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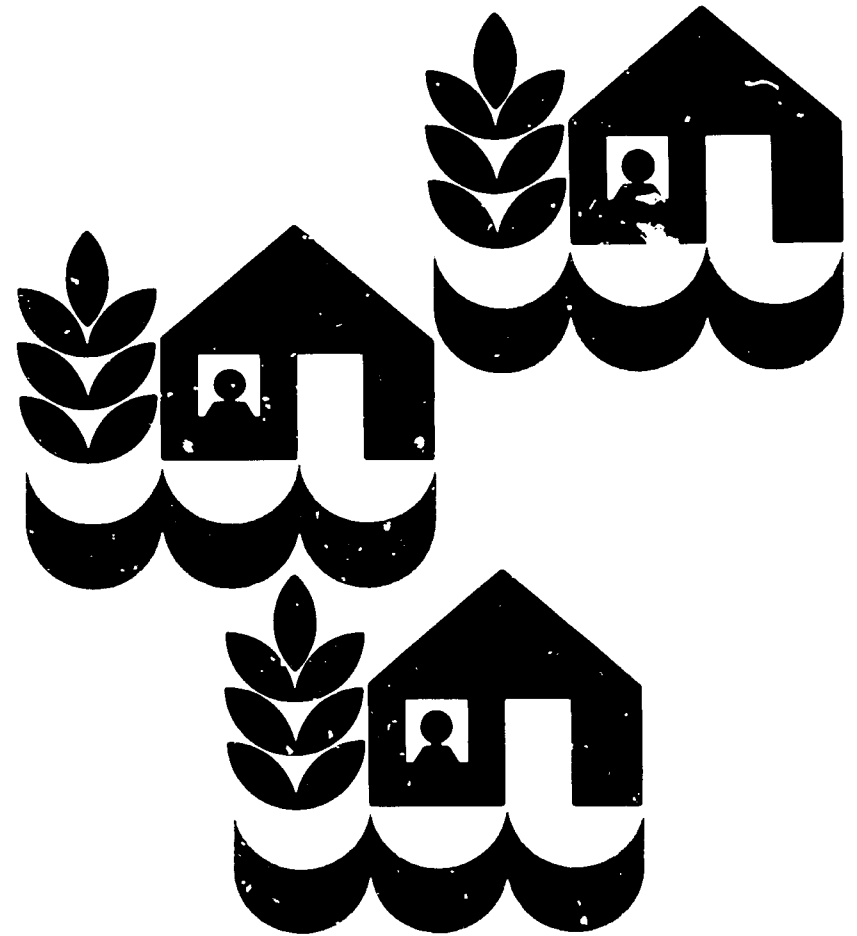
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LAND LEVELING

Planning Guide No.1, Water Management Synthesis Project



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LAND LEVELING
Planning Guide No. 1.
Water Management
Synthesis Project



PREFACE

Land leveling is not new. Farmers have practiced some form of land leveling since the beginning of irrigation more than 5,000 years ago. The purpose of this planning guide, though, is to provide an understanding of precision land leveling.

This guide is intended for all who are concerned with the development of irrigated land and increased agricultural production. This includes, among others, senior officials in irrigation and agricultural planning departments, and engineers, technicians, extension agents and development officers who carry out the programs.

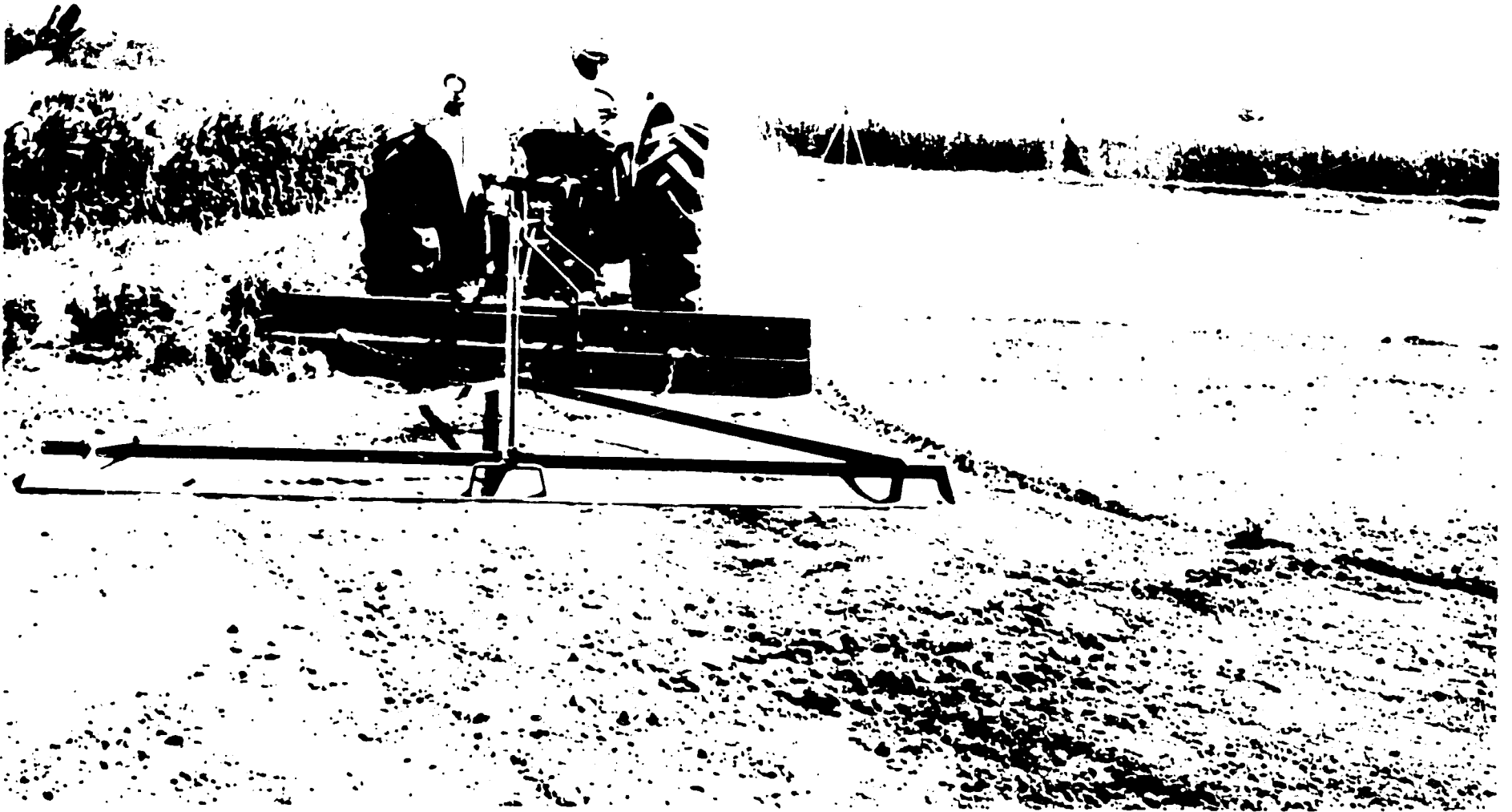
The material in the guide is based on many years of experience working with land leveling in several countries and in the United States. Some of the authors' experiences in Egypt, Pakistan, Turkey, and El Salvador are cited to illustrate how land leveling problems have been overcome in actual practice.

Special importance is placed on involving farmers in all phases of the land leveling process. Emphasis is also given to working on the small farm--one or two acres up to 25.

The first part of the guide looks at what land leveling is and why it is needed. The second part deals with how land leveling is actually done and the practices needed with a precision land leveling program. The third section investigates resources needed to develop and implement the program. Finally, the last section describes the need and process for evaluating a land leveling program.



The scraper being used with this tractor is an essential tool in precision land leveling. It is used to cut the high spots and fill the low places.



What Is Land Leveling ?



Technical assistance to farmers through surveying provides the precision needed in land leveling.

PRECISION LAND LEVELING

Land leveling is required in irrigated agriculture for good water management.

The accuracy required in precision land leveling depends on whether the fields have zero slope or have a grade (slope).

Precision land leveling is grading and smoothing the land surface of a field to a given degree of precision to facilitate efficient irrigation. How precise the leveling must be depends on several factors. Generally, it must be within 1.5 cm from the designed surface for level border or basin irrigation. Graded borders require slightly less accuracy. Tolerance can be within 3.0 cm for graded border systems as long as there are no reverse grades.

Good water management requires precision land leveling. Precision is possible in modern agriculture, but it requires more than the traditional "rough leveling" performed by most farmers without technical assistance.

Precision leveling for both the level border/basins and the graded border systems requires surveying of individual fields and careful checking during leveling if the field is to be within these tolerance levels.



Irrigation water flows quickly over a precision leveled field.



Engineers and farmers examine a precision leveled field in Pakistan. The surrounding wheat fields were also precision leveled.

WHO NEEDS PRECISION LAND LEVELING?

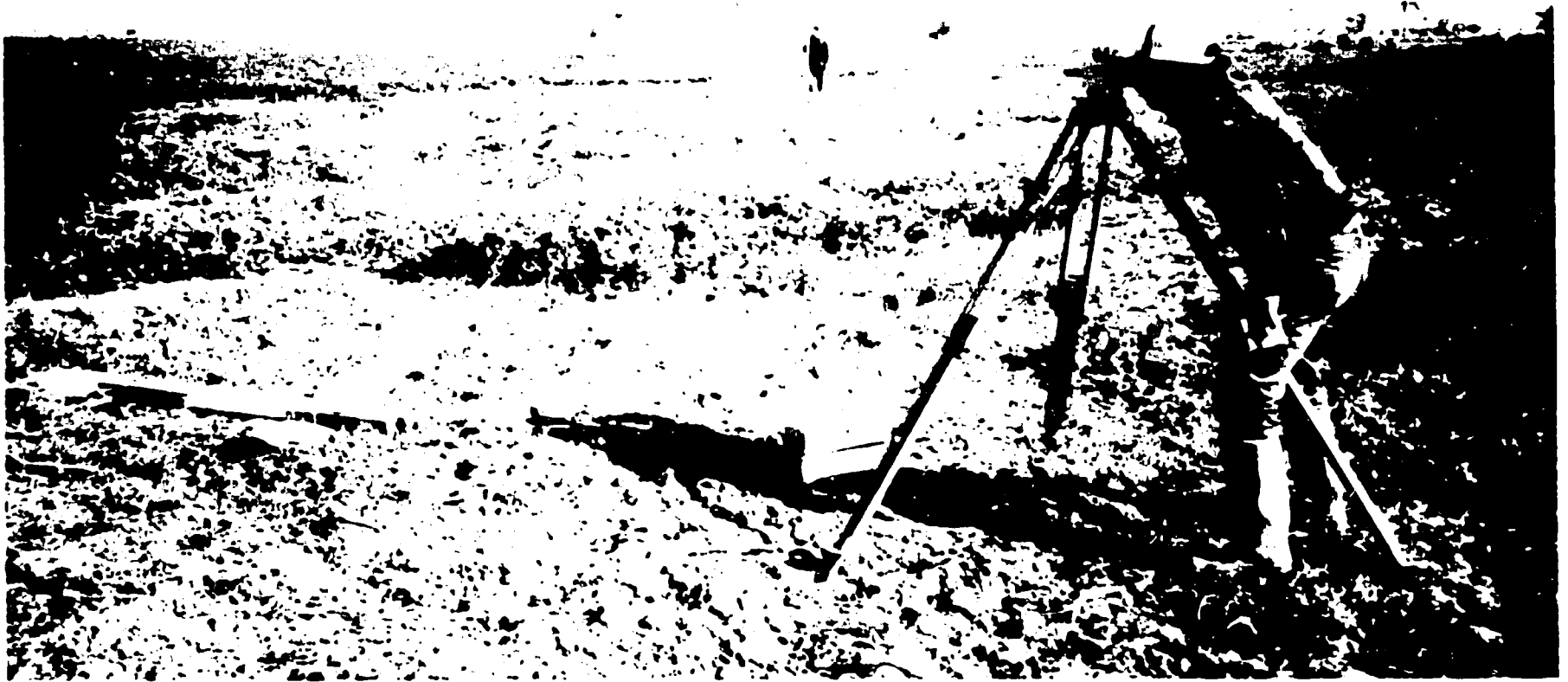
All irrigated land needs varying amounts of leveling to have efficient irrigation. Even the very flat Indus Valley in Pakistan that has an average slope of 14 cm in one km needs leveling to have good quality irrigation. "All irrigation methods are made more efficient by some degree of land leveling, and some require very accurate leveling in order to function at all." (Hudson)

Experience with farmers throughout the world shows that most of them recognize the importance of land leveling. In fact, many farmers invest considerable resources attempting to adequately level their land. Experience has taught them that land leveling will help them save water, save labor, create better water management, and make better tillage possible. These benefits make possible more uniform crop stands, more effective use of fertilizer, and ultimately increased yields.

In countries where the government has provided effective technical assistance and financial subsidy for a land leveling program there has been considerable farmer involvement. For example, Pakistan, Turkey and the United States have all had successful land leveling programs. The farmers were willing in those countries to invest considerable resources and time accomplishing land leveling because they understood the need for it and the benefits of it.



The farms in El Minya, Egypt, look level but are not precision leveled. A land leveling project is presently being done in this area to improve the efficiency of water use on the leveled fields.



Researchers find by surveying a field that it needs precision leveling.

UNLEVEL LAND

Land that is not precision leveled initially results in high spots being watered too little and the low spots being watered too much.

The ultimate results are reduced yields and wasted resources--water, fertilizer and energy.

Unlevel land causes poor stands in low and high areas, excess water in low areas, and inadequate water and crop stress on high areas. The total water applied to the field must be increased to cover the high areas. This results in overirrigation of the field, causing water-logging and possibly salinity problems.

For example, if a crop requires 7 cm of irrigation water during a particular water application, a 3 cm high spot may require 40 percent additional water to be applied to the whole field to cover the high spot.



The field shown here was unlevel. In the foreground no cotton was grown in the low spot because too much water was applied to reach the higher spots in the field.



In contrast, this 20-acre field is covered with only one inch of water because it is precisely leveled.

BENEFITS OF LAND LEVELING

Land leveling is an essential requirement for a modern farming operation.

All irrigation methods require some degree of land leveling. Methods like basin irrigation require precise leveling.

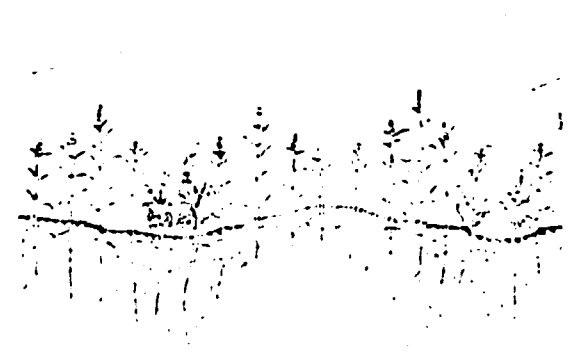
Benefits of precision land leveling include these:

- › Saves water and energy
- › Produces higher yields
- › Facilitates better, more uniform plant populations
- › Makes cropping and all farming operations more efficient
- › Improves surface drainage during rainy season
- › Saves labor
- › Saves fertilizer and makes its use more effective

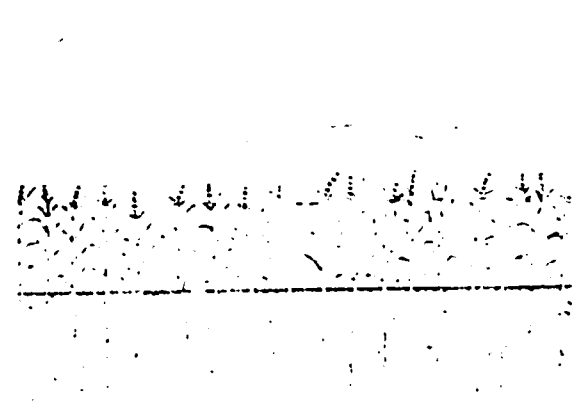
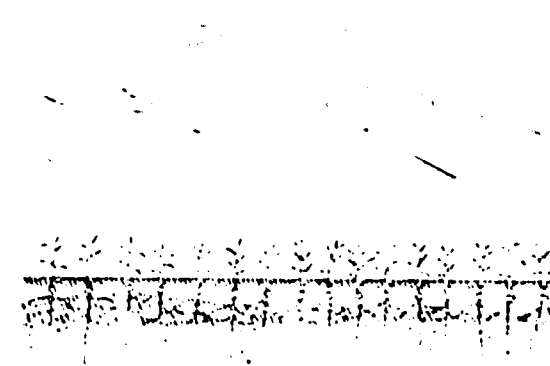
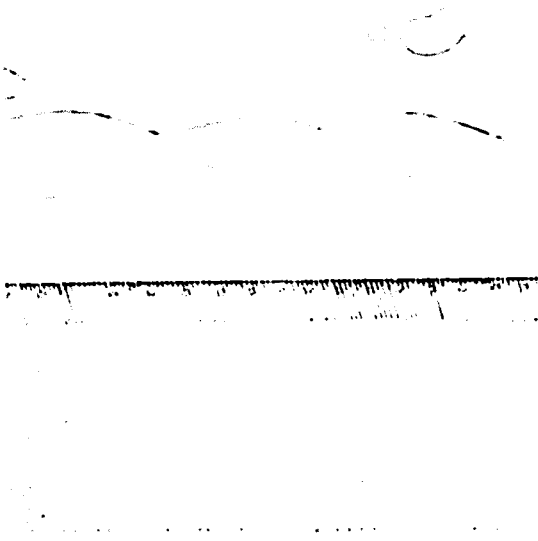
Actually, studies have shown that there is a cumulative effect of improvements once precision land leveling has been done. The combined improvements in farming practices and inputs result in total increases in yields many times that caused by land leveling itself.



One benefit of land leveling is that it facilitates better, more uniform crop stands like this tobacco field in India.



Unlevel Farm Fields



Level Farm Fields

LAND LEVELING MYTHS

Myth 1. Farmers aren't interested in land leveling.

Farmers are interested. They have been doing it for centuries. The problem is that it is not precision leveling. They have better results doing some leveling than none at all, but the efficiency could be considerably greater if precision leveling were done.

Myth 2. Farms are too small to precisely level.

No farm is too small for precision leveling for irrigation. Size may make a difference in the method used to level the land, but not in the need or benefits from leveling.

Myth 3. Lands are already level.

Even the "flat land" of the Indus Valley where land on the average slopes no more than 14 cm in a kilometer is not precision leveled. Precision leveling means accuracy within 1.5 cm of the desired surface.

Myth 4. Machinery is too expensive

It is expensive, but the value is too great to ignore. The precision and speed that comes with the use of machinery often makes it cost effective. The farmer can use traditional equipment, but needs engineering assistance to accomplish precision. If the machinery is too expensive for one farmer to buy alone, an irrigation association might buy the machinery cooperatively. Also, the government usually provides subsidy for machinery.

Myth 5. Land leveling is too costly.

Not only is the equipment expensive, but also time and labor make land leveling a major investment. However, the value to the country in resource conservation and to the farmer in improving his standard of living through increased productivity makes it a good investment.

Myth 6. Farmers must pay the full cost.

Most countries subsidize land leveling costs and make good credit terms available. Turkey, Pakistan and the United States are three countries that have heavily subsidized land leveling. The benefits to the country are high. (See Myth 10.)

Myth 7. Farmers will not accept land leveling.

Farmers want land leveling. They are, however, concerned about the high cost and are reluctant to commit themselves to it until they understand that they can afford it.

Myth 8. Farmers don't understand land leveling.

They understand its benefits and want it. They understand quality results. When quality is poor and cost is high, they can't pay costs for the value it will provide for the country as a whole. It must also be beneficial to them personally.

Myth 9. Once a field is level, it is always level.

Absolutely wrong. Land settles with the water applied to it. It is also affected by plowing, working, and harvesting. Care must be taken to maintain field level. Anytime some farming operation disturbs the level, it may have to be smoothed out.

Myth 10. Benefits of land leveling are small.

Benefits of level land are numerous--higher yields; saves water, energy and labor; improves surface drainage; makes cropping and all farm operations easier; saves fertilizer and makes its use more effective; saves land; and reduces imports needed.



What Is the Land Leveling Process?

PREPARATORY STEPS

Before beginning the actual land leveling process, there are some important activities that need to be done. These preparatory steps include:

- Study the entire farm. Leveling is a field by field process. It is best to divide into segments with about the same slope and soil conditions and level the subdivided areas at the same time.
- Prepare a topographic map. It is necessary. Several methods are available for this survey: grid, plane table, transit survey, or field cross section.
- Plan the irrigation system so the field boundaries, water supply, drains, and field roads are known.
- Clear field of trash and vegetative material.
- Design and stake a grid system for construction (if you have not already done so for the topographical survey.)



The entire farm should be considered before starting precision leveling of a field.



Farmer involvement to consider his preferences and needs should be a part of planning each farm for precision leveling.

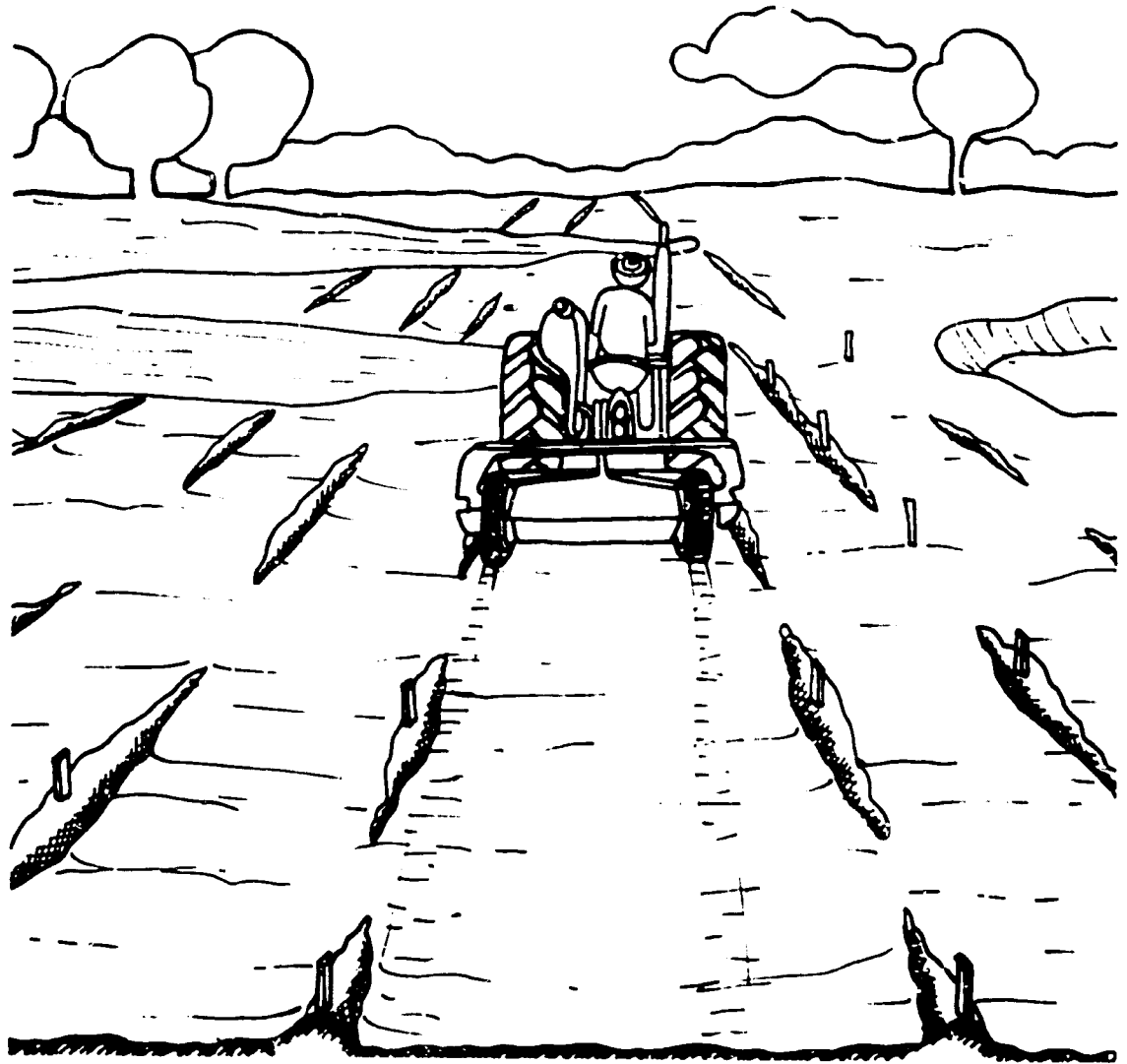
LAND LEVELING CONSTRUCTION CRITERIA

Leveling for irrigation is different from other earth moving in construction. The amount of soil to be moved is not large, but the depth of cut and height of the field have to be exact.

The problem in land leveling is to work out where to cut the high spots and where to fill the low spots to give the required land slope with the least earth movement.

Criteria for preparation to level a field include these:

- Time to do the work
- Skill of the operators
- Distance fill must be hauled
- Cost
- Availability of proper machinery



Transporting soil from high areas to low areas can be efficiently accomplished by using a tractor and soil scraper.



Machinery such as this tractor and scraper are important ingredients to a successful land leveling construction project.

LAND LEVELING PROCESS

Once the preliminary work has been done, the land leveling process begins. The process includes the following steps:

Design-Stakes--With a survey team the field to be leveled is staked out showing how much land must be cut or how much soil must be filled in each spot.

Scraping--A scraper is used to cut, move and fill the soil. This is the rough grading.

Planing--A land plane or float is used to smooth the land to precision.

Irrigation--The land must go through an irrigation to settle. Adjustment can then be made by planing again.

Touch-up--After the land settles and often after a cropping season, the land should be touched up. Usually this requires only planing, but in some cases the scraper may be needed.

Extension-farmer training--Farmers need to be shown how to increase production with their new, larger fields and greater quantity of water. They will be able to improve inputs and use better irrigation practices to obtain increased production.



Surveying is one of the first steps in the land leveling process.



The scraper is following the directions of the survey crew who are staking the field to show the high and low spots that need attention. When the scraper is finished the

field should be uniform and only need the final touch of the land plane to smooth the surface.

Conditions Affecting Land Leveling

Precision land leveling is influenced by the following conditions:

- Characteristics of the soil
- Prevailing land slopes
- Methods of irrigation
- Climate characteristics
- Crops to be grown
- Preferences of the farmers

Soils

A soil survey before the land leveling process begins is necessary to plan the best layout for accomplishing precision land leveling.

You need to know the nature and depth of the topsoil and the subsoil. The depth of cut or how the land leveling is done may be affected by the shallowness of the topsoil.

Information about infiltration rates of water must also be known. If infiltration rates are high, lengths of field must be shorter than if the infiltration rates are low.

Prevailing Land Slope

The slope of the land will affect land leveling.

Land that is too steep and rolling should often be left ungraded and used for permanent crops to prevent erosion.

Level borders and basin irrigation require the most precise grading. These are the popular methods in most countries and are growing most quickly in the United States.

Climate Characteristics

Rainfall in an area is important in determining the maximum or minimum grades permissible for field. The amount, intensity, and season of rainfall affect the drainage requirements that must be met by a minimum grade for a field. Rainfall characteristics also affect the maximum grade allowable to keep erosion from occurring.

Crops to be Grown

High value crops may justify more cost for precision land leveling than lower valued crops.

Farmer Preferences

Central to providing farmers with improved fields for irrigation is involvement of the farmers in each activity for improvement. The farmer's preferences for field design and layout, for example, should be considered as the field is being planned for leveling. The farmer must be consulted about various restraints.



A farmer and an engineer plan the leveling of a field considering farmer preferences.

IRRIGATION SYSTEMS AND LAND LEVELING

LEVEL BORDERS-BASINS

Advantages of using level borders or basins as an irrigation system include these:

Many different crops can be grown without major changes in the design layout or operating procedures

High application efficiency can be obtained

May be the only method possible to irrigate low intake soils.

Leaching of salts can be easily accomplished without changing operations

Irrigation management skills are less stringent--inexperienced persons can operate it efficiently

Limitations of this system are these:

Accurate (precision) land leveling is needed

Maintenance of level surface is essential

Excessive ponding and scalding of crops may occur with poor management

Adaptability:

Used for most row crops and closely growing crops, tree crops and especially rice

Best suited to soils that have moderate to low intake rates. Can be used on high intake soils but border areas must be smaller.

Best suited for smooth, gentle slopes

GRADED BORDERS

Advantages of using graded borders include these:

Can have good efficiencies if borders are designed and operated properly

Land leveling costs can be minimized

Surface drainage can be excellent

Limitations of this system include these:

Requires elimination of cross slope

Topography and soils suitable for land leveling

Considerable skill in irrigating

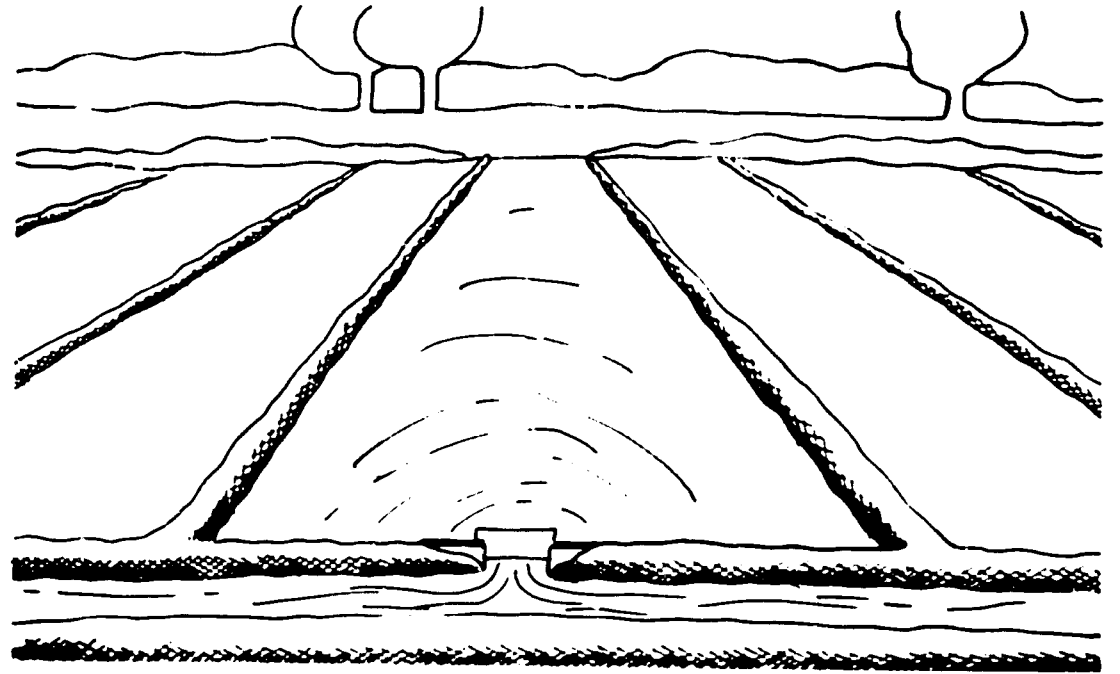
Adaptability:

Same crops as for level borders except rice

Best suited to moderately low to moderately high intake rates.

LEVEL

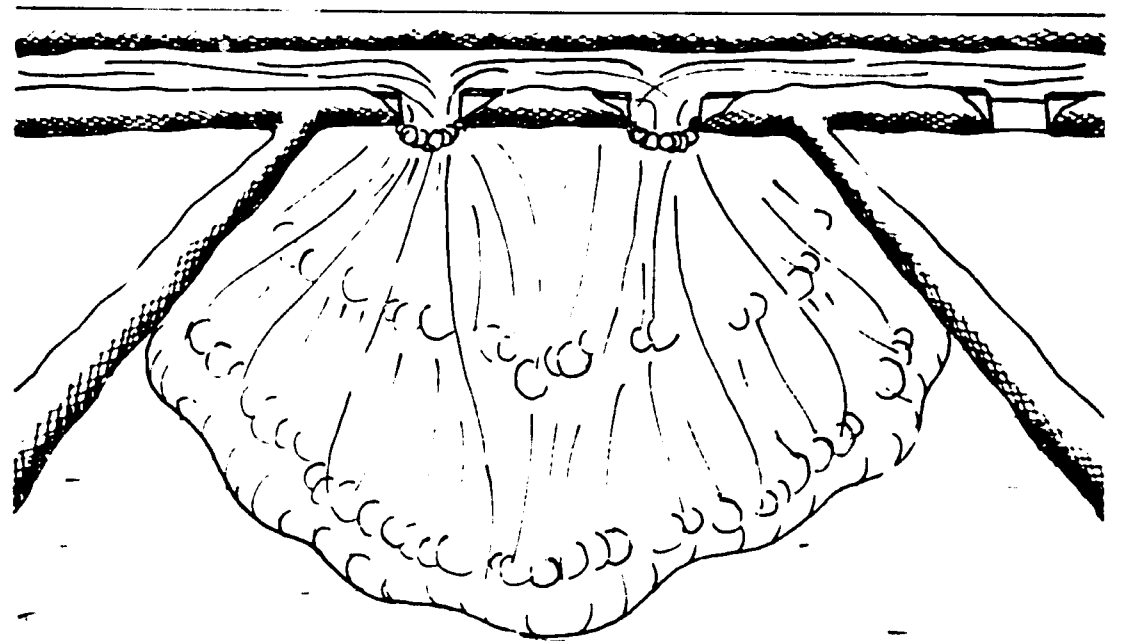
Tolerance: 1.5 cm



GRADED

Tolerance: 3.0 cm

No reverse grade



ACCURACY

Generally, tolerance is considered + or - 1.5 cm for precision leveling. Accuracy must be greatest on land with "zero" slope.

The most accurate method of precision land leveling is laser leveling, but the machinery to provide it is costly and difficult to manage on small fields.

After the first irrigation or rain following land leveling, the soil will settle in some spots. Adjustment for settling may have to be made.

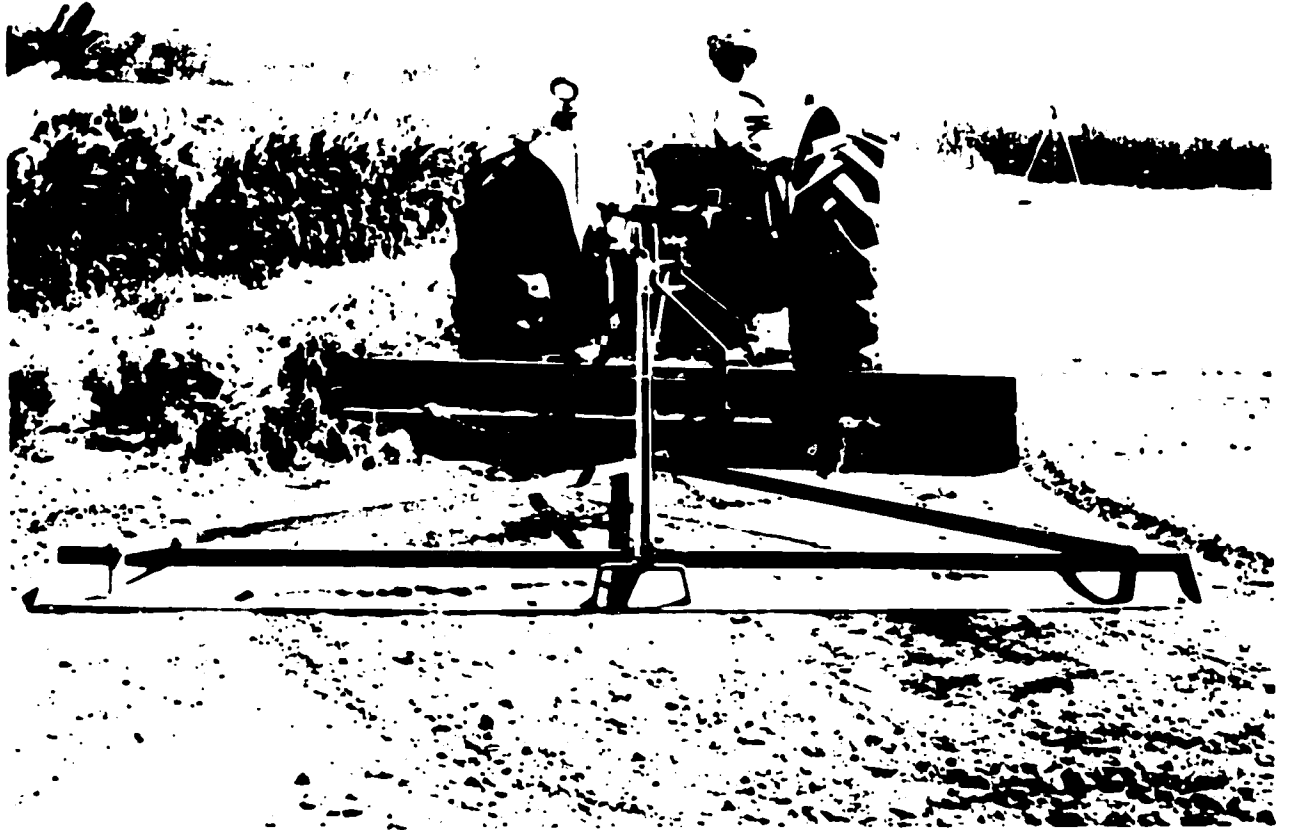
MAINTENANCE

Preservation of leveled fields requires continued maintenance.

Erosion from wind or water can change the surface of the land.

When carefully done tillage operations won't require the land to be relevelled, but in some cases maintenance may be needed to smooth the furrows and ridges.

Smoothing with small farm floats should be done frequently as part of the regular maintenance procedure.



A land plane is used to smooth the field surface and increase the precision of the leveling process.



Machinery must be maintained properly or frequent problems will occur like the problem with this scraper out in the field.

PROBLEMS OF LAND LEVELING

Land leveling does have problems, but these problems, once identified, can be solved.

Problems that are often associated with land leveling include these:

- Effect of removing topsoil
- Effect of soil disturbance on plant growth
- Cost of land leveling
- Availability of machinery
- Availability of skilled operators and technicians
- Training farmers by extension how to maintain level fields

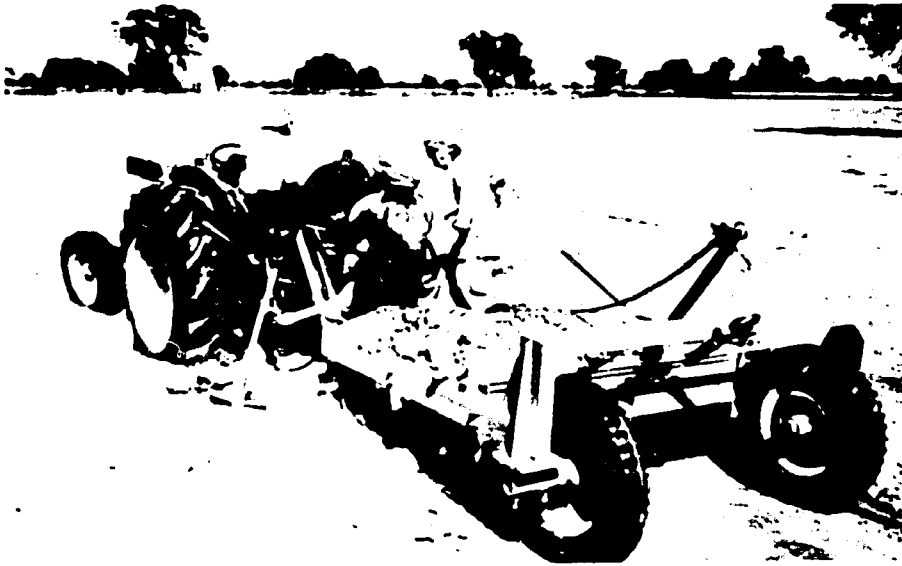
Topsoil is disturbed in the land leveling process. Effort can be made, however, to see that it is carefully replaced.

Leveling may affect plant growth the first cropping season, but the benefits of leveling should more than offset this problem even for the first crop. Also, proper irrigation timing, better inputs, and fertilizer can increase yields for that first crop.

Cost of land leveling depends on the method of leveling, the amount of leveling necessary, and the machinery available to do the leveling. However, with proper equipment, well-trained people, subsidy for small farmers and credit for financing the cost, the farmers will want their fields precision leveled...if the quality is good. Large farmers can and in many areas have paid for the entire costs because they know the benefits and have the resources to do it.

Associated with the cost factor is the problem of available equipment. Equipment needed varies depending upon the approach and commitment of the government and the abilities and needs of the farmers.

A similar problem is having trained technicians available to plan the leveling and operate the machinery, or teach the farmers how to use the machinery. A country may provide the service or it may be a private contractor who will be hired to institute a training program for technicians to learn the necessary skills. The key to the program is quality.



What Resources Are Needed?

PLANNING

A nationwide land leveling program requires careful planning.

Program planning should consist of the following:

Program definition--what are the needs and objectives of the program?

Program formulation steps include these:

- commitment of government
- effective organization
- well-trained personnel
- adequate budget and credit for farmers
- proper, adequate equipment

Program feasibility analysis--a careful study of the technical, financial, social, economic, environmental, political, legal organizational, and commercial aspects of the program should be conducted.

Organization

The next step is to determine what organization is best suited for execution of the program. Critical dimensions of the organization and its environment must be examined.

A checklist for what type of dimensions should be considered:

- Identify constraints of local conditions which may affect project design.
- Identify specific activities and functions.
- Delineate in detail all the components and elements in the project.
- Examine alternative organizational arrangements.
- Examine linkages needed with other organizations.
- Prepare initial operating plan and work schedule
- Prepare detailed job descriptions and terms of reference for personnel.
- Establish preliminary resource plan, technological requirements.
- Identify and include in organization design potential project managers.

In countries where precision land leveling is a new innovation, the pilot project approach is suggested. It is appropriate because of its adaptability to local situations and the testing of alternative methods of organization and working procedures. In pilot projects the program can begin with small steps and gradually build on procedures which prove successful.



A pilot project requires effective organization to be successful.

PERSONNEL TRAINING

Personnel selection, training and continuous evaluation are essential components of any program. A land leveling program can be no stronger than the quality of personnel. Training is needed for all levels of personnel, but the major focus needs to be directed toward field supervisors and technicians.

Training is necessary under field conditions for the acquisition of basic skills and behavior. Hands-on training instead of classroom training is recommended because each trainee must acquire basic skills and attitudes.

One or more of the following types of training are necessary.

On-The-Job Training

This is one of the most practical and frequent methods used when small numbers of personnel are to be trained, especially before a large program is undertaken. Training occurs on a one-to-one basis in the actual field environment. Before a program is launched, on-the-job training is strongly recommended. On-the-job training has the following benefits:

Benefits of On-Job Training

- It is a good method to build up an initial corps of trained personnel.
- No special facilities are needed except equipment and experienced trainees.
- Skills are easily transferred.
- Allows for trial and error and immediate feedback.
- Trainee is being paid while he learns and is contributing to the on-going work.
- Motivation of trainee is usually high since he is earning while learning and preparing for future employment.

On-the-job training is particularly appropriate for precision land leveling because it provides the learning skills one-to-one under actual farm conditions.

Even after more formal training programs are established, on-the-job training should be continued to allow personnel to practice skills learned in training courses.

Short Course

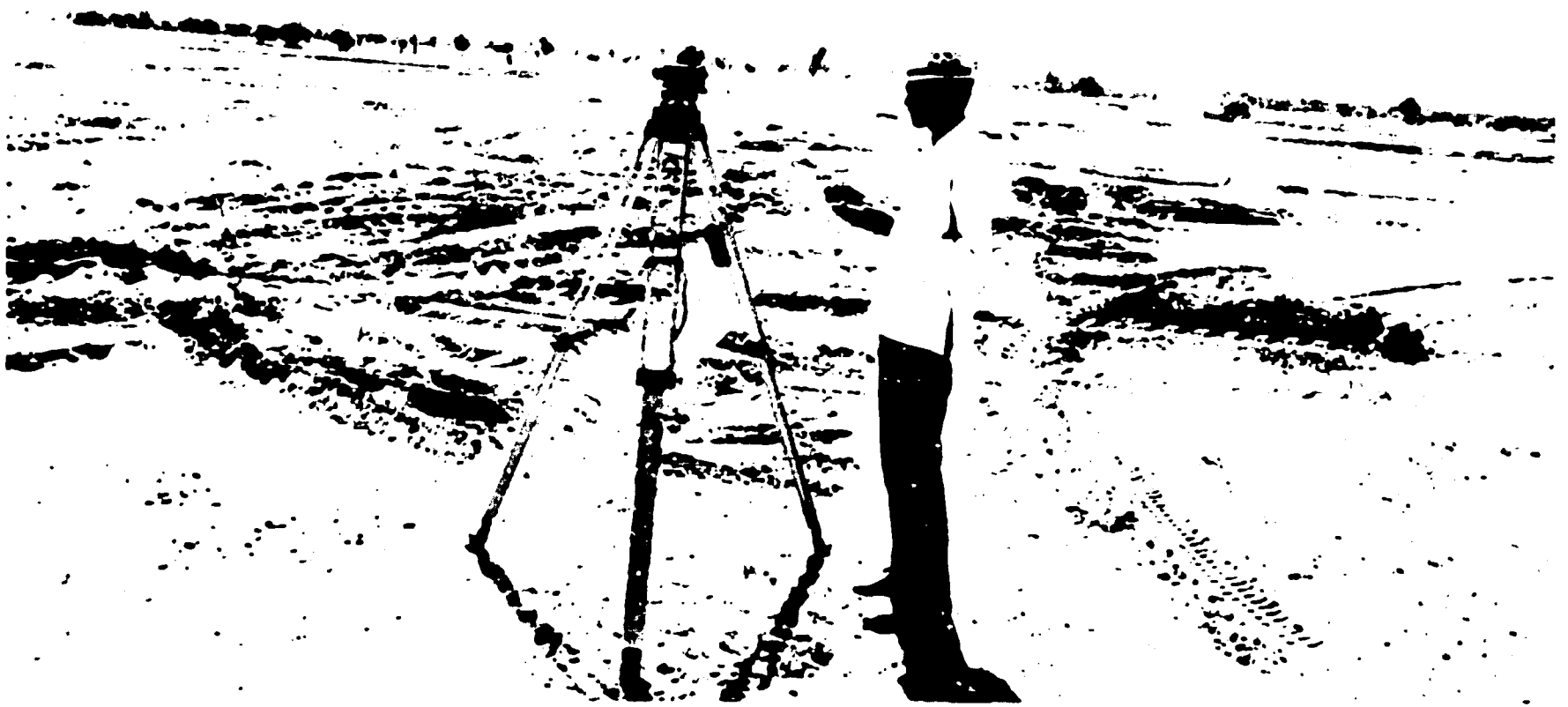
Land leveling training in short courses and institutes is quite important. Short courses can be conducted in the field, on research stations, at university or government farms, and many places without all the facilities usually required.

University Training

A long-term program of farm water management will necessitate university training be a part of the program. In far too many countries with vast irrigated acreage, there are few graduates prepared for these roles. Engineering and agronomic education need to emphasize practical field experience.

Farm Training

Farmer training can occur through a good extension program, in field days, or by systematic transfer of skills from project personnel to farmers and to other farmers by those farmers who have been trained. The most effective extension worker is the farmer who is convinced that a new practice or innovation is useful.



A short course in water management skills trains participants to survey a field to see how level it is.

EQUIPMENT

The type of equipment used depends on a number of factors such as local availability, nature of work to be done, size of farms, concern for developing local industry, foreign exchange position and policy, and skill levels of local mechanics. Each country must make decisions about equipment. In Pakistan, Turkey and other countries, local industries are playing a major role in fabricating land leveling equipment, but tractors are still being imported or assembled in the country.

A major consideration in the selection of equipment is field maintenance and repairs. Spare parts must be available, in good supply, and operators and mechanics must be able to understand instructions and know how to make repairs.

Suggested basic equipment and facilities for precision land leveling program includes:

Surveying Equipment

- Survey instruments with tripods,
- large poles, stakes
- Tape measures
- Drafting table and equipment
- Flags for marking cut and fill

Farm Water Management

- Flumes
- Infiltrimeters
- Tape Measures

Heavy Equipment

- Tractors with three-point hitch and hydraulic lift
- Soil scrapers
- Land planes, floats

Facilities for Maintenance, Repairs, Supplies

- Spare part supplies
- Central repair shop
- Mobile field workshop
- Field fuel tank
- Trucks for fuel, other supplies



An infiltrometer is used here to test infiltration rates in a farmer's field in India.

Traditional Equipment

Earth moving can be done with quite simple equipment if necessary. The equipment may be as simple as a board, or it may be a more complex metal scraper drawn by bullock or other animal that can carry soil from one location to another.

The final step of land smoothing for precision land leveling requires some kind of float or land plane, but they can be as simple as a wooden float that may be animal drawn.

Use of traditional equipment requires more time and labor to insure quality leveling and may be more costly in the long run.



Traditional leveling technique with a board for planing. This provides some leveling, but doesn't provide the precision often necessary to get many of the benefits of precision land leveling.



A metal scraper is pulled by the traditional power of bullocks.

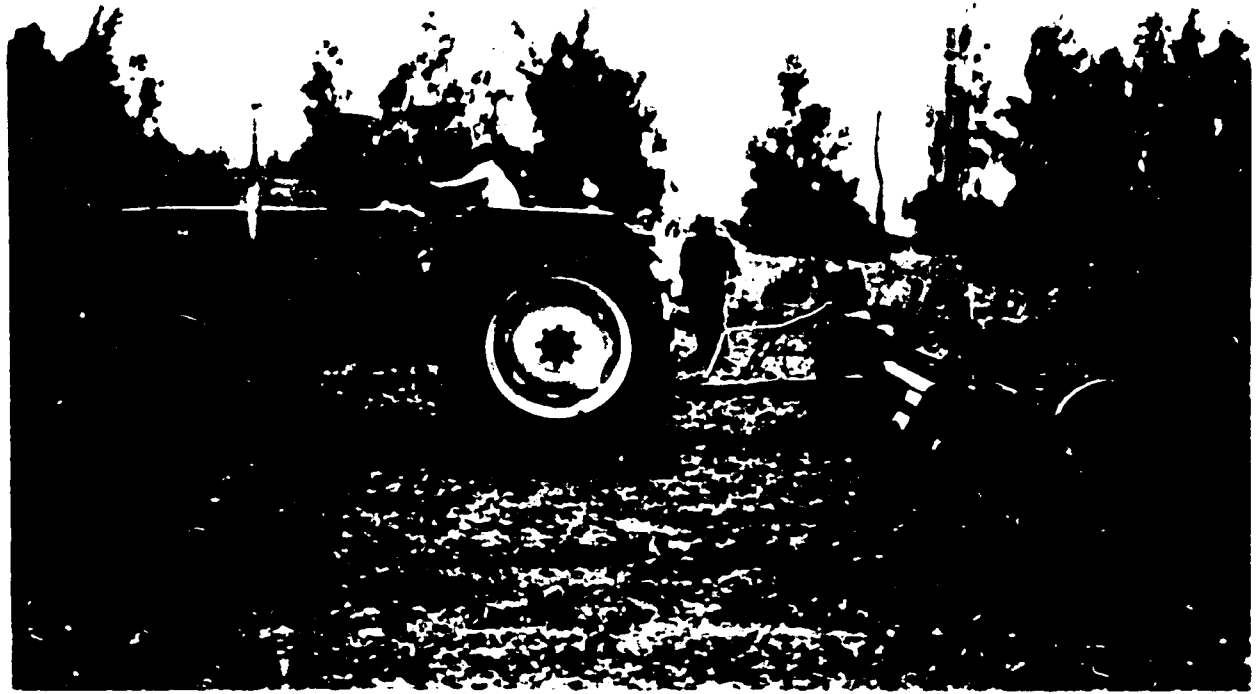
Laser Leveling

The most sophisticated equipment available for leveling is laser-controlled equipment. It is not practical in most situations that need relatively small fields leveled (under 40 acres). The Agency for International Development, however, is currently studying the feasibility of laser leveling on fields 1-2 acres or less.

The laser system works with a thin laser beam rotating from a command post providing a reference point for adjusting the depth of cut automatically for the scraper.

This system does not require manual surveying. It also increases accuracy of leveling and reduces the labor required. Leveling can be within 1.5 cm. The system is much faster than any other method and can produce many more leveled fields in a given period of time.

The major disadvantage is the high cost of equipment. However, the basic earth moving equipment is not different.



Laser leveling uses the most sophisticated machinery available to provide precision leveling as demonstrated in Kafre Sheikh, Egypt. (Photo by Laserplane Corp.)



Why Should You Evaluate the Program?

PROGRAM EVALUATION

Project evaluation should be planned for in the early days of program design. An essential aspect of that design should be monitoring, and periodic evaluation.

Monitoring should occur throughout the project. Monitoring of progress toward project goals is assessed and evaluated for quantity and quality of performance.

Good evaluation requires baseline data before a project begins as an indicator of change as the project progresses.

Data from control areas not involved in the experiment to compare with your project can be used to evaluate uncontrollable variables or changes.

The project may need changing if monitoring points out problem areas.

Evaluation is more than monitoring data as the project progresses.

Periodic indepth review and assessment, a midproject evaluation, and a final project evaluation should be planned.

Important to the evaluation process in land leveling is an actual field study. Primary focus of the evaluation should be implementation of project activities.

Evaluation of land leveling projects should include, but not be limited to, these areas:

- Available farm labor
- Use and availability of equipment
- Farmer acceptance
- Training and on-job performance
- Results of service to farmers
- Inputs-services such as credit, seed, fertilizers
- Organizational support
- Performance of extension personnel and activities.



Evaluating the performance of the traditional field irrigation system helps to establish the benefits of the system from land leveling.

Specific questions that may need to be asked include these:

1) Is the land leveling program adequately planned?

2) Is the program readily accepted by the farmers?

3) How can the program be made more effective?

4) Is there sufficient cooperation among affected department administrators?

5) Is the formal and on-the-job training adequate for the tasks to be done?

6) Should the objectives or components of the program be revised?

7) Is the program budget adequate?

Evaluation is often a weak line in the process of project development. A special unit may be needed for the evaluation. Of the several types of evaluation planned in the project design, the more significant are built-in self-evaluation, evaluation on a continual basis, internal periodic evaluation, external final project review.

In deciding on which type of evaluation to use, factors such as purpose, cost and time must be considered. The most useful type is that which is designed into the project and provides the following:

- Understanding of how initial objectives match up with actual outputs and inputs
- Clear statements of success criteria

- Involvement of clients of the project early to get their feedback

- Provision of data for decision makers

Since projects exist in an environment where all forces are not friendly, proper evaluation data constitutes part of the survival technique. Given good baseline data, measureable objectives and adequate records, the project is in a position to defend itself if needed. More importantly, the main benefit of evaluation is the information provided which helps the project to improve its operation.

Land Leveling Planning Guide

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