be studied by means of controlled, artificial rain application to small plots.

As mentioned before, the training and experience of the instructor is of far greater importance than the equipment needed for studies such as these. With this in mind, I would hesitate to attempt to draw up a list of equipment needed, just as a medical doctor would hesitate to write a prescription without seeing the patient. I would suggest that if the West German Government wishes to assist in this work, their most valuable contribution might be the loan of several well trained instructors.

The Need for Credit for Soil Conservation Practices.

September 10, 1958

Soil erosion is a serious problem in many cultivated fields in Taiwan. The two principal reasons are slope and intensity of rainfall. Man has not been able to control the intensity of the rainfall, but for years he has been able to alter the slope of the land by building bench terraces.

In a paddy field, the rain falls and churns up the soil but, because the water there stands still, the soil settles back down and no erosion takes place. Many of the upland fields cannot be made into paddy fields because there is no adequate water supply at present, but they can be benched so that they are level and so that rainwater will accumulate on them temporarily instead of running off, as it does on sloping fields. This provides water that the crops will need at a later date and also prevents the loss of soil and plant nutrients thru soil erosion.

Farmers on Taiwan have been building bench terraces for at least 300 years. They know the merits of benching and without exception, desire to bench their own lands. In the past practically all of the benches have been built by hand labor. The workmen chop the soil in the areas to be cut, rake it into their baskets, and then carry these baskets with a pole over their shoulder, to dump them in the areas to be filled. Very good benches can be built in this way but it is a slow, hard, and expensive method, even with the cheap labor available in Taiwan.

At each of the Soil Conservation Field Offices, a new method of bench construction has has proven practical. Cattle pull Fresno scrapers on gentle slopes where the benches are 4 or more meters wide, or V drags on steep slopes where the benches are less than 3 meters wide. One man and a buffalo can build as much terrace as four men working much harder with the old hoe and basket method. This makes the new method both cheaper and faster.

These tools ara made in the local workshops of materials to be found in most medium sized town. The Fresno scraper is made of 1/8 inch thick iron plate with a few pieces of pipe and rod. One shop at Chiayi makes them for NT$580 each. On competitive bids for larger orders a better price might be obtained. The V drag is made of 1 inch thick, light, lumber with an iron faced blade. The cost of these built one at a time is between NT$300 and NT$ 400.

While the cost of such implements is not prohibitive they are used only for the construction of benches and after this job is done there is no further need for them. Therefore, individual farmers might well hesitate to have them made. As an implement to be used once or twice and then no longer needed, they have been furnished free on a loan basis by the Soil Conservative Field Offices, to the first farmers to build benches. Each SCFO has about 10 such scrapers for loan. When the benching program gets into full swing this will not be enough to meet the demand. It would seem reasonable to have some organization that deals with these same farmers supply the needed equipment, perhaps on a rental basis, at a nominal fee for each day the farmer has it in his possession, Sundays and legal holidays excepted.

In getting the benching program started PDAF has been paying a subsidy of NT$ 1,000 per hectare for all benches built up to their specification as to slope, back slope and outlet protection. This subsidy has served its purpose in encouraging the first farmers to build benches by the new methods. Because of a limitation of funds and the increasing volume of benching, it is doubtful that this subsidy can be continued indefinitely.

The construction of a good set of benches increases the value of a field because it increases its productivity. Terraces do not add to the fertility of the soil but, by controlling the erosion that would take place on sloping fields, they make it possible to build up the fertility with green manure, fertilizers and compost so that the field will become more productive. Without the terrace, the manure and some of the top soil etc. is washed off at each typhoon ain. In addition to the increasd fertility, the benches cause more water to penetrate the soil so that there is more subsoil moisture to feed the plants. Because of these two reasons, the benched fields produce higher yields of crops per hectare after the first year or two during which subsoil may be left exposed.

The Ponlai Brown Sugar mill, which is in a position to know since they weigh the cane produced, says that some farmers there are producing 100 to 120 tons of sugarcane per hectare on benched land while the same farmer on adjacent sloping lands is producing only 30 to 40 tons of cane. A farmer in Hsinchu Hsien spent NT$7000 per hectare benching some very steep land that was formerly worth NT$15,000 per hectare. He and his neighbors valued it at NT$30,000 per hectare after it was benched. This increased production and increased appraised value indicate that benching is a profitable investment which should stand on its own merits and should require no subsidy.

The cost of constructing one hectare of bench terraces varies widely, depending upon the slope of the land, the width of benches built, the texture of the soil and the presence of rocks or stumps and roots. It is not possible to give an average figure for the cost per hectare any more than that of estimating the height of men. When you say the average man is 5' 6" high, some require clothing for a height of more than 6' and some for only 5'.

In the same way, if we estimate that the average cost of benching is NT$4,000 per hectare, there will be some very favorable site which can be benched for maybe NT$ 2,500 and there may be some others which because of steep slope, rocks or stumps may cost NT$7,000 or even more. Just as each man should be measured for his own suit, each field should have its own costs estimated. The technicians in the SCFO are in a position to make such estimates based on their past experience. Such estimate should be made in terms of man and buffalo days rather than dollars.

In addition to the actual construction but as in integral part of the practice, is the protection of the waterways. Unless some means is provided for removing the surplus water, that which cannot be absorbed by the soil after a reasonable period, the water will accumulate and break over at the lowest place. This may cause concentrated erosion. Therefore protection of the waterways is essential. This protection may be afforded by a grass sod covering a well shaped channel if the slope is not too steep or if the volume of water passing that point is not too great. For the more hazardous situations it will probably be necessary to construct drop structures or chutes of masonry work. Where there are rocks available locally, they can be picked up at the site with little expense and laid up with a little cement and sand mortar. Where there are no rocks available, brick will have to be used. The average structure will seldom require more than 150 bricks and one half sack of cement so they are not too expensive.

It is possible that PDAF may continue to subsidize the material for building such structures since the waterways, differing from the benches themselves, do not produce any cash return with which to repay a loan for their construction.

Following bench construction, a certain amount of subsoil is exposed. In order to improve the productive capacity of this area and get the most out of the bench, green manure crops should be planted. Green manure crops, like the benches, will increase the crop yields sufficiently to reimburse the farmer for their cost. Hence, credit rather than subsidy should be supplied for green manure crop seed.

Some farmers are financially able to construct their own benches, either by their own labor or by hiring men and animals to help get the work done faster. Any farmer with a buffalo or a bullock can build his own benches without having to pay out cash. However, some farmers have to take outside off the farm jobs, during certain seasons to earn money to support the family until the crops are harvested. These poorer farmers may need credit to either hire labor or feed the family while they work on their own fields. A loan, adequate in size to handle the job, to be repaid over a term of several years and carrying a reasonable rate of interest would be a very definite help to those who need it.

The area of steep cultivated land that needs benching and that would pay for the practice within a few years, is great. Just how many hectares, no one can say exactly. Knowing the exact area would be of little value unless at the same time you knew how many farmers intended to apply this practice. One nice thing about a program of this type is, that after the procedures are set up, the volume will adjust itself. If the volume is 500 or 5,000 hectares the procedure in dealing with each individual farmer is the same.

A land Use Policy has been approved by the Provincial Soil Conservation Technical Committee. This policy pertains to the stabilization of sloping cultivated public lands. If it is promulgated by the Provincial Government, as seems likely, the illegal occupiers of these public lands can, after proper application and permit, bench terrace the lands they are cultivating, provided the slope and soil are suitable, and receive a legal lease which will be the equivalent of ownership of the benched land.

When and if this policy is promulgated, the volume of bench terracing will be increased many fold. Since many of these illegal occupiers are among the lower economic strata of farmers, credit for this operation will be needed by many of them. This will give volume enough to make the program worth while and furnishing credit to help these hapless farmers become established on the land will be a real service to the community and the nation.

ABBREVIATIONS

ICA	International Cooperation Administration
JCRR	Joint Commission on Rural Reconstruction
MARDB	Mountain Agricultural Resources Development Bureau
MOEA	Ministry of Economic Affairs
NTU	National Taiwan University
PDAF	Provincial Department of Agriculture & Forestry
PDCA	Provincial Department of Civil Affairs
PWCB	Provincial Water Conservancy Bureau
RETSER	Retired Servicemen
SCFO	Soil Conservation Field Offices
SCS	Soil Conservation Service
SCWS	Soil Conservation Work Station
TARI	Taiwan Agriculture Research Institute
TFB(TFA)	Taiwan Forestry Bureau (Taiwan Forestry Administration)
TFRI	Taiwan Forest Research Institute
TPC	Taiwan Power Company
TPG	Taiwan Provincial Government
TSC	Taiwan Sugar Corporation