FARMING SYSTEMS RESEARCH IN THE BRAZILIAN SEMI-ARID TROPICS
THE EXPERIENCE OF OURICURI, STATE OF PERNAMBUCO

A. F. Lima, E. R. Porto, A. G. Vivallo Pinare
L. H. de O. Lopes, M. C. de Oliveira
G. J. A. Vallee, G. Doraswamy, H. Lal

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INTRODUCTION

Before 1970 the Brazilian agricultural research system was based on a diffuse model, where "each research unit tried to diversify its activity, researching on many different products and attempting to generate a wide array of technologies" (Pastore and Eliseu, 1975). The same authors suggest that this research model is appropriate for situations with the following features: abundance of monetary resources to support the research programmes, and predominance of individualism of the scientists with liberty to choose the research themes according to their interest and feelings. A considerable amount of information can result from such a model, possibly with low probability to generate new technologies. This implies the requirement of a large amount of resources to be devoted to agricultural research, which can fit into rich societies but is not the case with the third world where the resources available for research are scarce.

Another important event preceding the 1970's was the transfer of technology from the temperate climates to the Brazilian tropical environment, as well as the prevailing idea that what is good for the developed world should be good for Brazil.

The increasing demand of food supply in the country, coupled with the expansion of the external market, required a reorientation of the agricultural policy. To meet this need, the Brazilian government decided to modernize agricultural research and to develop an array of national technology based on national problems. As an instrument of this policy, the Brazilian Agricultural Research Enterprise (EMBRAPA) was created in December 1972 (EMBRAPA, 1975). There was a reinforcement of the existing research facilities through financial and technical support, and new research centres were created to cover the needs of the country. As a part of the modernization of Brazilian agricultural research, the emphasis on a farming systems approach was integrated into the programmes of EMBRAPA's research.

The Agricultural Research Centre for the Semi-Arid Tropics (CPATSA) was created in 1975 with the objective of generating new technologies to improve the quality of life of the peasant farmers of the Brazilian semi-arid tropics (SAT). With the creation of CPATSA many questions were raised during the conception of the research programmes, such as: what to do? how to do it? when to do it? and how to integrate the peasant farmers with the global society?

As an attempt to answer these questions, some basic principles were formulated, inspired by international research experiences from other parts of the SAT (Krantz and Kampen, 1976; Dillon et al., 1978 and Tourte, 1977). They were:

1. To work with an interdisciplinary team considering the following research areas: soil and water management, animal traction, cropping systems, animal production, agroclimatology and economics.

2. To develop technologies in each research area and to integrate them for operational scale trials.

The preliminary results on these experiences were reported by Queiroz (1979). Till that time the research was carried out without direct participation of the farmers. However, the participation of the farmer is of fundamental importance to check the adoption rate of the technologies. There has been considerable progress in the direction of CPATSA's research strategy resulting from the valuable experience which is described in this paper.

THE SETTING

Northeast Brazil occupies 18% of the Brazilian territory and according to Reddy and Amorim Neto (1984), 75% of this land is classified as semi-arid tropics. The Brazilian SAT comprises about 1.2 million km2, including parts of the following states: Maranhao, Piaui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, Bahia and Minas Gerais. The Brazilian SAT includes two major agro-ecological sub-regions namely Agreste and Sertao.

It is estimated that 94% of the rural holdings (around 2,300,000) are less than 100 ha and occupy approximately 30% of the area of Northeast Brazil. However, the crop production from small holdings represents more than 60% of the region's basic food supply (Ibge, 1981).

The Agreste is a transition zone between the coastal area and the arid Sertao. Rainfall in the region ranges between 600 and 1300 mm, and the average temperature is lower than that in the Sertao. It comprises about 15% of the Brazilian SAT and is one of the major agricultural production sub-regions of the Northeast. Intercropping is the predominant cropping pattern and a number of crop combinations are used involving the following crops: maize, beans (*Phaseolus vulgaris* L.), cassava, forage cactus (*Opuntia ficus-indica* Mill), cotton (*Gossypium hirsutum* L.) among others.

The Sertao corresponds to a rather dry zone where the rainfall is generally in the range of 400 and 700 mm, and comprises 74% of the Brazilian SAT. The farming systems presently in use in the Brazilian SAT is a result of more than 300 years of experience. Extensive livestock on natural rangelands (caatinga) is a very important component of the farming systems. The carrying capacity of the caatinga, estimated at one animal unit per 15 ha, is very low (Salviano et al., 1982). With the caatinga grazing system, steers are ready for slaughtering when they are around 5 years old and have attained an average live weight of 320 kg.

Cattle, goats, and sheep are raised in close integration with agriculture. The cropped area is normally fenced and crop residues are kept in the field for feeding purposes during the dry season. In general, the water sources are shared by the farm family and the animals. This leads to contamination of drinking water used by the family, mainly during the dry season. Agriculture tends to be concentrated in small areas, generally in more fertile lands or alluvial soils bordering small rivers. The receding cultivation along the margins of the water reservoirs or on the river beds is also common. Intercropping is a common situation for both subsistence and cash crops like cowpea, maize, cassava, castor beans, perennial cotton (Gossypium hirsutum L. var. Maria Galante Hutch.), and forage cactus. They are mixed in a number of ways. Maize, cowpea, and cassava are staple foods for human consumption and sorghum has been successfully introduced recently in the drought prone area as an animal feed crop (Faris et al., 1976).

Despite the great variability of the agro-ecological picture within the Brazilian SAT, there are some common features, as follows:

1. The farm families in general are aside of the services and welfare of the community.
2. The economy of the system is very fragile and a small weather aberration is sufficient to keep some farmers from the field.
3. The majority of households are based on a typical subsistence economy.
4. The farm families normally live isolated in the establishments scattered in the rural area.
5. There is a large predominance of small holdings.
6. Animal and human labor are the main source of power.
7. There is a high evaporative demand (about 2000 mm per year).
8. There is an inadequacy of credit facilities.
9. There are short rainy seasons.
10. Rainfall is intensive and interspersed with unpredicatable droughts.
11. There is high variability of the annual rainfall.

No specific data are available concerning the Brazilian SAT. However, it is reported that 31.4 million people live in the Northeast region, comprising 30% of the Brazilian population. The rural population is about 47% of that total and its annual rate of growth for the Northeast is estimated at 2.5% (Ibge, 1982).

According to Ibge (1983) the Northeast contributes 12.3% to the national product of Brazil, and its participation in the national agricultural, industrial, and services income are 15.5%, 10.8% and 11.2%, respectively. The same source indicates the following distribution of the regional income: agriculture, 16.9%; industry, 30.3%; and services, 52.8%. Table 1 shows the participation of the 14 most important crops of the Northeast in relation to the total of the country, and the increasing rate of their production in the region over a period of 20 years. These figures clearly show the considerable increase of the export and industrial crops, like orange (466.2%), tomatoes (185.6%), sugarcane (177.3%), etc., and a small increase or even decrease of some subsistence crops like cotton (1.6%), beans (1.3%) and maize (- 19.3%).

The experience presented has the following merits: 1) it leads to the validation of on-farm technologies integrating researchers, farmers, and extension agents in the process of regional development; 2) it represents the thoughts and efforts of an interdisciplinary team.

THE RESEARCH PROGRAMME AT CPATSA

The research programme of CPATSA considers the following (Figure 1): 1) evaluation of the natural and socioeconomic resources of the rural environment aimed to assess the traditional farming systems, their boundaries, limitations, and potentials; 2) analytic research, carried out at the experimental station; 3) synthesis experiments, comprising an integration of different disciplines; 4) experimental farming (FS) are undertaken on site and involve all the components of the FS; 5) introduction of improved farming systems (IFS) among farmers in different agroecological situations, and at the same time the testing (validation) of isolated technologies on farmers' fields which serve as a feedback to the IFS studies. As it can be seen from the flow chart, farming systems research (FSR) is a basic component of CPATSA's research programme.

The interdisciplinary team of FSR at CPATSA consists of scientists in the following disciplines:

- Soil and water management
- Intercropping
- Agricultural economics
- Mechanization (animal drawn equipment)
- Animal production
- Agricultural systems

FSR receives consultancy from CPATSA staff in other disciplines, such as: plant protection, agroclimatology, statistics, soil fertility, seed technology, etc.

METHODOLOGY OF FSR

Selection of Farms

A preliminary diagnostic survey was carried out in 1982 involving 400 farms already assisted by the Sertanejo Project[1] (Brazil. SUDENE, 1977), in the region of Ouricuri (7°30' - 8°30' south latitude and 39°30' - 40°30' west longitude), comprising an area of 7,500 km. This survey comprised a global analysis of the availability of technical assistance, credit, inventory, some socioeconomic characteristics, and agroecology (Kilian, 1981; Miranda, 1981 and Mantovani & Riche, 1982).

A sequence of procedures was developed involving a decreasing number

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[1]Government project to promote technical assistance to farmers in the SAT.

of farm families and an increasing number of variables, in order to provide an overview of the region in terms of the resource interactions between the farming systems and the rural services (credit, technical assistance, market, agricultural research, and agroindustry, etc.) (Miranda, 1981 and Pinare & Fuentes, 1984 a and b).

The final procedure resulted in the selection of five farms in 1983, where a detailed analysis was performed, comprising the following steps (Porto et al., 1984):

1. Analysis of the selected farms. The selected farms were analysed in detail for identification of the farm components as follows:

a. Tenancy. It is important to know the tenancy system in order to guide some decisions concerning credit, investment, and legal limits of the systems.

b. Farm size. A topographic map of the farms was made for surveying the total cropped and unproductive areas. All the infrastructures were located on the map, including stream courses, water reservoirs, etc.

c. Natural resources. The survey of the natural resources of the farm was divided into two stages:

1) Present and potential use of the fields; identification of the crops and cropping patterns in use; observation of weed, pest, and disease problems; and analysis of soil depth and fertility. The land use in the last three years was also recorded to give a picture of soil use. Such a characterization of the fields permits an evaluation of the potential in accordance with the capital and labor.

2) Water and other resources. Quantity and quality of water resources were assessed. Forestry products (charcoal, wood, etc.), soil products (bricks, tiles, lime, etc.), which represent additional income for the farmers were also surveyed.

d. Labor. Analysis of the existing human labor and its requirements for the development of the IFS were undertaken.

e. Capital. All the items of the inventory such as animals, infrastructures, perennial crops, machinery, tools, and land were valued to identify the existing potentials and limitations.

f. Liabilities. The short and long term debt to be paid during the implementation of the IFS were recorded in order to be considered in the repayment capacity.

2. Identification of potentialities, limitations and needs of the farm. The analysis of the natural resources, capital, and labor allowed a balance of quantity and quality of the existing resources, experiences of the farmer, needs of investment, links of the farm with the regional services (health, education, bank, market, etc.), and access to the farm all year round.

3. Identification of farm families' needs and objectives. This can be described as follows:

a. Needs of the farm families. These are represented by the basic consumption of the family in terms of food, water, energy, domestic consumption (maintenance of the family) and consumption of life quality (social and cultural services like festivals, entertainments, weddings, etc.) Equally important is the record of the needs of the farm, such as the requirements of inputs and investments to assure the survival and development of the family and farm activities.

b. Objectives of production. The aspirations, objectives, and hopes of the farm families are based on land, labor, and experiences. The farming system is the result of the interaction between the socioeconomic and production system and is expressed in terms of allocation of land for subsistence and cash purposes.

Project Formulation

From the detailed analysis of the diagnostic survey, three kinds of projects were formulated. They are:

1. Project with traditional technologies (Project A). This is a projection of the performance of the farm based on the existing resources and the traditional technologies currently adopted by the farm families. In this project the farmer defines the objectives and describes the traditional technologies. Based on this information the research team simulates the economic parameters in a range of five years.

2. Development project with improved technologies (Project B). This project incorporates the improved technologies available. It has a duration of five years and its performance is compared with Project A.

The farmers and researchers discuss allocation of space and implementation of the improved technologies. The project is entirely implemented on the farm jointly by the farmer and the interdisciplinary team. The farmer participates with the major part of the capital investment (land, fencing, clearing, small roads and buildings), working capital (animals, tools, inputs, equipment, and working animals), labor, and administration of the farm. The research component finances part of the improved technologies, i.e., compartmented reservoir, cistern, lending of the policultor, etc. The necessary investments varies from farm to farm, depending on the needs and availability of farm resources. In the case of the farm discussed earlier the investments amounted to US$ 3,600. The research financing can continue up to the third year. However, for economic evaluation purposes, the financial contribution of the research component is included in the costs. After the third year the farmer assumes the whole project and the research team will provide technical assistance for two more years.

3. Evaluation project - Project R (Doraswamy et al., 1984. This project comprises an economic, social, and technical evaluation of the real situation in order to measure the impact of the improved technologies on the farm and farm family.

Once implemented the set of improved technologies and all the variables within the farm are recorded at different intervals as follows:

Annual survey, comprising the following variables:

- Labor availability
- Space allocation with their respective uses
- Annual and perennial crops
- Use of water resources
- Information on fences

- Inventory of inputs, tools, and machinery
- Inventory of domestic animals
- Land and infrastructure value
- Information on financial assets
- Information on debts.

Monthly survey, comprising the following variable:
- Herd management.

Weekly surveys comprising the following variables:
- Changes in stock number
- Pasture utilization
- Supplementary feeding
- Production and sales of livestock products
- Sales of crop products and other receipts
- Expenditure on inputs and services for crop and animal production
- Expenditure on general management of the farm
- Expenditure on family consumption.

Daily survey comprising the following variables:
- Use of labor in crop and animal production
- Input use
- Use of machinery (animal machines and equipment).

All these variables are precodified and recorded in the proper questionnaires adjusted to a computer system. The data from these precodified questionnaires are directly transferred to the flexible disks with the Research Center's microcomputer Polymax (Poly 201 DP) with 64K bytes RAM memory. The analysis of these variables allows an assessment of three main aspects of the FS: technical (yield, productivity, and new technologies), economic (investments, income, and benefits), and social (employment, training, and improvement in the standard of living).

The aim of the FSR programme at CPATSA, is to transfer this experience to different ecological zones of Northeast Brazil through EMBRAPA's cooperative research network.

The extension service participates in the whole process in a joint action with farm families and researchers leading to the preparation for the process of transfer of technology.

INTRODUCTION OF NEW TECHNOLOGIES

The analysis of the available technologies stage confronts the farmers' objectives of production with the available technologies of the regional research system. It is understood that these technologies have been previously tested in an experimental farming systems. An important requirement in the whole process is that the IFS may give the farmers a condition to resist the drought effects.

The basic technology being used in the sampled farms is a cistern which is a basic requisite for family welfare. This is a protected reservoir for rainwater storage harvested from the houses' roof, or from the requirements of inputs and investments to assure the survival and development of the family and farm activities.

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Vegetable production under pot irrigation was introduced to improve the diet of the farm family. This activity is generally limited to a small area mainly to meet the household needs. The main crops are tomatoes, greenpeppers, okra, eggplants, lettuce, and carrots. The pots are made out of clay and release 5 litres of water per day on average. The system can also be used for fruit trees (Silva and Porto, 1982).

In situ rainwater harvesting techniques using modified leveled furrows are broadbed and furrows system, Guimaraes Duque system and "W" system. These techniques can be implanted both by animal and tractor power. All these techniques permit zonalized tillage systems clearly demarking a planting, traffic, and water harvesting zone. In all the three systems the furrows serve for traffic and water storage harvested from the water harvesting zone (Porto et al., 1984), (Figure 3).

Runoff water harvesting through a compartmented reservoir is a semi-circular shaped tank with two compartments destined to store runoff water for supplemental irrigation. It has three basic components (Figure 4), catchment area, storage tanks, and planting area (Silva et al., 1984). Supplemental irrigation is carried out by gravity only.

Receding cultivation with furrows and ridges system is a kind of cultivation on ridges and furrows built on the water level of the shores of lakes and dams as the water recedes (Silva et al., 1981).

The crops used were: maize, cowpea, annual cotton, sorghum, common bean, and watermelon. Improved varieties of these crops were introduced with intercropping being the predominate cropping system. Most of these crops are drought tolerant.

A multipurpose tool carrier/tool bar (policultor) has been used for various cultural operations such as land preparation, planting, and weeding. The tool carrier used in the IFS is drawn by a pair of bullock and used for transportation purposes of farm production. The tool bar has been used for low draft requiring use of one animal.

Pasture management is related to the use of caatinga vegetation during the rainy season when it is able to adequately carry the herd. Supplementary feeding includes the combined use of cultivated grass (Cenchrus ciliaris L. - buffel grass), legumes (Leucaena leucocephala [Lam.] de Wit) and Cajanus cajan (L.) Millsp - pigeonpea, crop residues (maize, cotton, sorghum, and cowpea), and other forages like (Opuntia ficus indica Mill) forage cactus and (Prosopis juliflora D.C.) mesquite. With respect to health management, the main techniques introduced are vaccination and deworming.

RESULTS AND CONCLUSIONS

The economic indicators of the project with traditional technologies (Project A) and the development project with improved technologies (Project B), in one of the selected farms, are presented in Tables 2 and 3. It is expected that the final cash balance in Project B is substantially higher in relation to Project A, and increase in cash balance ranges between US$ 450 in the first year, to US$ 3,700 in the fifth year, representing 169% and 650% increase, respectively. Table 4 presents the estimates of the internal rate of return of the investments in traditional and IFS and in the new technologies. The traditional system is characterized by a very low internal rate of return (2%) while it is substantially higher in the improved system (19%). The internal rate of return of investment in the new technologies is very high and represents 62%.

The data of the evaluation project (Project R), are being processed. However, it is important to consider that the IFS will modify the social and agroecological equilibrium, which characterizes the agricultural exploration, generating new equilibria. The farm family is the only component of the new equilibrium, and is the only one who is able to feel the global modifications introduced by the IFS. It has been observed with the present experience that the farmers began to operate the new animal power equipment and supplemental irrigation reasonably well. These are remarkable examples considering that these technologies are entirely new in this environment. The community has also reported a great interest.

With only one year of implementation of the IFS in rural areas it was not possible to assess any changes in the standard of living of the farmers.

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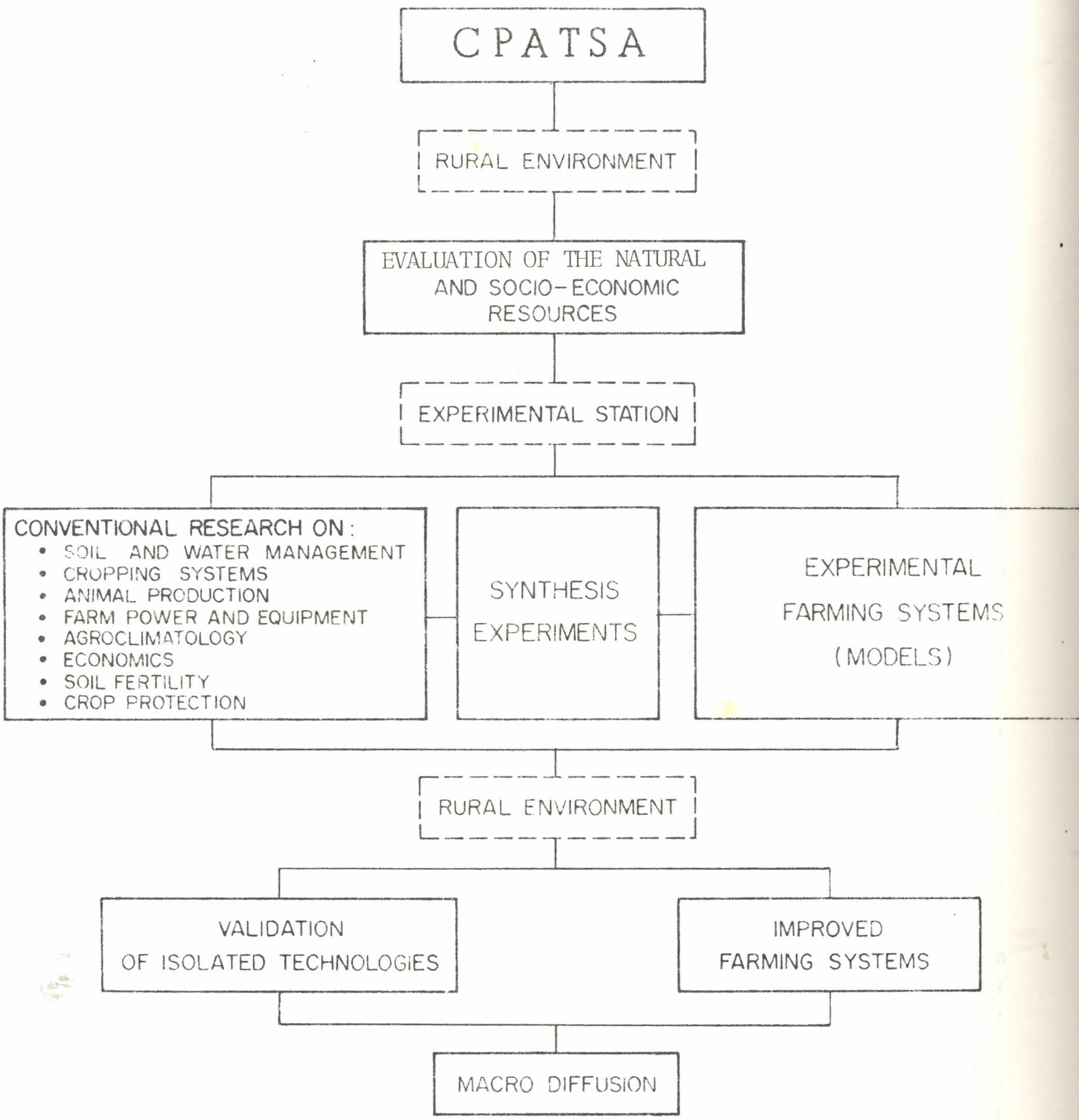

FIGURE 1. Flow chart of the research programme at CPATSA.

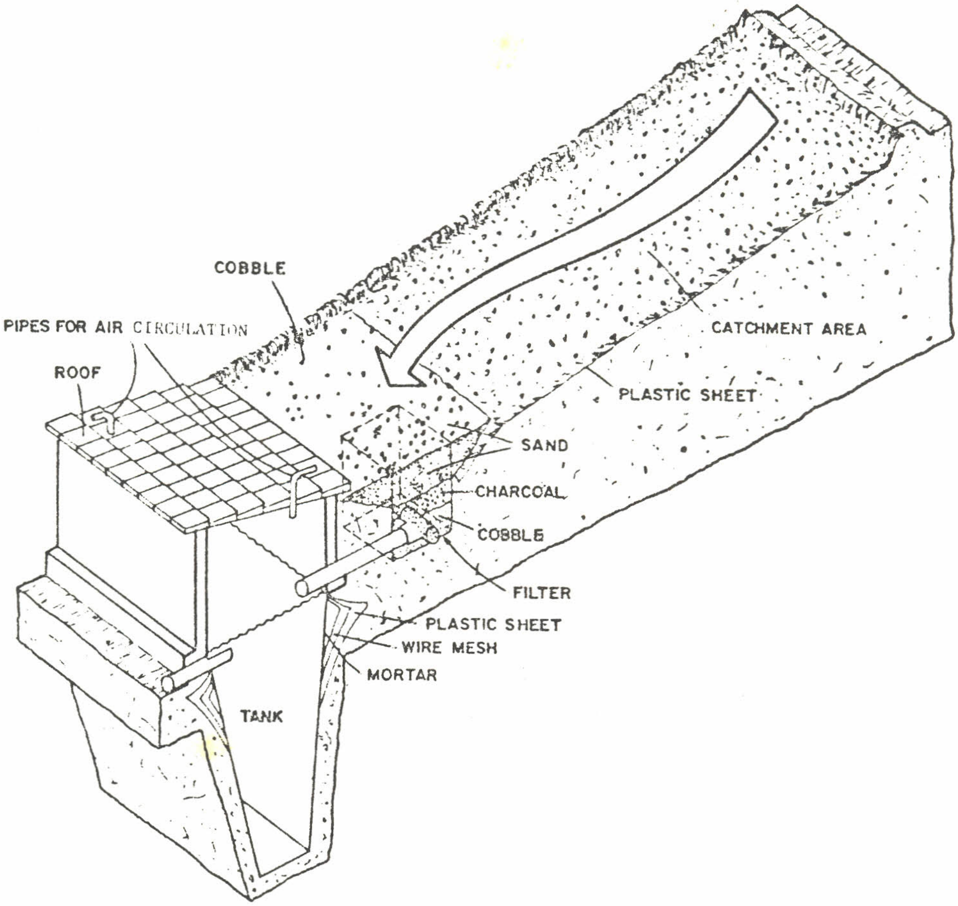

Figure 2. Rural Cistern with Catchment Area in the Ground.

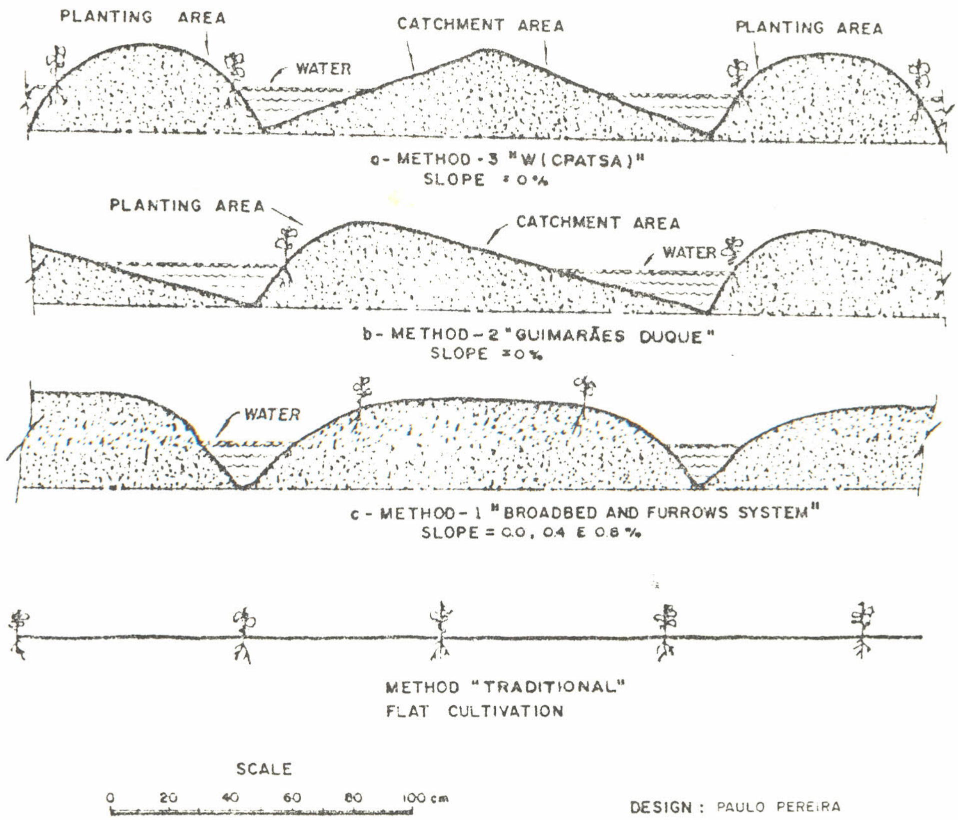

Figure 3. In Situ Runoff Water Harvesting Methods Adapted by CPATSA Designed to Grow Annual Crops in the Brasilian SAT.

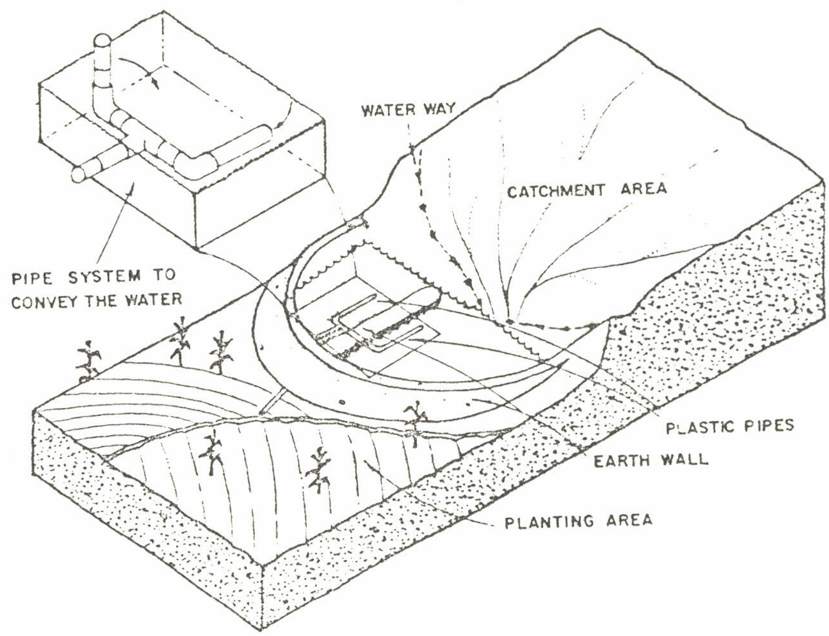

Figure 4. Diagrammatic Representation of the Runoff Water Harvesting System Through Compartmented Reservoir.

Table 1. Production of the Main Crops of Northeast Brazil and Its Relative Share in National Production (Adapted from F. Ibge 1961, 1981).

CROPS	SHARE IN THE NATIONAL PRODUCTION (%)		PRODUCTION OF THE NORTHEAST (1000 t)		
	1960	1980	1960	1980	INCREASE (%)
Cocoa	95.0	94.8	155.4	302.5	95.0
Cotton	48.9	59.1	786.1	798.3	1.6
Cassava	43.4	56.8	7631.5	13324.3	74.6
Beans	28.6	25.6	495.0	501.3	1.3
Sugarcane	35.6	37.8	20234.5	56111.3	177.3
Castor Beans	76.4	55.2	224.7	280.7	24.9
Sisal	99.7	100.0	164.1	235.0	43.2
Banana	30.1	44.0	77.0	197.0	155.6
Maize	11.9	4.1	1027.8	830.5	-19.2
Rice	30.0	15.2	1436.7	1483.5	3.3
Coconut	94.3	95.3	411.7	499.0	21.2
Orange	9.8	8.5	816.7	4623.6	466.2
Tobacco	33.8	18.0	54.6	72.8	33.4
Tomatoes	24.6	18.2	97.7	279.2	185.6

Table 2. Economic Indicators of the Farm "Tabuleiro" (Ouricuri PE) with Traditional Farming System (Value in US$).

ITEM	1983/84	1984/85	1985/86	1986/87	1987/88
1. Gross Income	2,700	3,550	3,740	3,685	4,052
2. Total Cost	3,267	3,323	3,520	3,321	3,506
3. Net Income (1-2)	- 567	227	220	364	546
4. Depreciation	731	731	731	731	731
5. Value of Family Labor	1,723	1,930	1,930	1,930	1,930
6. Annual Investment	---	1,824	29	2,092	782
7. Net Benefit (3+4-6)	164	- 866	922	- 997	495
8. Expenditure on Consumption	1,940	1,940	1,940	1,940	1,940
9. Expenditure on consumption - value of family labor (8-5)	217	10	10	10	10
10. Farm Cash Balance (7-9)	- 53	- 876	912	-1,007	485
11. Payment of Loans	370	76	75	73	71
12. Other Receipts	158	158	158	158	158
13. Final Cash Balance (10-11+12)	265	- 794	995	- 922	572

Table 3. Economic Indicators of the Farm "Tabuleiro" (Ouricuri PE) with the Improved Farming System (Value in US$).

ITEM	1983/84	1984/85	1985/86	1986/87	1987/88
1. Gross Income	3,654	5,293	7,396	7,307	7,852
2. Total Cost	3,248	3,436	3,403	3,235	3,251
3. Net Income (1-2)	406	1,857	3,993	4,072	4,601
4. Depreciation	815	857	880	863	865
5. Value of Family Labor	1,644	1,678	1,512	1,444	1,444
6. Annual Investment	---	1,824	29	2,092	782
7. Net Benefit (3+4-6)	1,221	890	4,844	2,843	4,684
8. Expenditure on Consumption	1,940	1,940	1,940	1,940	1,940
9. Expenditure on Consumption - Value of Family Labor (8-5)	296	262	428	496	496
10. Farm Cash Balance (7-9)	925	628	4,416	2,347	4,188
11. Payment of Loans	370	76	75	73	71
12. Other Receipts	158	158	158	158	158
13. Final Cash Balance (10-11+12)	713	710	4,499	2,432	4,275

Table 4. Initial and Final Value of Capital and the Internal Rate of Return in the Traditional and Improved Farming Systems of Ouricuri Region (PE).

Farm Name and Number	Value of Capital (US$)				Internal Rate of Return (%)		
	Traditional System		Improved System		Traditional System	Improved System	Investment in the New Technologies
	Initial	At the End of the 5th Year	Initial	At the End of the 5th Year			
Tabuleiro 87	11,860	13,307	15,455	17,924	1,9	18,9	61,9