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A working paper

on

IMPROVEMENT OF THE LAND AND WATER
RESOURCES OF THE SEMI-ARID REGIONS
OF NORTH-EAST BRASIL - A PROPOSAL
FOR RESEARCH *

by

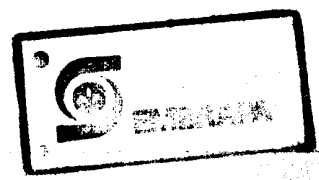
PREM N. SHARMA
IRRIGATION SPECIALIST
CPATSA/EMBRAPA/IICA

computador RNOE1

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IMPROVEMENT OF THE LAND & WATER RESOURCES OF THE SEMI-ARID REGION OF NORTH-EAST BRASIL - A PROPOSAL FOR RESEARCH.

1. INTRODUCTION:

The semi-arid tropics of the world are fragile ecosystems which are being substantially modified by the activities of mankind. Increasing human populations have resulted in greater demand on semi-arid regions for providing human substance and the possibility that this may enhance desertification is a grave concern (Hall et al, 1979). These zones are harsh habitats for humans. Water is the single most important natural constraint to agricultural production and human welfare in these regions. When feasible, irrigation by imported water can be used to increase and stabilize agricultural production of these regions. However, because of very limited availability of the surface and ground water resources, majority of the areas in the semi-arid tropics will continue to depend on direct rainfall for agriculture and livestock, for example, in the North-East Brasil, except for São Francisco and the Parnaíba river basins, opportunities for irrigated agriculture are limited in extent.

The semi-arid tropics (SAT) are characterized by limited, erratic and undependable distribution of rainfall. In North-East Brasil, sometimes a whole year may pass without rain in certain locations. When the rains do occur, the whole year's precipitation may fall in 4 to 5 days. Although the rainy season is normally during the high sun period, any month may have excessive downpours or be completely dry. Variations within a given month of from 0:00 to as much as 1335 mm have been recorded (Hargreaves, 1974). The situation is further exaggerated by poor soil resources in this region.

Bowdon (1974) claims that the original vegetation has been perhaps cleared several times in the last 400 years in North-East Brasil, which has reduced ^{reduced}

humus levels and left the soils more infertile. This has also resulted in accelerated erosion leaving soils with cropped rocks and gully formations in the upper reaches of watersheds. This can be confirmed by visiting already cleared lands. Thus better management of water and soil resources is of paramount importance to the North-East region of Brasil. This region has wide variations in its climate and soils hence any technology that is to be developed or recommended should suit its variable needs. In the following sections a brief description of climate and soils of the North-East region is included. Based on this, priorities for research in the area of land and water management and supplemental irrigation are developed.

2. CLIMATE:

A detailed analysis of the climate of North-East Brasil have been reported by Hargreaves (1973). He has delineated the North-East Brasil into various zones as very arid, arid, semi-arid and wet-dry (Fig.1) based on moisture availability indices* (MAI) as following (Hargreaves, 1974):

| CRITERIA | CLIMATIC CLASSIFICATION | REMARKS |
|--|-------------------------|-------------------------|
| All months with MAI in the range of 0.00 to 0.33 | Very arid | Very low rainfall zones |
| One or two months with MAI of 0.34 or above | Arid | Low rainfall zones |
| Three or four consecutive months with MAI of 0.34 or above | Semi-Arid | Medium rainfall zones |
| Five or more consecutive months with MAI of 0.34 or above | Wet-dry | High rainfall zones |

The Wet-Dry areas are out of the scope of this report. The very arid zones are areas of low rainfall (< 500 mm) and in general not suited for rainfed agriculture but water can be harvested for livestock use and/or very limited agriculture. The arid zones, - - - -

* Moisture Availability index is defined as ratio of amount of monthly rainfall at 75% probability level (PD) with the amount of monthly potential evapotranspiration (PET).

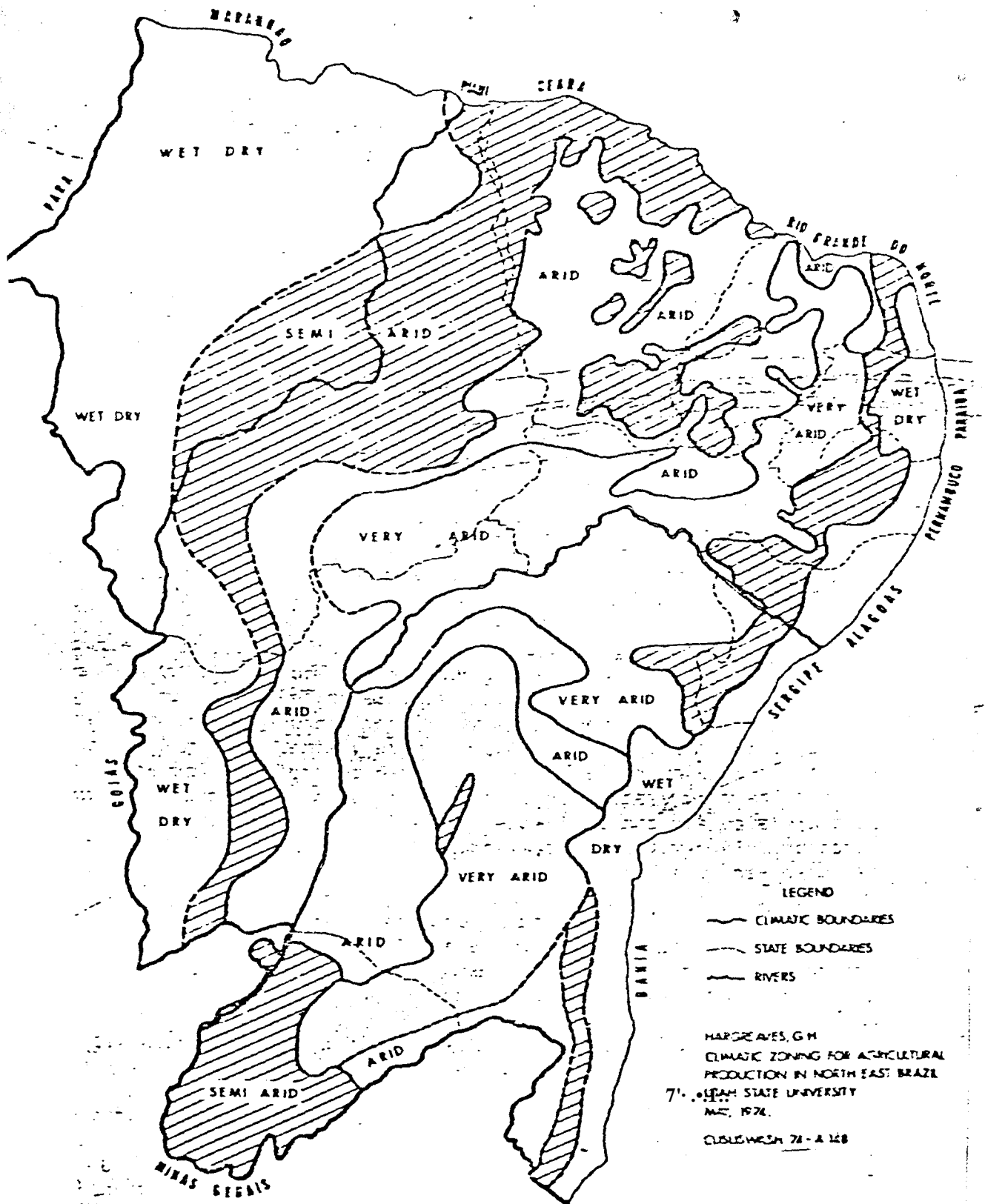


FIGURE 1. CLIMATIC CLASSIFICATIONS FOR NORTH-EAST BRAZIL

are areas receiving 500 to 750 mm rainfall and have limited suitability for rainfed agriculture. It is this author's belief that a successful rainfed crop can be grown in many years with appropriate in-situ conservation of soil and water and by backing up the agriculture with supplemental irrigation from harvested water.

In the semi-arid areas as classified above, more rainfall with better distribution is expected and appropriately chosen short duration crops can be grown without additional water. However, proper management and conservation of water and soil along with water harvesting for supplemental irrigation can be easily utilized to stabilize and boost the agricultural production. In addition a second short duration crop may be grown on part of the area with the help of collected runoff. Thus it can be concluded that suitable soil and water management measures which conserve and utilize the limited rainfall better, can provide better environment;

- (I) for livestock and fodder production and some very limited agriculture in very arid zones (very low rainfall zones)
- (II) for stabilizing and increasing the production of one short duration crop in arid zones (low rainfall zones), and
- (III) stabilizing and increasing production of one short duration crop with possibilities of producing another short duration crop in part of the area of a catchment in semi-arid zones (medium rainfall zones).

In general descriptions, all these areas classified as very arid, arid and semi-arid are referred to as semi-arid only at CPATSA, thus to avoid confusion in this report very arid areas will be referred to as very low rainfall zones, arid areas are referred to as low rainfall zones and semi arid as medium rainfall zones. The term semi-arid will be used for all the 3 rainfall zones in general.

3. SOILS:

The important soils of North-East Brasil (in SAT region) consist of Planosols solodized, Non Calcic Brown Soils, Solanetz, Vertisols, Latosols and some Regosols (Dematte, 1981). The Planosols, Solonets solodized, Vertisols and Non Calcic Brown soils are poor in drainage due to higher clay contents and presence of higher quantities of exchangeable sodium (except in Vertisols & Non Calcic Brown soils). Latosols & Regosols are relatively sandy and do not pose any drainage problems. Thus it can be inferred that problems of management of soil and water for better utilization, are of different nature on different type of soils. However, it can be anticipated that a technology (for soil & water management), developed for a given soil type within a given climatic classification can be approximately duplicated on areas of similar soils within same climatic zone (Hargreave, 1974).

4. THE APPROACH TO DEVELOPING A TECHNOLOGY FOR MANAGEMENT OF WATER & SOIL RESOURCES IN NORTH-EAST BRAZIL:

The goal of any proposed technology for management of soil, water and crop system is to achieve a highest possible water utilization efficiency (WUE) by conserving and utilizing the water and soil resources for highest beneficial use. This aim is to be achieved in collaboration with nature rather than by disturbing or destroying the natural ecosystem. The movement of water follows soil topography in a watershed (or catchment). Thus, a watershed or catchment becomes the natural unit for developing the soil and water resources. This has been amply demonstrated at ICRISAT where the author alongwith Drs. Krantz and Kampen has the credit of developing a watershed based technology for managing soil and water resources of Vertisols (Sharma and Kampen, 1975, Sharma and Kampen, 1977, and Krantz and Kampen, 1978). Some recent work of the optimization of small reservoir irrigation System for Semi-Arid tro

1981), also very clearly demonstrates that a catchment should be chosen as a unit of development of soil and water resources, if optimum benefits of the system are to be achieved. The recent work carried out at CPATSA in last 3 years (Ederaldo - verbal discussion, 1982) has generated some excellent lead data base for such an approach and shall prove very useful in generating an integrated technology for soil and water management and supplemental irrigation systems in North-East Brasil.

CPATSA is located in a very arid area (Petrolina) according to Hargreaves (1974) classification. Thus it becomes responsible for developing a range of technologies to serve very arid, arid as well as semi arid areas of North-East Brasil. It should be pointed out here that technologies developed for a particular zone (and a particular soil type) can not be transferred in total to other zones. Similarly efforts at transferring technologies for management of soil and water from other countries with disregard to the conditions of N-E Brasil will prove futile. An example of such an effort is the work of Liu (1977) where he tried to screen all possible locations in North-East Brasil to fit the technology developed at ICRISAT (Sharma, 1977 and Kampen, 1980), in vain. The approach should have been to try to adapt and modify that technology to suit the needs of North-East Brasil without compromising on the principles (e.g. watershed based) and concepts.

It is concluded from the above discussion that approach to generating an integrated technology for soil and water management and supplemental irrigation should be:

(1) A watershed is to be taken as a unit of planning and development of soil and water resources.

(2) The research on development of a technology for soil and water management & utilization should be conducted at atleast 3 locations, namely:

(a) in very low rainfall zones (very arid areas)

(b) in low rainfall zones (arid areas)

(c) in medium rainfall zones (semi-arid areas)

This is to be done in the most predominant soil type of a zone in collaboration with the State agencies and other local agencies.

(3) The development of a technology should be in an integrated manner rather than in components. This should result in development of appropriate models of the proposed systems to facilitate fast transfer of the technology.

(4) After the technology have been developed at research stage; it should be tested at a pilot project stage at operational scale at a number of locations before it can be recommended for use, and before heavy investments are made in transferring and executing the technology at farmers level.

Keeping the above discussion in mind, following two research proposals are made. The first proposal is on optimization of small reservoir irrigation system and the second proposal is on development of an appropriate technology for management of soil and water resources in various zones of N-E Brasil.

5. RESEARCH PROPOSAL I:

TITLE: OPTIMIZATION OF SMALL RESERVOIR SUPPLEMENTAL IRRIGATION SYSTEM FOR THE NORTH-EAST BRASILIAN REGION.

OBJECTIVE:

To develop methods for making optimum use of the existing system of small reservoirs and to develop a model for optimization of small reservoir supplemental irrigation system for stabilizing and increasing the agricultural production of the North-Eastern Brazilian Region.

¹ SPECIFIC OBJECTIVES:

1. Improvement of existing system of small reservoirs:

- (a) To study the hydrologic water balance of a few representative existing small reservoirs in three distinctly different agroclimatic zones of the semi-arid tropics of North-East Brazil. The three distinct areas should be in the very low, low and medium rainfall zones of the semi-arid North-East Brazil.
- (b) To adopt, modify and to develop methods for improving the water utilization efficacy for agricultural production and/or livestock of the existing small reservoirs in various zones of the Semi-Arid Brazil.
- (c) To test and demonstrate the developed methods under on-farm conditions at a few representative locations in North-East Brazil and develop detailed guidelines for use of the execution agencies for modification of the existing small reservoirs such that these reservoirs can be converted into productive agricultural systems.

2. Development of an optimization model for small reservoir supplemental irrigation systems on small watershed basis:

- (a) To adapt and/or develop a generalized mathematical model for optimization of storage capacity, location and design of the small reservoir (also called farm ponds or tanks) systems for supplemental irrigation by maximizing net benefits and water use efficiency, and by minimizing investment, associated seepage and evaporation losses, and land occupied by the reservoirs. This model should become a tool to provide general guidelines for planning of small reservoir

water resource systems in the North-East region of Brazil. The objective function and associated constraints will vary in different zones.

- (b) To search, gather and develop the input data needs of the proposed model for a no. of representative locations in N-E Brazil which will be required by the model to be useful as a guiding technique in aiding water resource planning of the proposed region for rainfed agriculture.

The important data needs are rainfall-runoff relations for various zones in North-East Brazil, water production functions of various crops grown in the region, cost of excavation as related to lift and lead (cost functions), agroclimatic data e.g. evaporation & seepage rates of various zones in the region, watershed contour maps, information on agricultural input & operations cost for crop production, and knowledge of market conditions of the region.

- (c) To test and search locally available cheap seepage control materials for controlling seepage losses in small reservoirs which in turn will increase the water use efficiency of the small reservoir irrigation systems. It is presumed that the research on evaporation control is already being carried out under a different project.
- (d) To test the model results under research station & later under on-farm conditions to establish the viability of the model and develop generalized guidelines for the development of the small reservoir irrigation system in North-East Brazil.

RESEARCH PROPOSAL II

TITLE: DEVELOPMENT OF SUITABLE LAND & WATER MANAGEMENT TECHNOLOGY FOR VARIOUS ZONES IN THE SEMI ARID TROPICS OF NORTH-EAST BRAZIL.

OBJECTIVE: Adaptation and Development of a suitable technology for better management and utilization of the water & soil resources in the semi-arid tropics (SAT) in N-E Brazil for stabilizing and increasing the agricultural production of the region on small watershed basis.

SPECIFIC OBJECTIVES:

1. FOR VERY LOW RAINFALL ZONES (very arid)

- (a) To establish a technology for soil conservation in already cleared areas.
- (b) To evaluate & develop runoff inducement systems for increasing the available runoff yield from the upper reaches of catchments for water harvesting.
- (c) To select and establish appropriate technology for conservation of soil & water and for facilitating supplemental irrigation on the down stream areas of small reservoirs to stabilize & increase agricultural production (and/or livestock).

2. FOR LOW RAINFALL ZONES (arid)

To adopt and develop technology for conservation of soil & water on a watershed to stabilize and increase agricultural production. The approach here will differ from the approach in (1). Here the major emphasis will be on in-situ ^{irrigation.} conservation of water and soil and suitable arrangement of supplemental irrigation.

3. FOR MEDIUM RAINFALL ZONES (SAT areas)

To develop a land & water management technology for soil & water conservation and appropriate surface drainage to create an optimum environment for plant growth for increasing and stabilizing the agricultural productions of these zones. Here the emphasis will be on in-situ moisture and soil conservation, appropriate surface drainage & supplemental irrigation.

The details of the above proposals, their methodology and associated manpower and financial needs of the above proposals are discussed elsewhere (Attached).

7. CONCLUSION:

The soil and water are national resources. Appropriate development and optimum utilization of these resources will result in the welfare of small farmers in general. These are the farmers which are badly hit by the vagaries of rain. The small watershed based approach suits the small farmer's requirements.

An integrated approach to the solution of the problems of water & soil management can bring visible benefits to the small farmers by increasing and stabilizing their agricultural (including livestock) production.

To develop technology for management of soil and water resources in N-E Brazil, the technology development research should be carried out in most representative soils of at least the three suggested (very low, low & medium rainfall) zones. This will ensure appropriate technologies for the whole of North-East Brazil.

After a technology has been developed it should be tested at Pilot project scale where selected farmers participate in the adaptation of the developed technology. Only after successful pilot project level testing, it should be recommended for general use.

This working paper is for very restricted internal distribution and is written to generate a discussion on the suggested approaches.

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RAPA**A P P E N D I X**

Based on this proposal following 7 projects have been developed:

- (1)** Improvement of existing small Reservoir systems in N-E Brasil
- (2)** Adoptation/Development of an operational model for optimization of small reservoir supplemental irrigation systems for N-E Brasil
- (3)** Development of water production functions relating timing and quantity of supplemental irrigation for important dryland crops of N-E Brasil
- (4)** Selection, testing and if needed development of cheap seepage & evaporation control materials & methods for increasing the water utilization efficiency of small reservoir systems in North-East Brasil
- (5)** Land & Water development, utilization & management technology for the very arid areas of N-E Brasil
- (6)** Development of Land & Water Management & utilization technology for arid areas of N-E Brasil
- (7)** Development of Land & Water Management & utilization technology for semi-arid areas of N-E Brasil.

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