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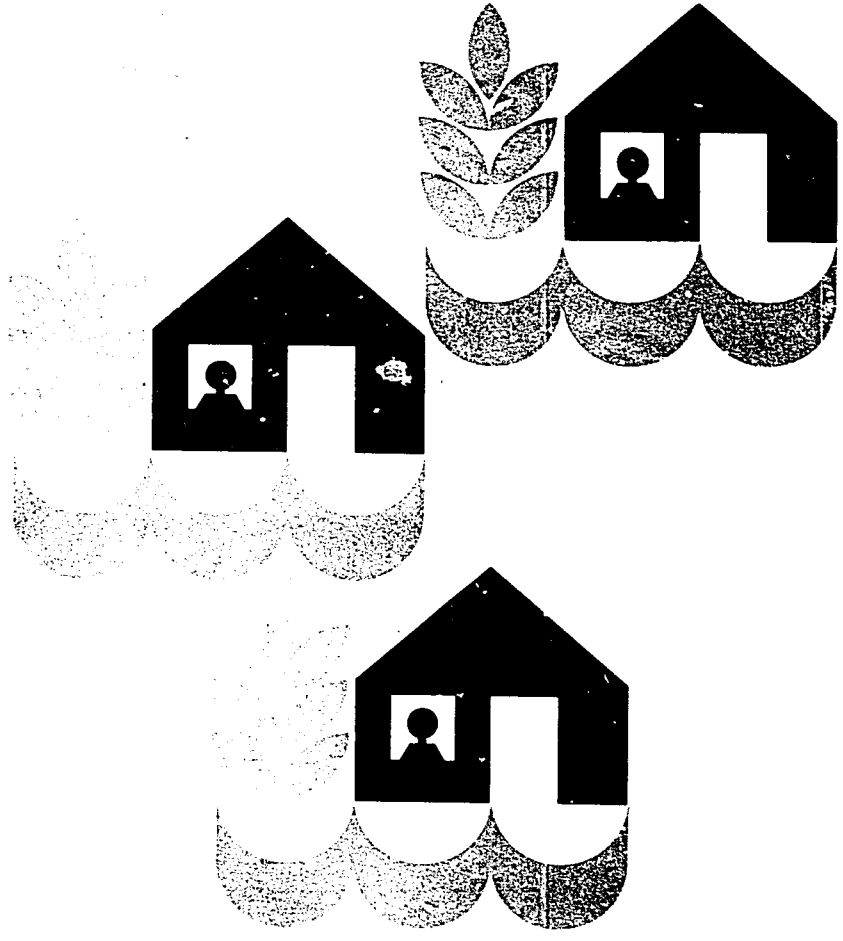
IRRIGATION PUMPING

Planning Guide No. 3, Water Management Synthesis Project



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IRRIGATION PUMPING

Planning Guide No. 3

Water Management

Synthesis Project

INTRODUCTION

Man has pumped water for centuries

- to irrigate his crops
- to supply his domestic needs.

An increasing need to produce more food has placed greater demands upon pumping more and more water from where it is--in rivers, lakes or underground--to where it is needed to grow crops and also to meet domestic needs.

The purpose of this planning guide is to:

- Outline the important factors which should be considered when pumping water.

- Serve as a guide when planning pumping projects.

The focus is on both project and individual pumping enterprises.

PUMPING WATER CAN MEAN:

- higher yields can be achieved

- more crops per year can be grown, resulting in a higher standard of living

- more land can be irrigated

- fluctuations in yield caused by drouth can be reduced

- bogs, marshes, and swamps can become productive and beneficial

- water supply for irrigation is more dependable

- health conditions can be improved.

This guide is intended for use by all who are concerned with the development of irrigated land for increasing food production, including:

- government officials
- social scientists
- leading farmers
- agriculturalists
- economists
- engineers

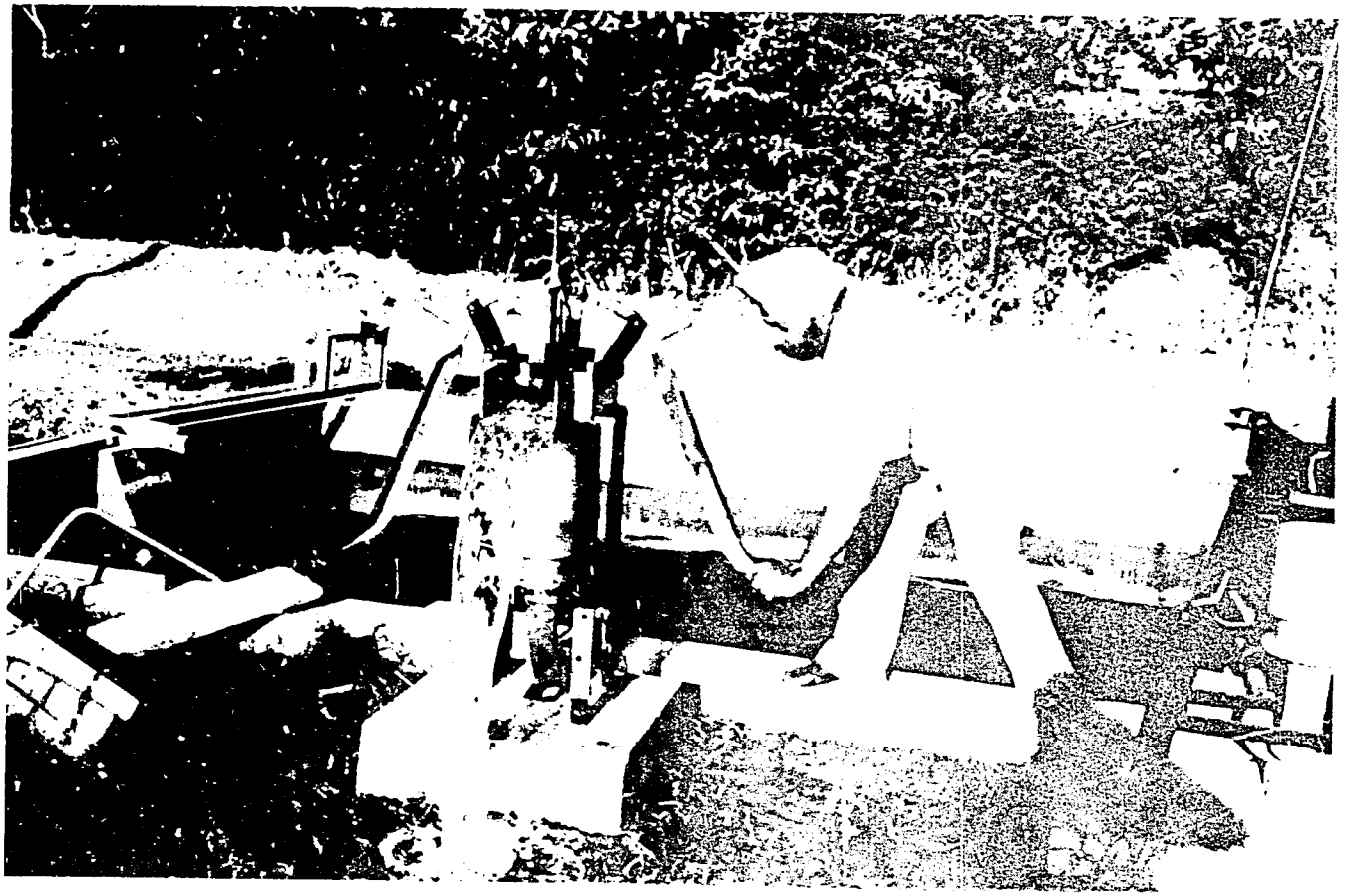
Man has lifted water for centuries to supply his needs.

THE NEED TO PUMP WATER

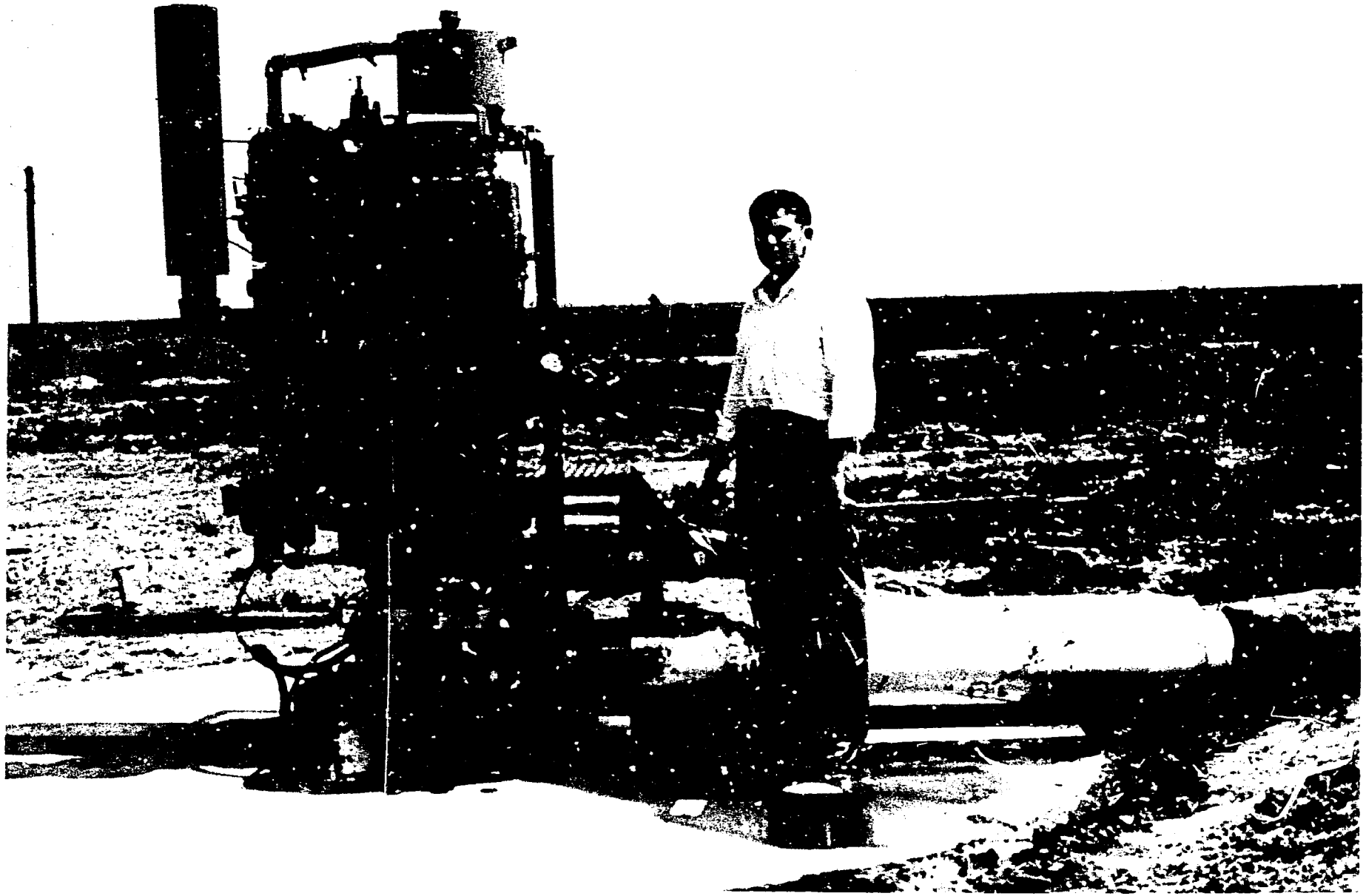
The need for increased food production is great. Projected population increases in Asia indicate that by the year 2000, about 100 million new hectares of irrigated land should be developed to avoid serious food shortages.

India has 27 million hectares irrigated by low lift pumping. Bangladesh is proposing to irrigate 9 million new hectares by pumping. In Africa, pumped irrigation provides the best hope for increasing food supplies. Also, competition for water between agriculture, industry and other uses will place more emphasis upon localized pumping in the future.

In many areas of the world, pumping water may be the only solution to irrigating lands needed for agricultural production.



One person can only pump enough water to irrigate at most one-half hectare when the lift is not more than 2 meters.



One liter of diesel fuel can pump about as much water as one man working for 5 days or an ox working 1 day.

POWER SELECTION

Man and Animal Powered Pumps

Where irrigation is primarily associated with subsistence agriculture and where there is no alternative demand for labor, man and animal powered pumps can be considered for providing irrigation water supplies.

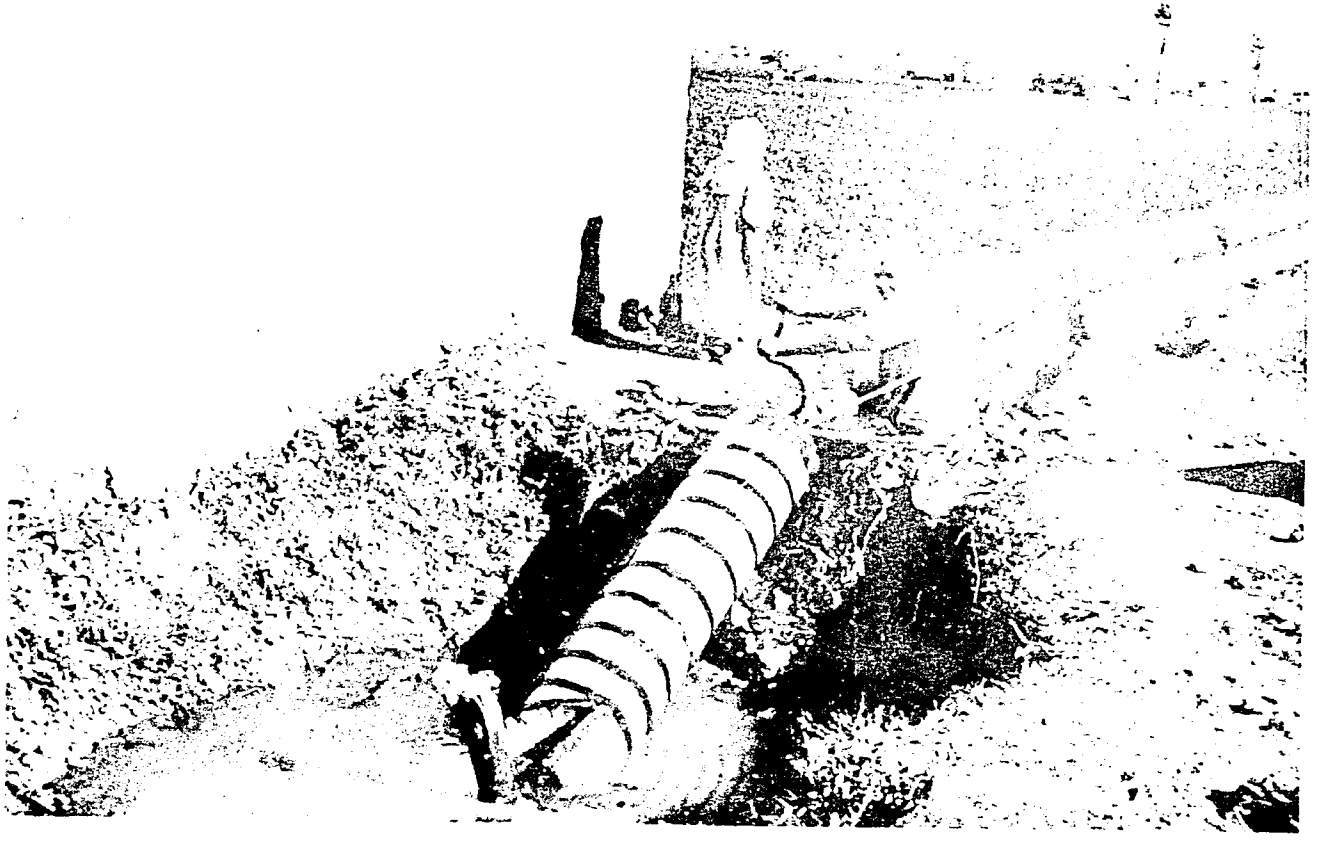
Mechanical Powered Pumps

The combined efforts of man and animals will not be able to supply future water needs. The extremely large amounts of water needed for food production will require the use of mechanical powered pumps. For example:

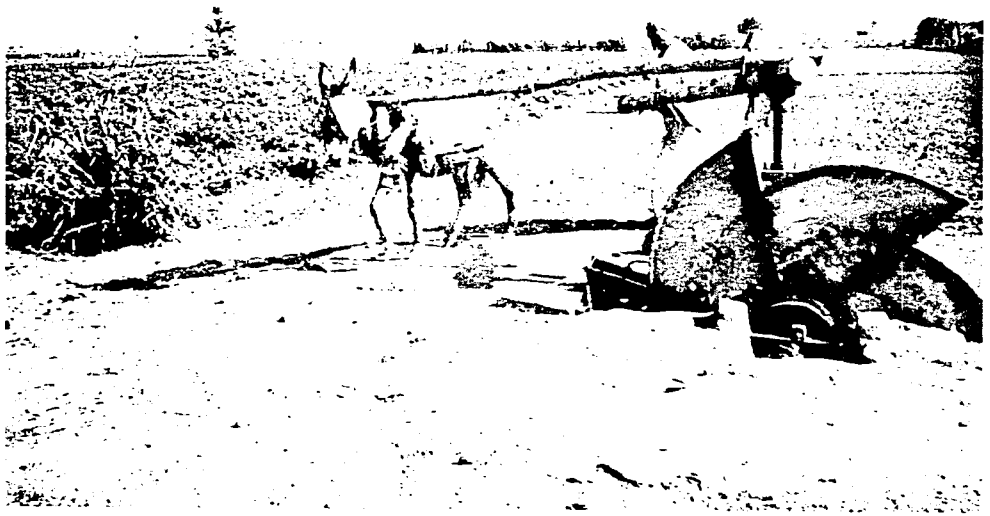
A one-horse mechanical pump

- operates continually
- pumps 20-30 times more water than man EVERY DAY.

Other power sources, such as wind and sun, may some day be an important source of energy for man. At the present time, their use can only be considered as a supplemental source. Some areas of the world are beginning to use nuclear energy to generate electricity and this may become a vital power source for pumping water.



Water lifting by manual power is limited to small flows (low discharge) and low lifts (low heads).



An animal-powered waterwheel. This pumping system can pump about 5 times as much water as can be pumped by one man.

Deep tubewells powered by electric motors supply much of the water pumped today throughout the world.

POWER SOURCES

The most common and readily available energy sources for mechanically driven pumps are:

Gasoline engine driven pumps are suitable where power requirements are below 25 horsepower. These pumps are portable and can be used in remote areas.

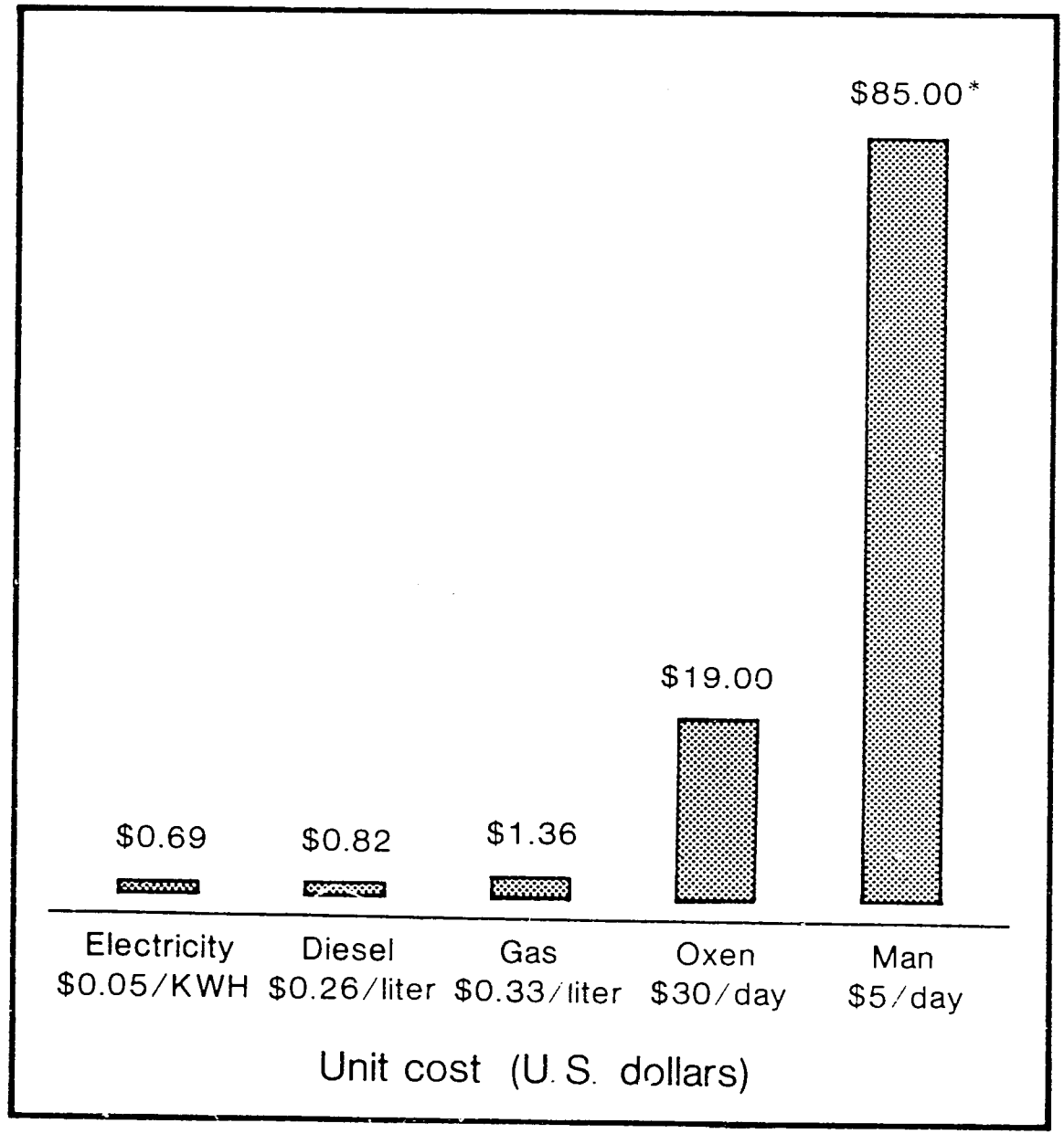
Diesel engine driven pumps are usually more economical than gasoline. Larger units can be used and have a long, useful life.

Electric motor driven pumps are often the most economical when available. They have low cost and long life with low maintenance costs.

Propane and natural gas, when available, are often quite inexpensive as sources of power.

The size of the power unit depends upon the amount of water to be pumped, the total height to which water must be lifted, and the friction losses in the conveyance pipes.

Man and animal power are the only energy sources used to pump water in some areas of the world. However, the amount of water pumped is small and the cost is large compared to that pumped with motors and engines.



Comparative costs (U.S. dollars) to pump 1,000 cubic meters of water to a height of 2 meters in 8 hours (1.52 BHP at 60% efficiency).

**This figure represents 16 man-days, although it may not be a cash outlay for an individual farmer as he might provide the man power from his own family. However, his worth in more productive labor ought to be considered.*

PUMP SELECTION

A wide variety of mechanical pumps are available to meet almost any kind of pumping requirement.

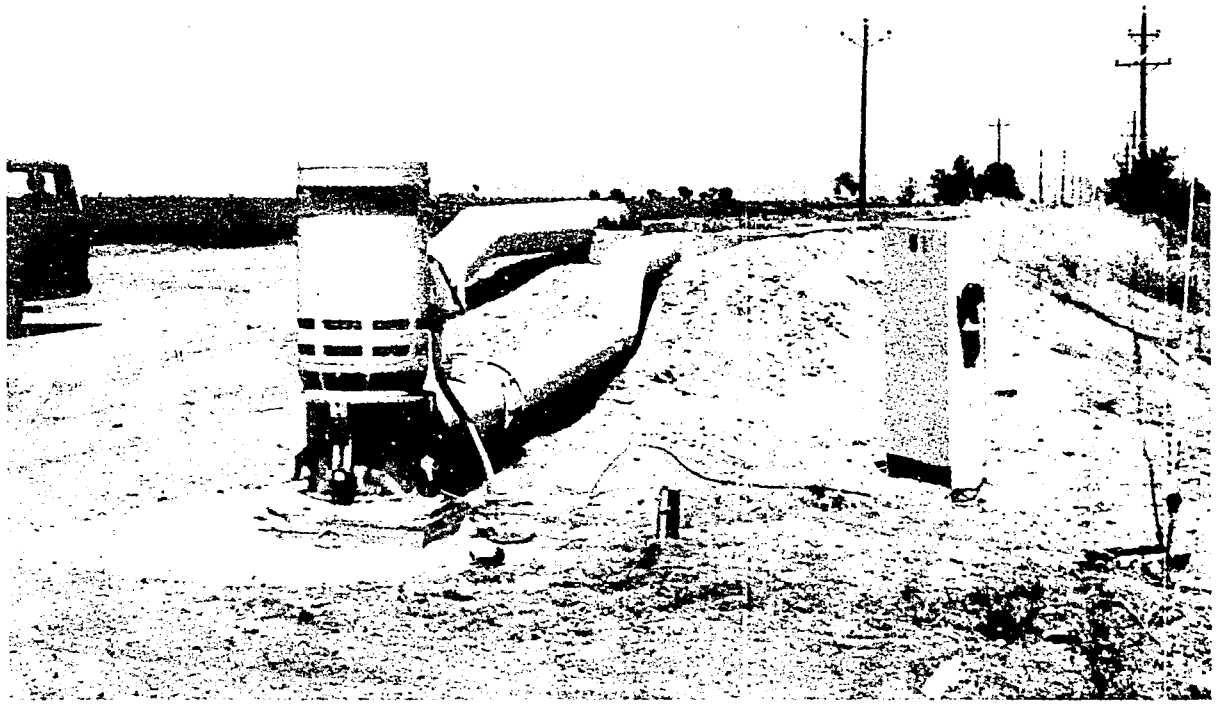
They can be classified into three general groups:

Centrifugal Used to pump from canals, rivers, lakes, sumps, and shallow wells for total lifts from 3 to 150 meters. The pump is usually located close above the water surface.

Propeller For lifting water from a few centimeters up to 6 meters. Appropriate for low lifts in both irrigation and drainage and when large volumes are to be lifted.

Turbine For pumping water from wells.

Many different kinds of pumps are available within these three groups.



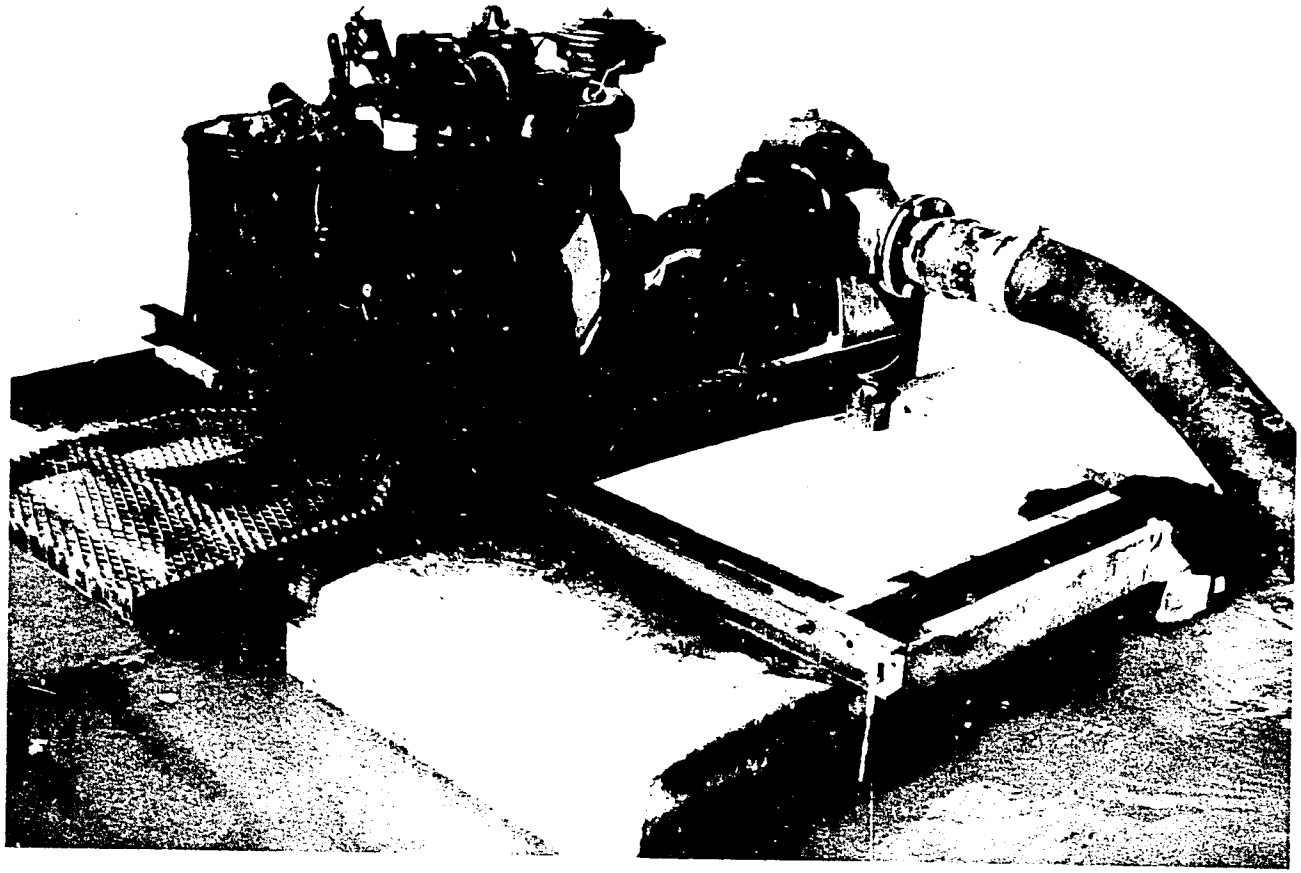
A deep tubewell delivering water to an irrigation canal.

PUMPING PLANT DESIGN

The design of a pumping plant for a given situation should be based upon:

1. The amount of water to be pumped.
2. The lift and changes in lift expected because of surface water level changes or water table changes during the year and from year to year.
3. The required pump discharge.
4. The total lift and discharge pressure.
5. The energy source available and respective prices.
6. The level and availability of mechanical maintenance and operational services.

After these six conditions have been determined, select the type of pump - centrifugal, propeller or turbine - and the power source which best meets the needs.



A pumping plant designed to meet fluctuating water levels. The pump and motor are mounted on a float and as the water in the pond or river raises or lowers so does the pump, eliminating the possibility of suction loss and damage to the pump.

Proper design of the pumping plant is essential to maximum efficiency and energy savings. Here water is being pumped an extra meter or more in height, wasting energy.

SELECT THE RIGHT PUMP TO DO THE JOB!

For Example:

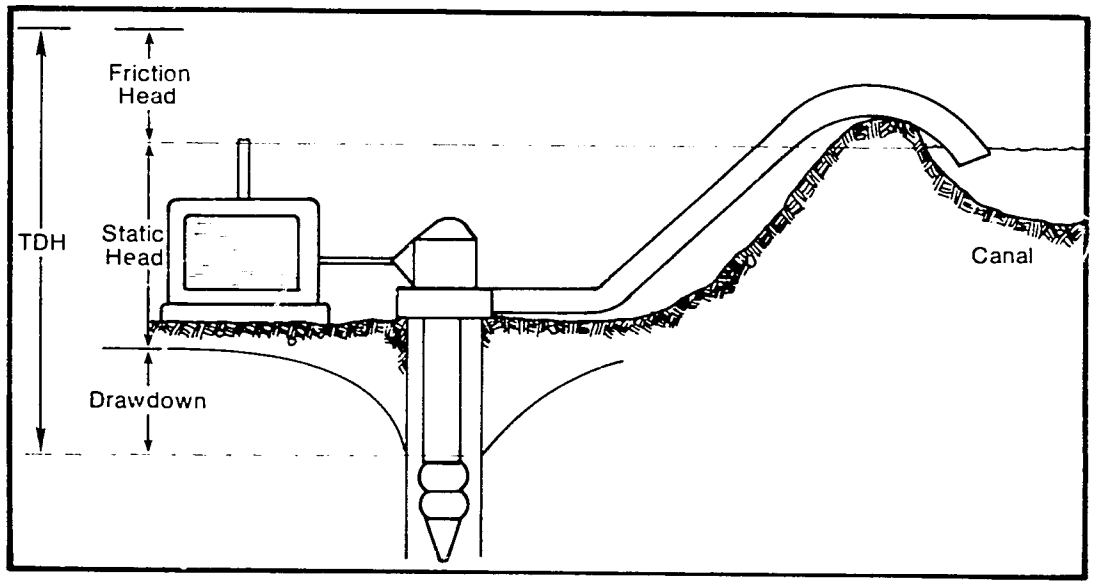
A propeller pump will lift a large volume of water a few meters high at less cost than a centrifugal pump. To lift 5.7 liters/sec to a height of 2.5 meters, the horsepower and cost comparisons would be:

Pump type	Horsepower required	Cost/month U.S. dollars
Propeller	2.5	$65.00
Centrifugal	8.0	$214.00

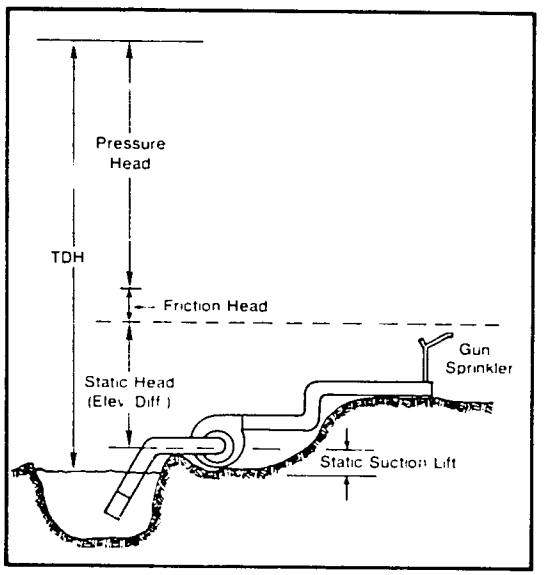
[For low lift pumping of larger quantities of water the cost differential is even greater.]

In many areas of the world, low lift (propeller type) pumps are the most economical, can be indigenously manufactured, and are best for lifting water up to a few meters in height.

After selecting the type of pump, refer to the manufacturer's pump characteristic curves and select the pump which most efficiently meets the design needs.

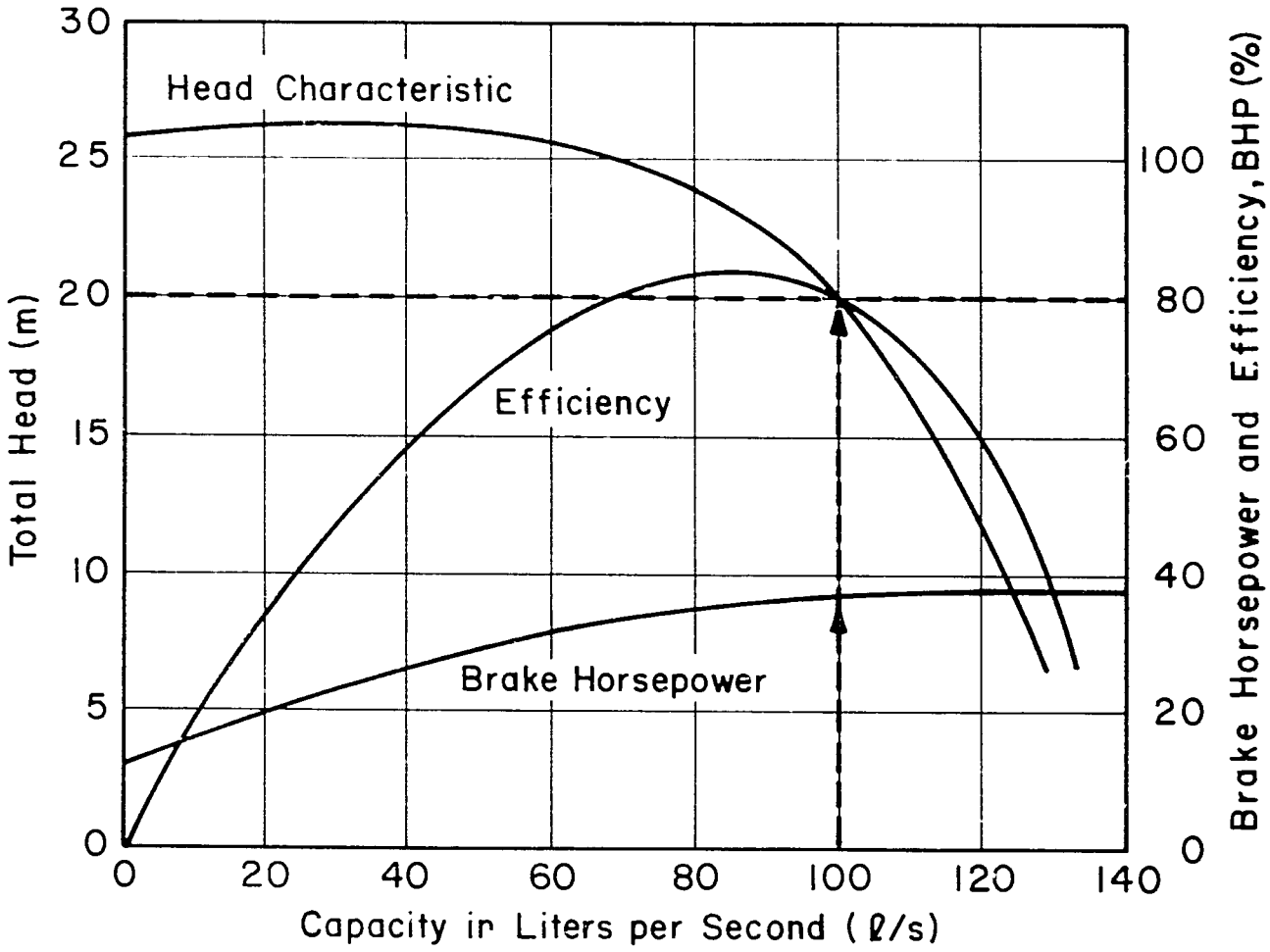


A deep well turbine pump, pumping into a ditch, showing the components of Total Dynamic Head.(TDH)



A centrifugal pump, pumping water from a canal through a sprinkler. Also showing the components of Total Dynamic Head.(TDH)

Every pump has its own pump characteristic curve which shows total head, i.e., height to which water can be pumped (or the pressure it will develop), the discharge (or flow), efficiency, and power requirements.



A typical pump characteristic curve for a centrifugal pump, showing the relationships between capacity or discharge, TDH, efficiency and brake horsepower requirements.

If the design requirements are to lift 100 l/sec to a height of 15 meters and if friction and other losses equal 5 meters for a total dynamic head (TDH) of 20 meters, then the pump which this curve was designed for will meet these requirements and do so at an efficiency of 80% with a engine or motor that can develop 37 bhp.

If the design requirements are to lift 40 l/sec to a TDH of 27 meters, it would require 25 bhp, but the efficiency would be only 60%. To meet these requirements, it would probably be best to find a pump from a different curve.

The reason is the pumping energy costs would be almost three times greater per unit volume of water in the second example.

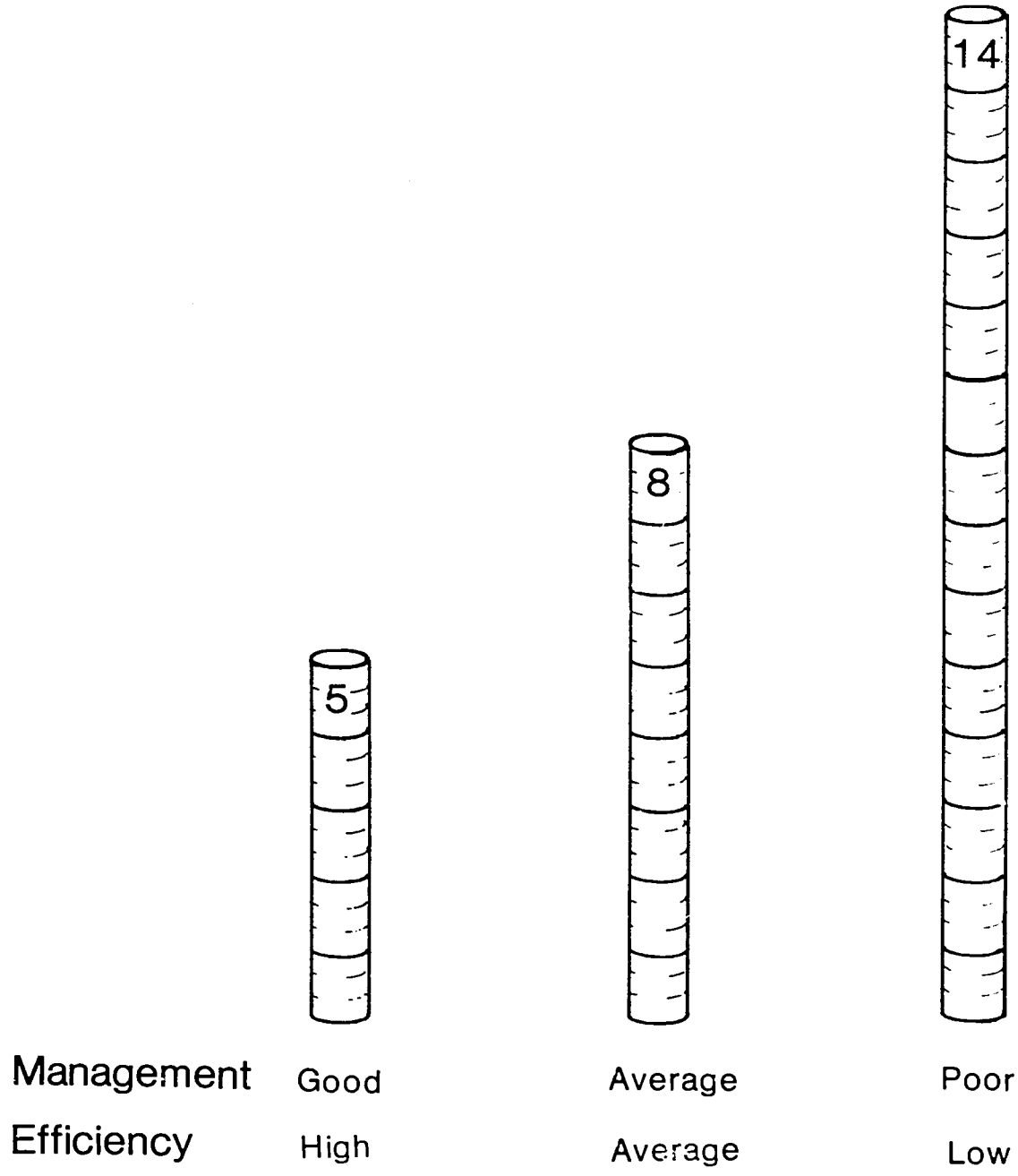
For energy conservation and economics, pumps should be selected and designed to operate near their peak efficiency for the given TDH and desired discharge.

MANAGEMENT AND MAINTENANCE

The success of a pump irrigation project to produce food depends to a great extent upon the quality of management. This is true on a small farm or on a large project. This is also true on a sophisticated, automated system, as well as a simple furrow irrigation system.

Proper design, proper selection of pump and motor, and good management means higher pumping efficiency, lower energy costs, and better crop production.

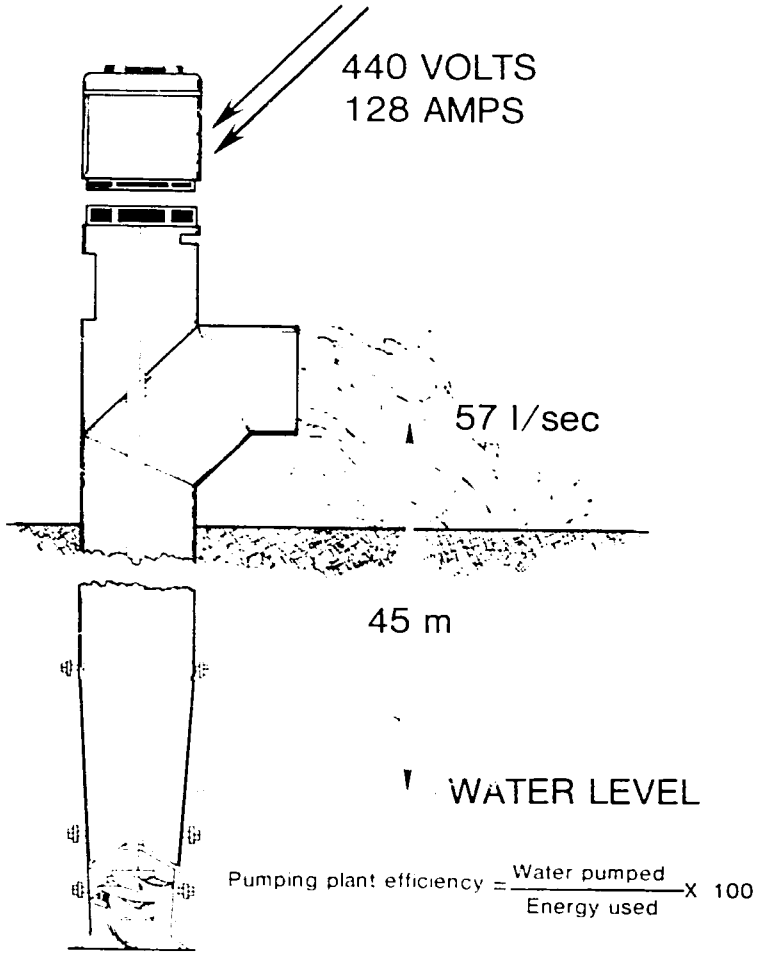
Repairs made on time can mean the difference between success or failure of a crop.



Number of barrels of diesel fuel required to irrigate 10 hectares with good and poor management and efficiency. Pumping lift is 5 meters.

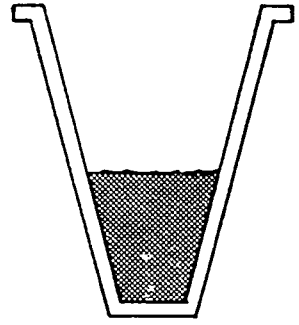
Efficient Operation of a Pumping Plant

Pumping efficiency is the ratio of water pumped to the energy (fuel or electricity) used.



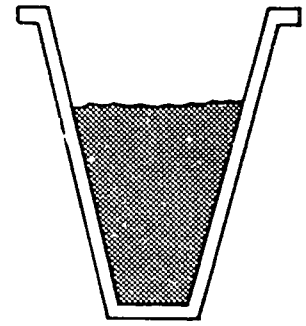
$$\text{Pumping plant efficiency} = \frac{\text{Water pumped}}{\text{Energy used}} \times 100$$

A pump and motor operating in the field at a 65% efficiency is considered good. There are always unavoidable energy losses. If a pumping plant efficiency is below 50%, the unit should be repaired or replaced.



4 L/Sec

A pump and motor operating at 30% efficiency will only pump this much water.



8.7 L/Sec

A pump and motor operating at 65% efficiency will pump more than twice as much water.

BOTH PUMPS WILL USE THE SAME AMOUNT OF FUEL OR ENERGY.

The difference is 400 cubic meters per day that is available for use in growing crops--enough to irrigate an extra 8-10 hectares.

Repairs made on time can result in higher efficiency and considerable energy savings.

LEGAL AND ADMINISTRATIVE ASPECTS OF IRRIGATION

Individuals interested in irrigation should become intimately acquainted with the legal and administrative structures used in their own areas, and then do their utmost to improve the existing patterns. The most successful enterprises have been those owned and operated by the water users. Irrigation cooperatives operating in many parts of the world are successful.

Other Factors To Consider for a Successful Pumping Project are:

SOIL
CROP WATER REQUIREMENTS
WATER SUPPLY
AGRONOMIC FACTORS
ECONOMICS
EDUCATION AND TRAINING

Irrigation and government officials discuss administrative matters concerning water delivery. Discussion among administrative officials and farmers who use the water is essential for successful operation of an irrigation enterprise.

SOIL

A knowledge of soils is necessary for a successful agricultural project.

- They must be well drained.
- Infiltration rates must be determined.
- If saline and/or alkaline conditions exist, they must be corrected.
- The water holding capacity must be known.

The amount of water available for crop growth is:

Soil type	Centimeters water/ meter depth of soil
Light-textured sand	8 to 10 cm
Medium-textured loam	10 to 17 cm
Heavy-textured clays	17 to 23 cm

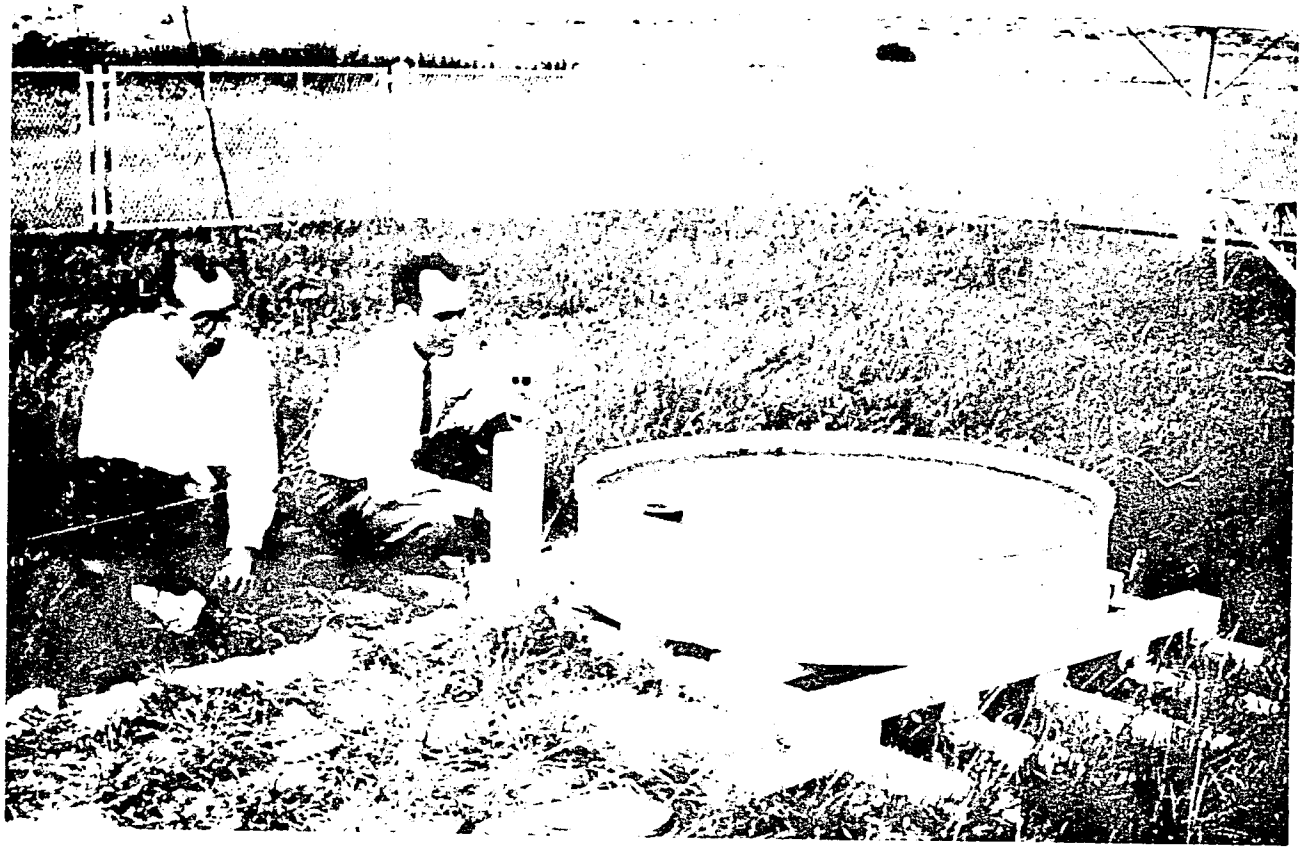
Understanding the soil, its water holding capacity, and infiltration rate is essential to successful agriculture.

CROP WATER REQUIREMENTS

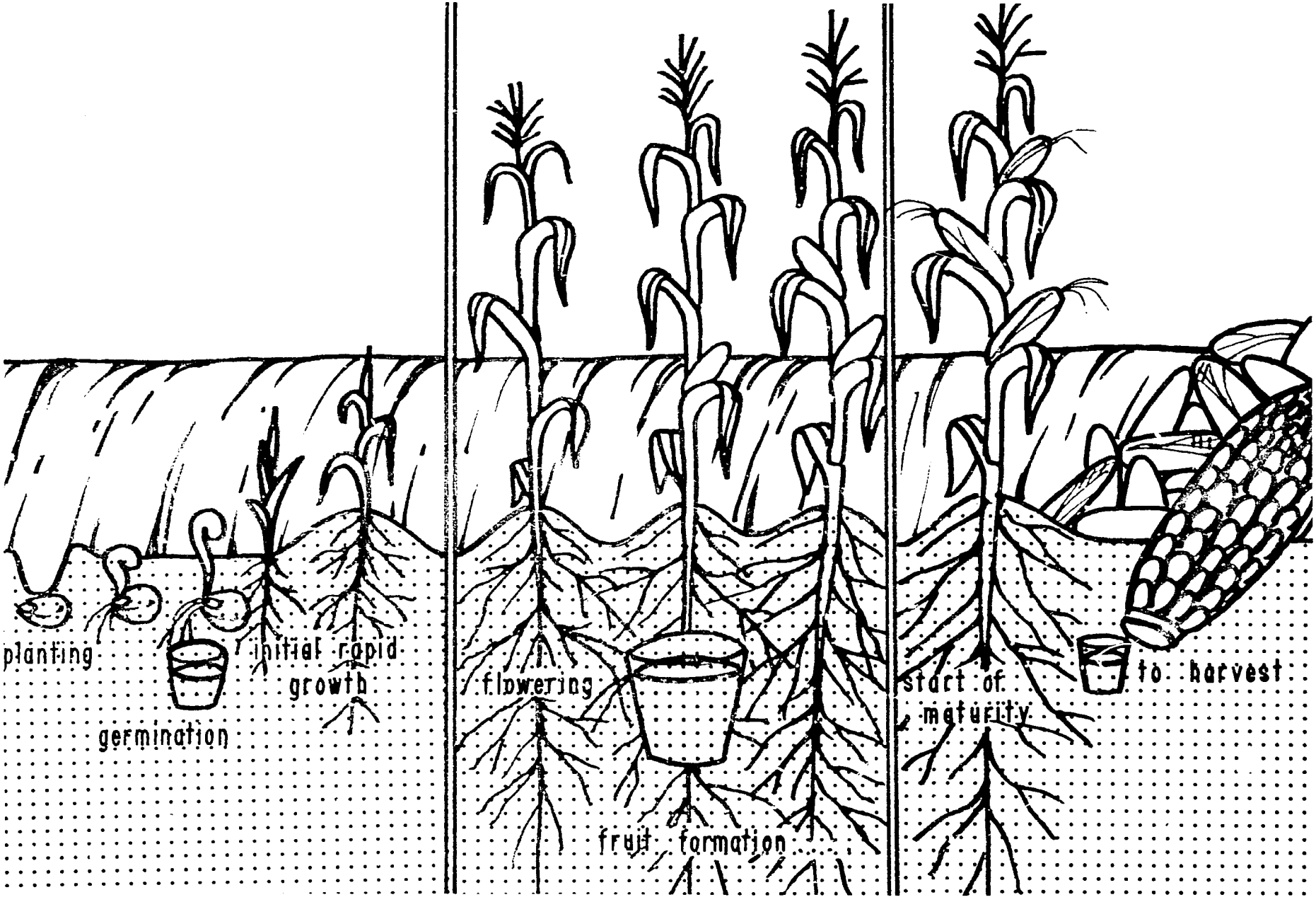
For an agricultural project to be successful, the water supply must be adequate and the pumping system should be able to supply the maximum crop water needs or decreased crop production will result. Management and operation must be flexible to respond to the changing crop water needs as plants begin their growth and approach the harvest stage.

Several methods are available for determining crop water needs from climatic data. One method is correlated with evaporation from a Class A pan located in a fairly large irrigated area. Crop water use averages about 80% of the amount of water evaporated from the pan. Maximum use at mid-season is about 90% to 95% of the pan evaporation rate.

Crop water needs during all seasons of the year must be determined for comparison with available water supply. If actual local data are not available, an estimate can be used for pre-planning purposes. For example, a pump should continuously supply about 1 liter per second for each hectare irrigated.



A U.S. Weather Bureau Class A evaporation pan located in an irrigated area within a fenced plot which also contains a weather station. Recommended weather measurements include maximum and minimum temperatures, solar radiation, sunshine hours and relative humidity for more precise estimation of crop water needs.



Crop water needs are greatest at the flowering or reproductive stage and decrease before and after. A successful pumping project must be designed accordingly.

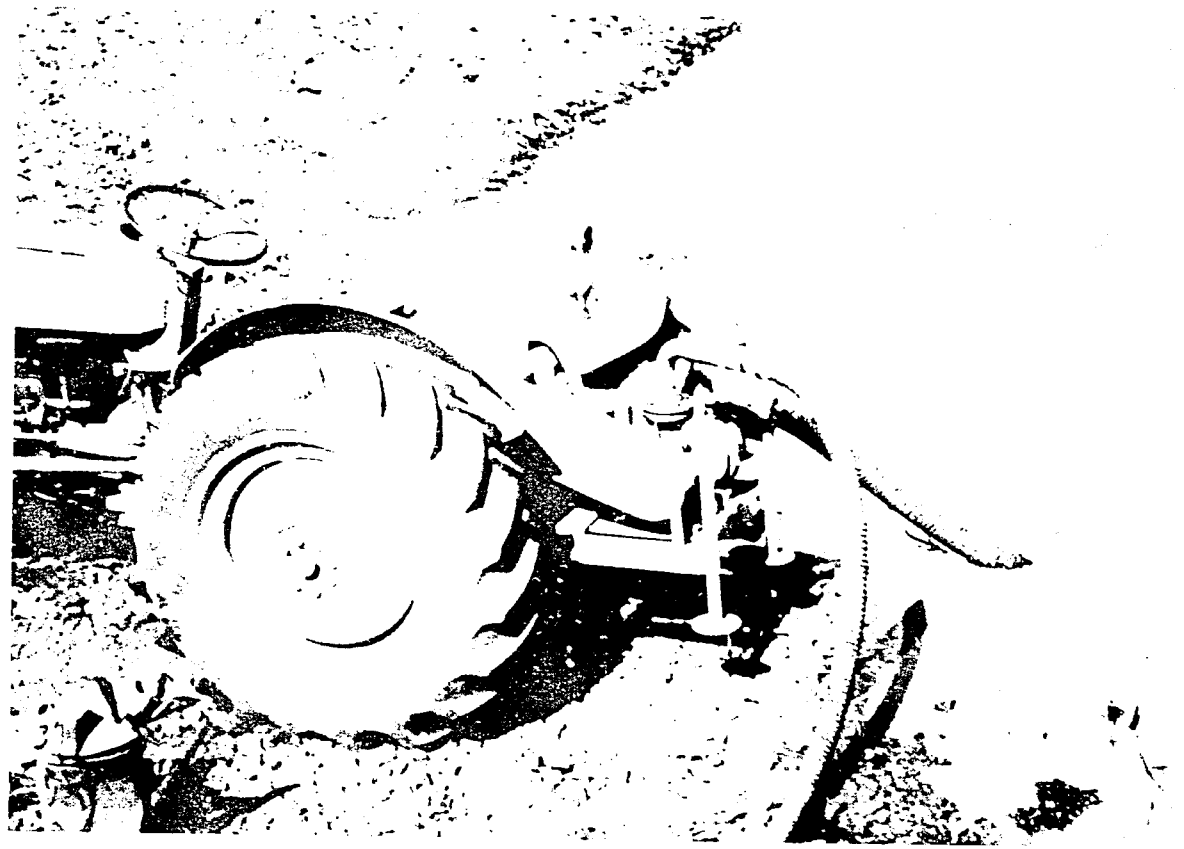
WATER SUPPLY

Water can be pumped from wells, rivers, lakes, ponds, reservoirs and swamp areas. A careful evaluation of the adequacy of both water quality and quantity is essential for sound pump irrigation planning.

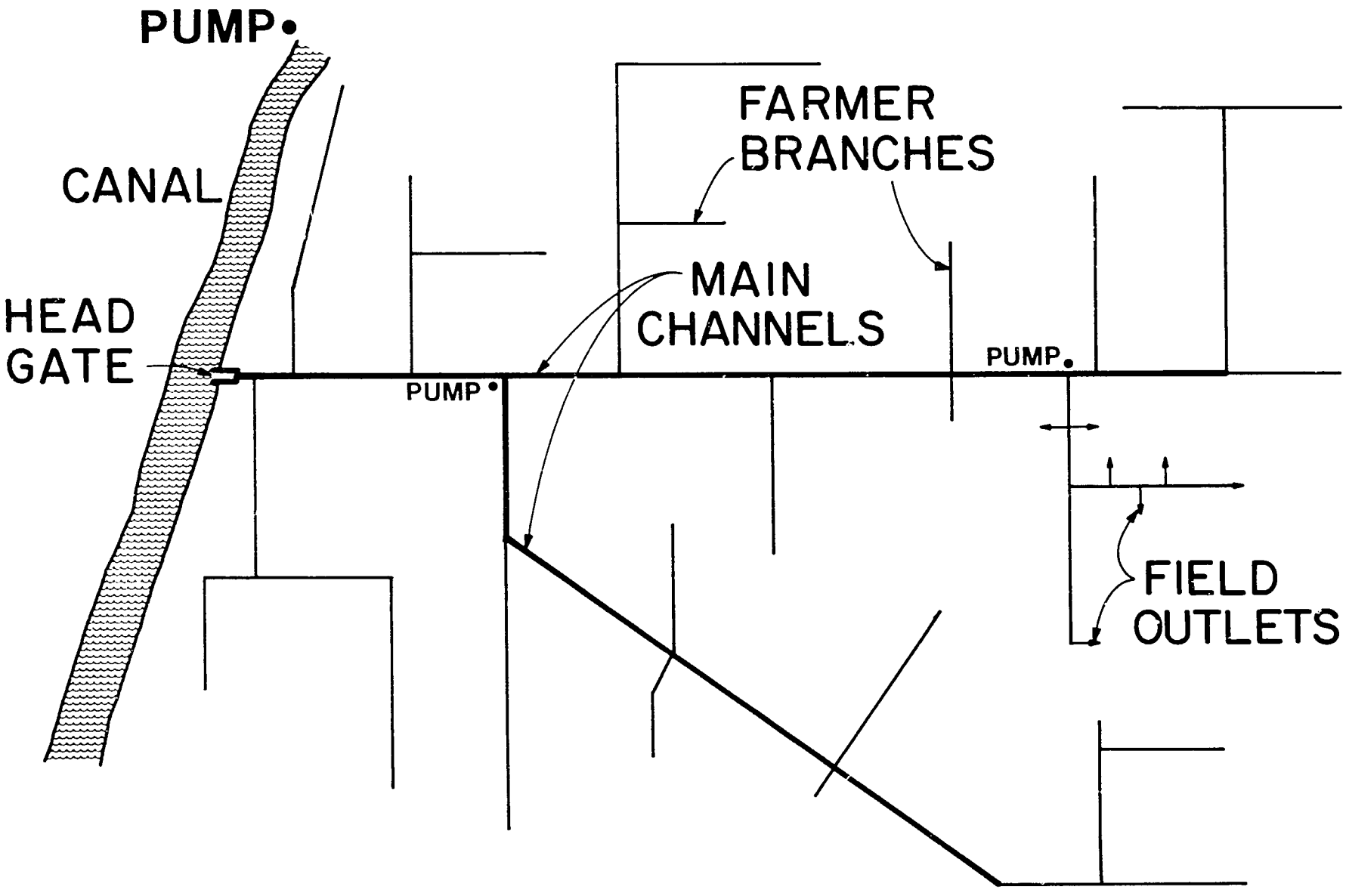
Overpumping of the water supply will result in depletion, water shortages, and crop failure. Overpumping from a well results in a lowering of the water table, increased pumping costs and even physical failure of the well. The amount of water pumped from underground aquifers should not exceed the average annual amount supplied to the aquifer by precipitation and other sources.

There is often significant lag time between low rainfall and its effect on streamflow and groundwater supplies. The effects of a series of drier or wetter than normal years is cumulative. A water supply that is adequate during a period of favorable rainfall may be most inadequate during a dry cycle. In many areas, streams dry up within a month or 6 weeks after the rainy season ends.

A careful analysis of the water supply is essential to prevent serious crop losses in dry periods.



In emergencies, a tractor-mounted pump that uses the tractor engine for power can be used between cultivation and harvest activities.



Pumps may be required at several places in the irrigation system.

OTHER AGRONOMIC FACTORS

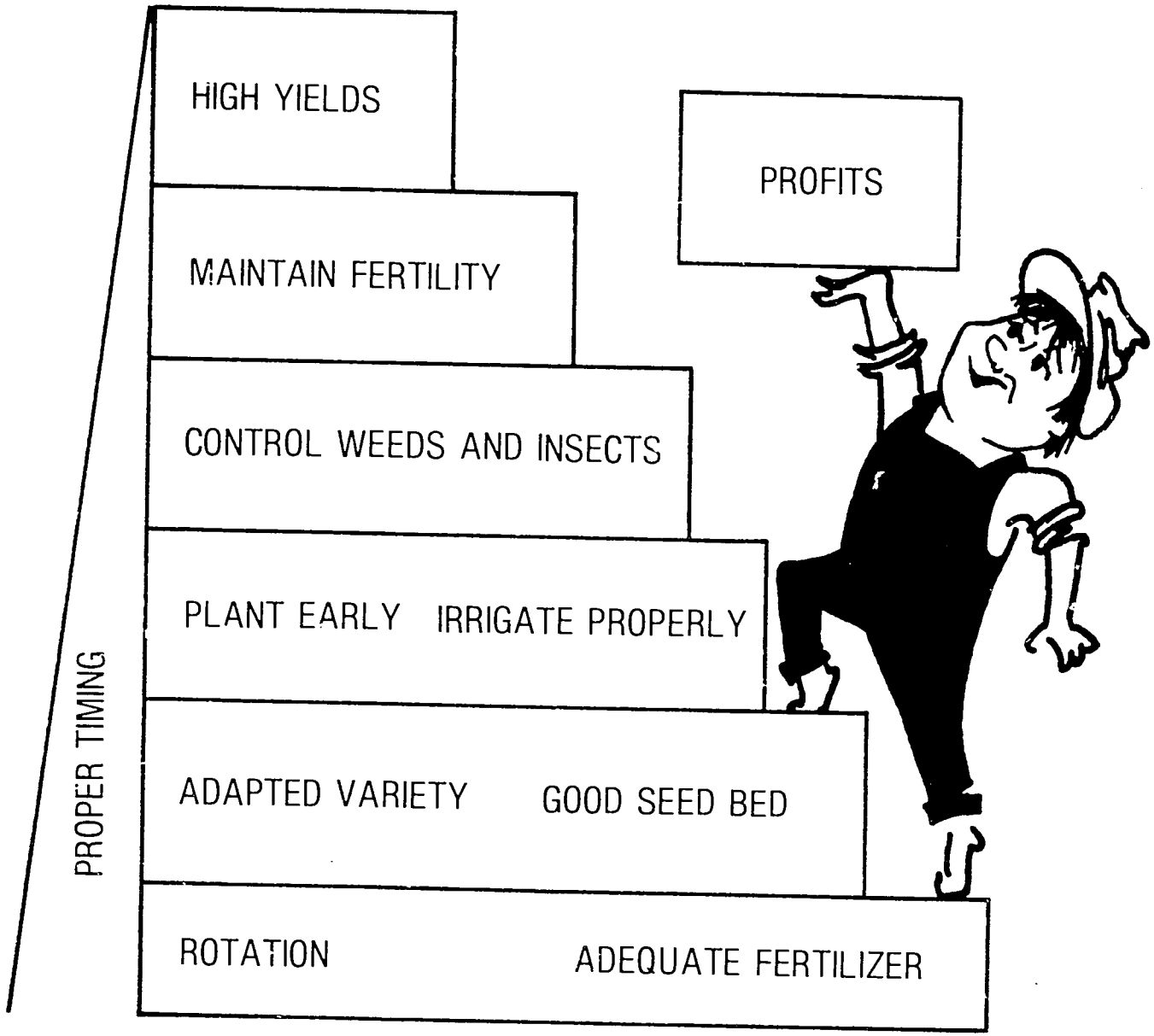
Pumping the right amount of water is important from a standpoint of economics and crop production. However, other agronomic and crop production practices must also be given proper consideration. For example, applying more water to a crop when the fertility level is low will probably not increase the yield. Applying excess fertilizers when the water supply is low may even decrease yields. Only when water and fertility are both available to fully meet crop requirements can optimum yields be obtained.

To justify the higher production costs usually associated with pump irrigation programs, careful attention should be paid to all necessary agricultural inputs to obtain optimum or economic yields.

ECONOMICS

Any business venture should stand on its own merits. A subsidized economy is often not strong and progressive.

A pumping project should be profitable.



MAXIMUM BENEFITS ARE DERIVED WHEN ALL FACTORS ARE PROPERLY MANAGED.

EDUCATION AND TRAINING

Irrigation is a powerful tool for preventing crop failures, thereby permitting advances to a higher level of agricultural technology. Good management is the key to success.

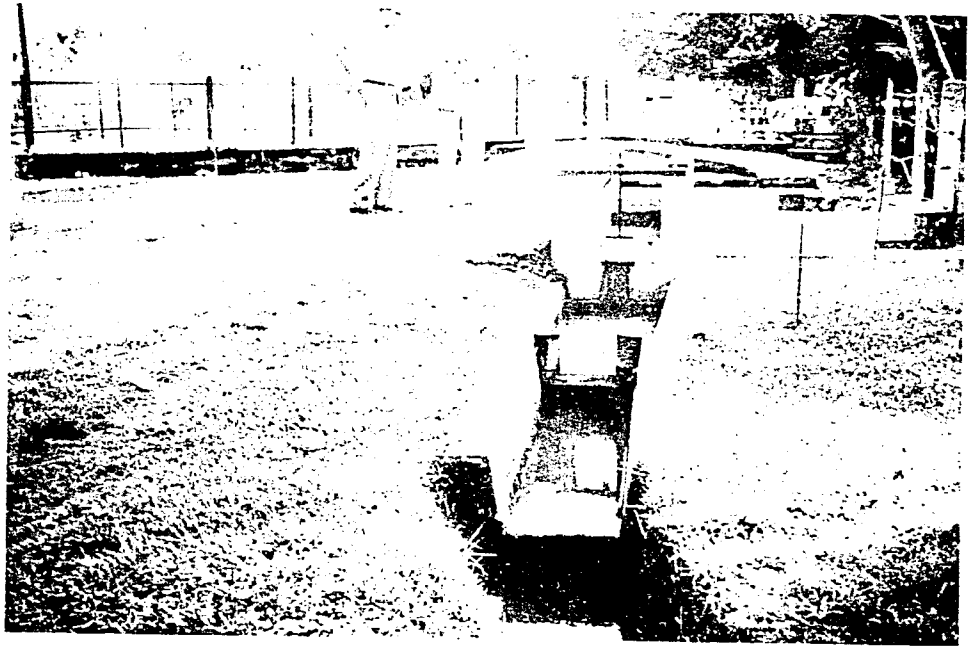
To save or economize on energy and water requires skill on the part of both the farmers and managers of pump irrigation projects. To achieve the level of management proficiency necessary, it is essential to have adequate in-service training programs. The training should be continuous through some type of extension program and should include all aspects from pumping the water to applying it to the soil and growing the crops.

Successful pump irrigation is easier to accomplish where well-trained extension personnel provide assistance with water management and cropping practices.

Successful pump irrigation requires careful investigation of the soil and water resources and participation of the beneficiaries in the planning and management of the project.

Good irrigation management involves the farmers who use the water in each phase of the project.

Participants of a training course learning water infiltration properties of a soil to be irrigated.



Efficient water management requires water measurement.

SUMMARY AND CONCLUSIONS

The success or failure of pump irrigation programs depends upon the adequacy of natural resources (soil and water), the availability and dependability of fuel, the proper system design, the market or demand for the crops to be grown, and the various levels of management and technical assistance provided. Pump irrigation facilities provided on credit to individuals and small cooperatives have achieved a good level of success where adequate fuel was available, the systems were well designed, and mechanics and ample agricultural technical assistance was provided.

Each situation needs to be evaluated and all essential elements provided. If any important consideration is deficient, then steps need to be taken to provide that element prior to proceeding with development.

To achieve an increase in food production consistent with population growth, a major emphasis is required on increasing the irrigated areas. Irrigation alone will not be either profitable enough or productive enough without major advances in the use of fertilizers and other agricultural inputs. Since the more feasible gravity projects already have been constructed in many areas, emphasis on pump irrigation is now required.

The real measure of the success or failure of irrigation is not in the amount of water pumped and at what cost, but in the amount of food production per unit of energy compared with the cost to the country or area of providing that amount of energy.

Irrigation Pumping Planning Guide

This planning guide was prepared by staff of the Water Management Synthesis Project of the Consortium for International Development, with Colorado State University and Utah State University serving as lead universities. It is also available in Spanish and French.

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All reported opinions, conclusions and recommendations are those of the authors (contractors) and not those of the funding agency or the United States government.

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