AEROFORESTRY SYSTEMS FOR INCREASING THE PRODUCTION OF WOOD FOOD AND FODDER FROM NORTHEAST BRAZIL

AGROFORESTRY SYSTEMS FOR INCREASING THE PRODUCTION OF WOOD FOOD AND FODDER FROM NORTH EAST BRAZIL

AN AGROFORESTRY RESEARCH PROJECT DOCUMENT

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BRAZIL

B R A Z I L

AGROFORESTRY SYSTEMS FOR INCREASING THE PRODUCTION OF WOOD AND FODDER FROM NORTHEAST BRAZIL

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AGROFORESTRY SYSTEMS FOR INCREASING THE PRODUCTION OF WOOD AND FO[illegible] FROM NORTHEAST BRAZIL

SUMMARY

The Brazilian Northeast region, comprising an area of 1.5 million square kilometres, has a predominantly semi-arid to arid climate. Three distinct climatic types are recognisable: a sub-humid zone w[illegible] average precipitation about 1500 mm; a semi-arid zone that is cha[illegible]rized by a pronounced dry season, but with moderate precipitation [illegible] the rainy season; and an arid zone with average annual precipitati[illegible] below 750 mm with some locations recording as low as 275 mm. The arid zone comprises 50 per cent of the Northeast.

Apart from in the sub-humid zone, the physical conditions for agri[illegible] production are at best marginal. And yet, the region is densely po[illegible]lated. Pressures on land resources have intensified during this century with a rapid increase in human population (expected to dou[illegible] to about 65 million by the turn of this century). In addition, the best arable land is utilised for plantation crops and there is extan[illegible] grazing and an increase in animal population especially of the intr[illegible] zebu cattle which feed more on the grasses and herbs than do the lo[illegible] cattle. The increase in rural population densities has also led to over-exploitation of the vegetation in the caatinga for timber and [illegible] The combined effect of all these is that the region is one of the [illegible] depressed, in a social and economic sense, in Brazil.

Within the region, there is a shortage of both wood and food crops [illegible] the situation is almost certain to worsen, unless more productive [illegible] sustained land management systems are evolved and practised. There[illegible] it seems desirable to conduct research on tree-based agroforestry [illegible] with a view to increasing production, and to rehabilitating enviro[illegible]tally degraded areas and/or arresting further deterioration of such [illegible]

The scope and need for such agroforestry research programmes have [illegible] recognized by the Brazilian National Programme of Forest Research [illegible] of the Brazilian Agricultural Research Enterprise (EMBRAPA), and the project proposed here is the outcome of a joint EMBRAPA/IBDF/ICRAF initiative. The document has been prepared by ICRAF and EMBRAPA.

The project has the following objectives:

(i) ascertaining the optimum combinations of tree and fodder crops in arid and semi-moist areas;

(ii) the selection of forage and fodder species for agroforestry systems in the caatinga;

(iii) the development of farming systems involving various treee and arable food crop combinations in the semi-arid zone; and

(iv) the development of agroforestry systems involving tree plantations and cattle raising in the semi-arid and arid zones.

To attain these objectives, it will be necessary to conduct:

(i) espacement trials;

(ii) screening trials of multipurpose tree species, and of shrubs and trees with a fodder producing potential in different climatic zones; and

(iii) tests involving various types and intensities of cultural treatments, (site preparation, planting methods, pruning and thinning).

Because of the great amount of diversity of the region in ecological characteristics, socio-economic conditions and farming practices, the research projects for the region are different in scope, methodology, and resource requirements. In the circumstances, four sub-projects have been identified:

a. Sub-project I - Selection of forage and fodder species for agroforestry systems in the caatinga region. It aims at identifying and evaluating species of trees and herbaceous forage plants, and at devising and evaluating suitable management systems.

b. Sub-project II - Screening of tree species suitable for agroforestry in the caatinga area, i.e. "elimination trials" of both native and exotic tree species.

c. Sub-project III - Land management systems involving trees and arable food crops for Northeast Brazil. This sub-project has the specific objectives of developing combinations cultures of trees and arable crops, devising suitable agro-techniques for them, assessing the growth and production potentials of individual species, and evaluating the

effects of such systems on soil properties.

d. Sub-project IV - Agroforestry systems involving plantation trees and cattle raising, aims at developing integrated agroforestry systems involving cattle raising and tree crops, and studying the various aspects of such systems.

The project also envisages several ancillary studies from each of the sub-projects.

The headquarters of the Project will be in Brasilia. Sub-projects I and II will be located at Teresina, sub-project III at Natal and Nisia-Florestal, and along the Salvador-Petrolina Road, and sub-project IV at Acú. There are research stations at or near all these sites.

The project period is three years initially. The anticipated donor contribution will be US $ 1,131,400 or US $ 377,100 annually for three years. This includes a capital budget of US $ 25,000 and a training component of US $ 112,000. The Brazilian Government contribution for the same period is US $ 862,500 or US $ 287,500 annually for three years.

BACKGROUND

Area

The Brazilian Northeast region has an area of 1.5 million square kilometres, and ranges in latitudes from 1°S in Maranhão to 18°S in Bahia. Elevations are generally low with about 90 per cent of the land lying at less than 600 metres above sea level.

Climate

Average annual temperatures are above 20°C. The Northeast region may be classified into three major climatic types:

(i) the sub-humid climate found along the coast, extending from Natal to the southern boundary of Bahia, and in the western half of Maranhão. Precipitation is adequate all year, and averages are generally about 1,500 mm;

(ii) semi-arid and characterized by a pronounced dry season, but with moderate precipitation in the rainy season. Semi-arid climates are found to the west of the sub-humid zone of the east coast, and to the east of the sub-humid zone of Maranhão;

(iii) arid and occupying 50% of the area. This climatic zone extends from the north coast in the states of Ceará and Rio Grande do Norte, southwestward into the interior for a distance of about 1,300 km. The average annual precipitation in the arid zone is generally below 750 mm, with some locations recording as little as 275 mm. A climatic map of the region is presented in Appendix II.

The climate of the Northeast varies considerably from year to year both in terms of total amount of rainfall and in terms of its distribution within the rainy season. Short periods of little or no rainfall may occur at any time during the rainy season. Droughts are recurrent and are especially serious in the "arid" regions. Also, there appear to be cycles of groups of dry and wet years in the Northeast creating even more serious problems associated with drought. Rainfall variability in the Northeast also results in years of excessive rainfall which is nearly as serious a problem as drought.

Vegetation

On the basis of the region's natural vegetation, the area has been divided

into four major ecological zones:-

(i) the forest zone - this vegetation type was originally tropical rain forest or tropical seasonal forest. However, virtually all of the vegetative cover has been removed because of agricultural and urban land use;

(ii) the agreste, representing a transitional zone between the forest zone and the caatinga and extending from Rio Grande do Norte to Bahia is characterized by scattered trees alternating with a fairly dense lower growth of small trees and shrubs;

(iii) the caatinga, which may be described as decidious shrub forest of thorny small trees and shrubs and cacti. The caating vegetation is not homogeneous, but varies in density and composition depending upon the amount of rainfall. Under the driest conditions, vegetative cover is discontinuous with patches of bare ground and a high frequency of cacti. The caatinga exhibits dramatic changes from the wet to the dry season, and in the latter, only a few evergreen species are to be found; and

(iv) the palm forest which predominates in western Piaui and over most of Maranhão. Here, the almost pure stands of babaçu palms provide a dense forest cover.

Soils

Soil conditions vary greatly over the Northeast and present an even more complicated pattern than vegetation. In the forest zone, soils are heavy, deep and fertile, and not easily eroded. In the agreste, soils are lighter and of moderate depth with a low humus content. In the caatinga, soils tend to be shallow, sandy, contain little humus and have a low natural fertility. These soils are easily eroded if the vegetative cover is removed. An additional problem of the caatinga soils is the occurrence sometimes of indurated layer beneath the surface which prevents root penetration. In the caatinga, the most favourable soils are alluvial in origin. These cover, however, only a small area and their occurrence is haphazard.

Some socio-economic features

The Northeast of Brazil provides an excellent example of skewed distribution

of land which sometimes occurs in many developing countries. Although the size of the average holding in the forest zone and the caatinga is about 300 hectares, the existence of numerous holdings in excess of 5,000 hectares means that about 90% of the land is owned by about 4% of the population.

The major area of small holdings is found in the agreste zone, and share-cropping is widely practised in the caatinga. Shifting cultivation is also a dominant form of land-use both in the caatinga and in the forest zone.

Pressures on the land resources have intensified during this century as the population began to increase rapidly, as more and more arable land was being utilised for sugarcane production and very little was left for the production of food, and as there was an increase in animal populations. This last factor was exacerbated through the introduction of zebu cattle around the turn of the century. Because zebu feed more on grasses and herbs than do the local cattle, an additional strain was placed on the land resource. Increasing population in the caatinga has also pushed shifting cultivation into more marginal areas.

Such circumstances have tended to overstrain the natural land resources to the extent that today overgrazing is evident virtually everywhere, and loss of vegetative cover and associated soil erosion are a common sight. The repercussions of such practices are reflected in declining yields of basic food stuffs such as maize and the decreasing slaughter weight of livestock.

The increase in rural population densities has led also to over-felling of the "forests" in the caatinga for timber and fuel. This is especially important since the volume of the growing stock in the caatinga is extremely low, and the selective cutting of the more utilised tree species has impoverished the quality of the remaining crop.

JUSTIFICATION

Apart from in the sub-humid zone, the physical conditions for agricultural production in the conventional sense in the Northeast region are at best [illegible], the region is densely populated. As we have seen, this pressure has been aggravated by the utilization of the best arable land in

the area for the production of plantation crops, by extensive livestock grazing (available statistics suggest that current animal densities are in excess of carrying capacity), which has led to further land degradation, and by high rates of natural population growth. The combined result is that the region is perhaps the most depressed, in a social and economic sense, in Brazil. What is certain is that there is much human misery and suffering.

Within the region, there is a shortage of both wood and food crops and there is little doubt that the situation will worsen. Indeed, the population of the Northeast is expected to double to about 65 million by the year 2000. To sustain such a level of population, land management systems must be more productive.

Accordingly, it seems desirable to conduct research on tree-based agroforestry systems not only to attempt to increase production, but also as a means of rehabilitating environmentally degraded areas and arresting the deterioration of others.

The beneficiaries of the research which it is planned to undertake in these projects will be the rural populations of the Northeast, particularly the small cultivators.

The need for agroforestry systems is not confined only to any particular region of the Northeast, they are equally relevant for arid as well as more humid forest zones and to the palm forests. Any attempt to improve the overall conditions must consider each zone in terms of the particular systems most appropriate to it. Emphasis should be on combining multipurpose trees suitable for each zone, with annual and perennial food and fodder crops to increase the total production of the land.

THE PROJECT

GENERAL CONSIDERATIONS

Choice of techniques

The research results that will be obtained from this project will be mainly applied by small to medium scale farmers. To facilitate the widespread application of any successful results it is essential that the techniques

employed be pratical, and that these and the species used be generally acceptable to the population. Emphasis will therefore be on the use of locally known species and on systems which can be implemented. This does not mean that studies of exotic species or of systems that require special techniques will not be undertaken. These will, however, be complementary to the main programme of applied research.

Time frame

The emphasis will be on relatively short-term applied research in preference to long term basic research, so that the results could be of immediate practical applicability. Even so, the treatments cannot be fully evaluated until the tree component has completed a significant part of its growth cycle, which could mean anything from 5 to 15 years. In order to obtain useful and relevant information before this inevitable time-lag, it will be necessary to supplement conventional field trials with careful observations of existing applied or experimental practices. For example, full advantage would be taken of the knowledge that is available on species performance and cultural techniques to avoid duplication of work and to ensure that the treatments selected are the "best" under the current situations.

Choice of species

a. Tree species

As far as possible, multi-purpose tree species will be selected for use in agroforestry research programmes in the arid areas of the Northeast.

Species which inter alia

(i) produce wood that can be utilised for timber, fuelwood and charcoal;

(ii) produce foliage that is suitable for animal feed;

(iii) are drought resistant;

(iv) are well adapted to the soils and climatic conditions of the area;

(v) grow relatively quickly; and

(vi) possess soil improving qualities, will be tested.

It is unlikely that any one species will meet all these requirements, but the following four indigenous species will meet most of them:

Angico Branco/Vermelho	Piptadenia rigida/colubrina
Canafistula	Cassia excelsa
Pau ferro	Caesalpinia ferrea
Juazeiro	Zizyphus joazeiro

In addition, the exotic species Algarobeira (Prospopis juliflora) meets most of the requirements, and appears to be adaptable to the site conditions of the caatinga.

In the moister areas, less emphasis will be placed on fodder properties and drought resistance, and more will be placed on other useful characteristics. Species of interest are:

Babaçu palm	Orbignya martiana
Cashew	Anacardium occidentale
Coconut	Cocos nucifera
Carnauba palm	Copernicia prunifera
Mango	Mangifera indica
Eucalyptus	Eucalyptus spp.
Pines	Pinus caribaea var. hondurensis

b. Agricultural species

The agricultural species which will be tried in the agroforestry research programme in the arid areas are as follows:-

Buffel grass	Cenchrus cilaris
Sorghum	Sorghum vulgare
Pearl Millet	Pennisetum typhoides

In the moister areas the requirements are less exacting and more emphasis will be placed on food crops such as:

Corn	Zea mays
Rice	Oryza sativa
Cowpea	Vigna unguiculata
Cassava	Manihot esculenta

Objectives of the research

The various research projects will seek to fulfil the following objectives:-

a. ascertaining the optimum combinations of tree and fodder crops in arid areas;

b. ascertaining the optimum combinations of tree and food crops in the semi-moist zone;

c. the selection of forage and fodder species for agroforestry systems in the caatinga;

d. the development of farming systems involving various tree and arable food crop combinations in the semi-arid zone; and

e. the development of agroforestry systems involving tree plantations and cattle raising in the semi-arid and arid zones.

To attain these objectives it will be necessary to conduct:-

(i) espacement trials;

(ii) screening trials of potential multipurpose tree species, and of shrubs and trees with a fodder producing potential in different climatic zones;

(iii) tests involving various types and intensities of cultural treatments, (site preparation, planting methods, pruning and thinning).

The Strategy

The foregoing analysis indicates that the Northeast region possesses a great amount of diversity both in its ecological characteristics, as well as in the socio-economic conditions and farming practices. The research projects for the region will, therefore, be different in scope, methodology, and resource requirements. In these circumstances, four sub-projects have been identified. They are each described in the following sections.

SUB-PROJECT I

SELECTION OF FORAGE AND FODDER SPECIES FOR AGROFORESTRY SYSTEMS IN THE CAATINGA REGION

The short intense rainy season, the association of herbaceous species with trees, the long dry season, and the extremely low nutrient status of the soil all pose special problems in the production of herbaceous forage plants in agroforestry systems. Screening of herbaceous species for their suitability for inclusion in grazing systems is now in progress in some Brazilian programmes.

Objectives:

1. To identify and evaluate species of trees and herbaceous forage plants suitable for agroforestry production of wood and fodder in the Caatinga area.

2. To devise and evaluate suitable management systems for the agroforestry plantations.

Methodology:

Screening of both native and introduced species will be conducted in a programme consisting of three phases. These may overlap to some extent. Both grasses and legumes will be included in the programme.

First phase: Screening herbaceous species for agronomic characteristics and suitability for the region. Some of the screening trials now in progress should yield valuable information for this phase.

The first phase screening will be conducted on a small plot basis with candidate species planted in pure stands. Plots will be replicated at least 3 times and will be a minimum of 2 x 15 metres in size with 1/3 of the area unmowed. This will provide an area large enough to permit forage harvest for yield determinations. No animal will be included in these evaluation trials.

The following criteria will be considered in the evaluation:

(i) forage or biomass production;
(ii) ease of establishment;
(iii) rate of recovery after defoliation;

(iv) growth during the dry season - evaluate by yield from successive harvests extending into the dry period;

(v) survival

a) Recovery of established perennials after the dry season ends.

b) re-establishment of annuals during the next rainy season. For this, part of the plot should be unmowed so the plants form seed;

(vi) growth during the rainy season;

(vii) spread of species into unoccupied areas; and

(viii) survival rate.

The first phase in the screening exercise will be a continuous process and will be conducted at a minimum of 3 locations in the drier Caatinga area, each area possessing different rainfall and soil characteristics, but being representative of the area. Screening will also be conducted in thinned Caatinga.

Second phase: Forage species identified as promising from the first phase of the trials will be included in the second or evaluation phase. Two experimental areas will be established at each location with plots varying from 100 to 200 $m.^2$ These experimental plots will be located in areas where cattle may be introduced to test the effects of grazing on the growth and survival of the species. No attempt will be made to determine the performance of the cattle or their growth in these trials.

The intensity of grazing will be as follows:

a) Moderate grazing: Cattle will be turned loose in the area and will be permitted to feed until most of the foliage is removed. Cattle will be removed before plants are completely defoliated. This will be done once during the rainy season and again on regrowth during the dry season.

b) Heavy grazing: The cattle will be allowed to defoliate plants completely at least once during the growing season and again during the dry season.

Observations on the species included in the second phase will be made on the following criteria:

(i) palatability;

(ii) amount of forage destroyed by trampling;

(iii) rapidity of recovery after grazing

a) during rainy season

b) during dry season; and

(iv) survival of perennials and re-seeding of annuals in the next season following different grazing schemes.

Species that show promise from these trials should be sampled at various stages of growth and for mature forage during the next dry intervals in the dry season. The in vitro dry matter digestibility of the forage should then be determined by suitable techniques such as the Lilly and Terry method and/or the acid detergent fibre method. Crude protein should also be determined from the samples.

At least 3 species that should be included in phase II trials have already been identified. These are: Buffel grass (Cenchrus ciliaris), the forage bean Phaseolus sp., and Opuntia sp.

Third phase: The species which have survived the initial screening trials should be then planted out with multipurpose woody species. The tree species which seem to be suitable for multipurpose plantation, in the Caatinga area are:

- Caesalpinia ferrea (Pau ferro)
- Cassia excelsa (Canafistula)
- Mimosa caesalpinifolia (Sabia)
- Piptadenia spp. (Angico vermilho)
- Prosopis juliflora (Lagarobo)
- Zizyphus joazeiro (Juazeiro)

Information on more species will be available from the trials proposed in Sub-project II.

These trees will be planted in mixed stands at 3 metres spacing within rows and alternatively at 5 and 8 metres between the rows.

Measurements of growth be taken annually for the first three years of the project. Selected trees will be pruned each year to ¼, ½ and [illegible] of crown depth.

Assessment of the yield of fodder will be carried out by weighing pods and lopped branches, or by sampling in the case of strict browsing. The fodder value will be assessed by chemical analysis.

Prosopis juliflora has proved to be well adapted to conditions in the Caatinga area, and has been used as a fodder species. Separate trials will be conducted with this species in combination with forage species, on comparatively deep and fertile soils where Prosopis can reach a large size in a short time, and yield an appreciable volume of fuelwood, pods and even small saw timber in addition to valuable foods (6000 kg/ha on an average according to some investigations). The trees will be planted at a 6 m espacement within the rows, with 3 different spacings between the rows being applied: 6, 12 and 18 metres. The trees will also be pruned each year to ¼, ½ and ¾ of crown depth.

Trials of Acacia albida on deep alluvial soils with a permanent water table even at great depth will also be undertaken. Spacing at planting out will be 4 x 4 m. The species has a slow growth in the young age, and needs pruning and possibly staking in order to obtain a straight bole of adequate height. As soon as the roots reach the water table, the trees develop quickly, and thinnings which leave a final stand of about 100 of the best trees will be carried out. All the tree species will be interplanted with forage species. Plots will include 3 rows of trees at the specified spacings with a buffer row on the border. The forage species will be interplanted in plots 15 to 20 m long and randomized within the tree plots.

Evaluations will be of the following:

(i) initial growth of different woody species with various forage combinations;

(ii) height and/or diameter growth of trees, annually for the period of the experiment;

(iii) productivity of individual forage species, and in combination;

(iv) production of forage and tree species;

(v) survival of individual species, and in the combination;

(vi) changes in productivity of different species with passage of time;

(vii) shade tolerance of forage species;

(viii) performance of plant associations when grazed.

The third phase evaluations would include several small experiments. Some measure of forage production will be determined from ungrazed areas and grazing will be introduced in other experiments to evaluate survival on systems that include animals. Some of the grazing studies will be directed toward deferred utilization of forage during dry periods.

The research in this sub-project will be conducted at several locations and coordinated with trials currently in progress.

The next phase of this research will be the initiating grazing trials with promising combinations.

SUB-PROJECT II

SCREENING OF TREE SPECIES SUITABLE FOR AGROFORESTRY IN THE CAATINGA AREA

Screening trials (or "elimination trials" as they are often described in the forestry literature) are the first step in identifying suitable tree species, for introduction in new or difficult localities. They should aim at assessing adaptability of a range of species to the site conditions, and at obtaining a rough estimate of their potential productivity. One of the main criteria to be considered here is the yield of fodder in the form of foliage and/or pods. Therefore the list of species to be tried will be largely limited to the Leguminosae, the outstanding exception being Zizyphus spp.

Other useful products will be mainly wood for fuel, charcoal, posts, poles, and small size saw timber, tannin (pods, bark), gum, fruits, honey, etc.

Native species

The native species found in the Caatinga are well adapted to the local climate and soil conditions. Therefore, the main purpose of the screening exercise will be to eliminate those species which have a slow growth rate and/or are too difficult to establish. In addition, of course, promising species will be identified for further trials and studies.

The list will include the following species:

Mimosaceae:

Acacia piahuiensis (Rama de Boi).
Anadenanthera macrocarpa (Anjico). Also for timber production.
Mimosa caesalpinifolia (Sabia). Excellent species, fast growing. It will retain its leaves during the dry season only in wetter areas. Yields good fuelwood, charcoal and posts, and coppices vigorously after exploitation. It is a good species for honey. It has been used successfully in association with timber species (e.g. Swietenia macrophylla) in wetter areas.

Mimosa hostilis (Jurema preta)

Mimosa invisa (Jurema preta)

Parkia platycephala (Faveiro) - found only in the wetter parts of the Caatinga area.

Piptadinia colubrina (Anjico branco).

Piptadinia macrocarpa (Anjico vermelho) - Both species have a bark rich in tannin.

Piptadinia obliqua (Anjico de Beserro).

Pithecellobium multiflorum (Canafistula).

Pithecellobium parviflorum (Arapiraca).

Pithecellobium viridiflorum (Espinheiro).

Caesalpiniaceae:

Bauhinia cheilantha (Morocco). This shrub is one of the best fodder species found in the Caatinga.

Caesalpinia ferrea (Juca Pau Ferro) - Some authors consider Juca as a variety distinct from Pau Ferro found in wetter areas. This is one of the best fodder and timber species of the Caatinga.

Caesalpinia piramidalis (Catingueira). Also a good fodder species.

Casia excelsa (Canafistula). Good fodder species.

Papilionaceae:

Torresea cearensis (Camaru)-Yields a medium density timber, resistant to insect attack; suitable for furniture.

Rhamnaceae:

Zizyphus joazeiro (Juazeiro). Due to its deep rooting system, Juazeiro is one of the very few Caatinga species that retain their foliage throughout the dry season. The leaves can be used as fodder both in the green and dry forms.

Exotic species

Only the most drought resistant tree species are liable to succeed in the Caatinga area, where the shallowness of soils and the irregular distribution of rainfall create conditions extremely unfavourable to tree growth. Trees which are found under similar latitudes in Africa, with an annual rainfall as low as 200 mm or less, but with no deep sandy soils, may not succeed here where soils have a very low water retention capacity and possess a shallow fragipan.

Anacardiaceae:

Spondias tuberosa (Umbu) - yields edible fruit, rich in Vitamin C.

Euphorbiaceae:

Cnidoscolus phyllacanthus (Faveleiro) - yields edible seeds with a high content of oils, protein and minerals.

Acacia albida - to be tried only in deep alluvial soils, where its roots are capable of penetrating to a considerable depth to reach the permanent water table. The leaves are borne during the dry season. Together with the thick fleshy pods they provide valuable fodder.

Acacia nilotica spp adansonii (Syn. A. scorpioides var adstringens).

This xerophilous sub-species of Acacia nilotica yields leaf fodder and pods, which are a major source of tannin in the Sahelian zone of Africa.

Acacia senegal: main source of gum arabic in Africa. Will be tried in deep sandy soils.

Acacia tortilis: this is the most drought resistant tree Acacia in the sub-desertic zones of Africa and Asia. There are several sub-species, the best adapted to the Caatinga area being probably those occurring in low latitudes, spp. raddiana of the Sahelian zone, and spp. spirocarpa of East Africa.

Conocarpus lancifolius: native of Somalia, and one of the very few timber species found in the very arid zones of Africa. It would however succeed only in alluvial soils with a permanent water table of reasonable depth.

Pithecellobium dulce: yields pods which are suitable as fodder and even for human consumption.

Prosopis juliflora (Algarobo): the genus Prosopis was revised by A. Borkart (1976), who recognized some forestry species native to North, and South America. Prosopis juliflora, as now accepted, is found, according to Borkart, in Northern South America (Venezuela, Colombia) Panama, Central America to Mexico and the Antillean Islands, whereas P. chilensis, with which it had been confused in the past, is found from Peru and Bolivia to central Chile and north-eastern Argentina. It would seem therefore that the Prosopis introduced to North-East Brazil,

from northeastern Peru, would actually be P. chilensis, although Borkart mentions P. juliflora as "cultivated in northeastern Brazil".

Whatever the species, it seems to be well adapted to local conditions. However, various provenances from dry areas of low latitudes will be tried in an attempt to identify provenances with a high yield and high fodder value of pods.

Zizyphus spina-christi: this extremely drought resistant African species will be tried and compared to the native Zizyphus joazaro. It yields edible fruits.

Layout of trials

The trials will be sited on homogenous areas of comparatively deep and fertile soils, the final objective being to find tree species with a high potential for fodder and wood production to supplement the relatively poor grazing now supplied by the vegetation of the Caatinga, and produce wood mainly to be converted into charcoal to meet the requirements of rural and urban populations, and also some roundwood for fence posts, poles, etc. At least 3 experimental areas will be set up in various locations in Caatinga areas with different rainfall. The trees should be planted at 2 x 2 m spacing, on square plots in randomised distribution. There will be 4 repetitions for each species.

Each square will comprise 25 plants. Only the inner part, i.e., 9 plants in each square, will be assessed for growth.

Plants will be counted in each plot at the end of the first growing season, in order to assess the rate of survival. Dead plants will be replaced at the beginning of the next rainy season.

Measurements should be taken at the end of each growing season for:

- height growth
- stem diameter
- crown diameter.

In addition, permanent phenological observations will be carried out, e.g. flushing and shedding of foliage, flowering, fruiting, etc., as well as observations on susceptibility to diseases and pests.

The species which show the best performance in the screening trials will be selected for further trials in combination with forage herbaceous species as described in the separate sub-project.

SUB-PROJECT III

LAND MANAGEMENT SYSTEMS INVOLVING TREES AND ARABLE FOOD CROPS FOR NORTHEAST BRAZIL

Objectives:

(i) To develop systems of combination cultures of trees and arable crops suitable for the relatively wetter regions of Northeast Brazil.

(ii) To devise suitable agrotechniques for such systems.

(iii) To assess the growth and production potential of the individual species in combination cultures and the total productivity of the system.

(iv) To evaluate the effect of combination cultures on the soil and suggest appropriate soil management practices.

Strategy:

These systems are mainly intended for those areas in the Northeast of Brazil where rainfall is comparatively high (over 1000 mm/annum) and where tree crops such as coconut, cashew, babaçu palm etc. are grown. Defective cultivation practices in these area have led to considerable soil erosion and to a deterioration in the fertility of the soil. Agroforestry systems combining tree crops and arable (annual) crops seem suitable for increasing the productivity of the areas and the profitability of farming in areas where the pressure on land is high and farm size is small. In addition, of course, to helping in the conservation of the ecosystem.

Two types of situations are contemplated:

(i) areas where tree crops are already existing, and

(ii) areas in which new plantation are to be established.

In existing plantations, where the canopy has not yet closed, the strategy will be to plant arable crops under the tree crops. Canopy closure will depend, of course upon the tree species, its age, system of planting and planting density. As a working rule, if the area of interspaces in the plantation receive more than 50% of sunlight than in the open, such plantations will be considered suitable for intercropping.

The interspace will be cleared of weeds before planting the intercrops.

Thereafter, systematic mechanical thinnings of the forest trees will be employed as and when the canopy closes. In addition, in some of the plots pruning will be conducted at ¼, ½ and ¾ of the length of the crowns of the forest trees.

In areas in which new plantations are to be established, the interspaces will be interplanted at the time of planting out of the tree species. After canopy closure, the plantations will be subjected to the same treatment and pruning regimes as in the established plots.

Treatments

Tree crops: cashew, *Anacardium occidentale*
coconut, *Cocos nucifera*

Pines: *Pinus caribaea*, var. *caribaea*
Pinus caribaea var. *hondurensis*

Eucalyptus: *Eucalyptus* (*camaldulensis*)
E. (*tereticornis*)

leucaena leucocephala

Annual crops: Maize, *Zea mays*
Cassava, *Manihot esculenta*
Rice, *Oryza sativa*
Peas, *Vigna* spp.
Maize + Peas
Soybeans, *Glycine max*

Areas already planted with any of these tree crops will be considered the experimental site and the inter-crop schedules will be the treatments. The experiment will be repeated for different tree crops.

The intercrops will be planted continuously on the same plot every year; in addition, the same intercrop will be grown in rotation with other crops every year in another set of treatments. The treatments will be chosen and restricted, depending upon the availability of uniform areas and other resources. There will be a "no intercrop" control. A list of treatments is given below:

(i) No intercrop control
(ii) Cassava as intercrop every year
(iii) Maize as intercrop every year
(iv) Peas as intercrop every year
(v) Rice as intercrop every year
(vi) Soybeans as intercrop every year
(vii) Maize and beans as intercrops every year
(viii) Rotation of intercrops: Cassava - maize & peas - rice - peas - maize - soybean

Any of the intercrops may be excluded from the scheme; so also, the number of crop rotations may be increased.

Methodology

1. The intercrops and the tree crops will be planted and managed (including fertilizer application to the crops) according to the regular cultural practices for the sole crops stands of those crops.

2. The plot size will be sufficiently large to have at least 8 trees in a plot with a row of border trees all around which could form a common border with the adjacent plots.

3. The experiment 3 be laid out in a Randomized Block Design with sufficient replications so as to have enough degrees of freedom for error in the analysis of variance. (e.g., for 7 treatments, the number of replications to be a minimum of 3).

4. In the experiment in existing plantations with irregular plantings of tree crops, the total area available for intercropping per plot should be almost uniform in size. The area used for intercropping will be so chosen that computations on a unit area basis will be facilitated.

5. The trials will be conducted for 3 years in the first instance.

6. The experiments will be conducted in existing research stations.

Studies/Observations

1. Measurements on the growth of the intercrops from sample areas selected at random at periodic intervals.

2. Observations of the growth characters of tree crops. In new plantings of tree crops, the growth characters during early years of growth can be

easily recorded. But in existing plantations, the measurements may be recorded before initiating the experiments and after the harvest of each intercrop. The general vigour of trees will be recorded by a score of relative rankings, e.g. height, basal diameter, degree of branching etc.

3. Yields of the individual crops.

4. Inventory of the inputs used for each treatment.

5. Economic calculations on income accrued, to be recorded based on the current market price of the produce at the time of harvest.

Soil studies

1. Fertility status of the soil before the commencement of experiments and after the harvest of each intercrop.

2. Foliar analyses of the tree crops at yearly intervals.

3. Soil erosion studies: Run off, sedimentation etc.

SUB-PROJECT IV

AGROFORESTRY SYSTEMS INVOLVING PLANTATION TREES AND CATTLE RAISING

Objectives:

(i) To develop integrated systems of cattle raising and tree crops in the more favourable climatic regions of the Northeast.

(ii) To develop suitable agroforestry techniques for such areas.

(iii) To assess the growth and production potential of planted grass species and natural vegetation as forage.

(iv) To evaluate the effects of cattle raising on tree crop production.

(v) To determine what periods in the life of the plantations are suited to cattle raising.

Research Strategy:

A feasibility study to assess the current systems of cattle and tree crops in the Northeast will be the initial step. The ICRAF survey revealed that cattle raising exists to a limited degree in association with coconut, cashew, babaçu and carnauba cultivation. For purposes of the feasibility study, natural stands of babaçc and carnauba palms which receive some management will be included.

The feasibility study will seek information on the following points:

(i) the extent to which cattle are currently being grazed in the four types of plantation;

(ii) the livestock breeds of the animals;

(iii) the types of grasses and/or forage species being grazed;

(iv) the periodicity of grazing within the plantations. How early in plantation development does it begin? How long does grazing continue?

(v) are cattle grazed in the plantations only during certain seasons? For the entire year, what is the approximate carrying capacity of the four plantation types, considering the conditions and forage type?

(vi) the specific problem associated with cattle raising in plantations.

Methodology:

Treatments will be carried out in stands of mature existing babaçu and carnauba palms through thinning to densities to 7.5 x 7.5 and 10 x 10 metres. Randomly selected plots of 20 hectares will be subdivided into 5 hectare sections, the four plots receiving the following treatments:

(i) spacing of 7.5 x 7.5 with planted grass;
(ii) spacing of 7.5 x 7.5 with natural vegetation - regeneration except palms;
(iii) spacing of 10 x 10 with planted grass;
(iv) spacing of 10 x 10 with natural vegetation. (All spacings in metres)

Once the paddocks have been established, cattle will be introduced at a density of 2 ha per paddock. The animals used will be approximately of the same age and weight; this treatment will continue for one year. The treatment will be repeated for a second year with only 1 head of cattle per paddock. Stocking rates may be varied if the feasibility study shows them to be inappropriate.

Another set of treatments will be carried out in existing cashew and coconut plantations. Here it will not be possible to vary tree density of the cashew plantations because of uniform 10 x 10 spacing, but it will be possible to select sites which have two different spacing densities of coconut palms.

Randomly selected plots of 20 hectares will be subdivided into 5 hectare sections. The four plots would have the following treatments:

(i) planted grass with 2 heads of cattle;
(ii) planted grass with 1 head of cattle;
(iii) natural vegetation regeneration with 2 heads of cattle;
(iv) natural vegetation with 1 head of cattle.

Randomly chosen plots of 10 hectares (2 plots) selected for different coconut tree densities of mature trees. The four plots would have the following treatments:

(i) close density with planted grass, with 2 heads of cattle;
(ii) close density with natural vegetation with 2 heads;
(iii) sparse density with planted grass with 2 heads;
(iv) sparse density with natural vegetation with 2 heads.

Continue for one year, then repeat treatment with 1 head of cattle per paddock.

Studies and observations

1. Determination of optimal carrying capacities for different plantation types, different tree densities and different types of forages.
2. Determination of stands of plantation growth where grazing can be practised.
3. Bi-weekly recordings of the weight of animals confined to the paddocks.
4. Measurement of dry matter productivity and protein content of forage once every four weeks.
5. Calculation of the effect of grazing on tree product yields as compared to average yields per hectare without cattle grazing.
6. Determination of overall income from integrated cattle raising and tree crop production compared with that obtained from sole map production systems.

PROJECT LOCATIONS

The headquarters of the Project will be in Brasilia.

Sub-projects I and II will be located at Teresina. Sub-project III will be located at Natal and Nisa Florestal, and along the Salvador-Petrolina Road. Sub-project IV's location will be Acú. There are reseach stations at or near all these sites.

ANCILLIARY STUDIES

The sub-projects indentified and described in this document offer a measure of flexibility and adaptability to varying conditions with respect to selection of research areas in a variety of experimental locations. The results of these projects can give satisfactory solutions to only some of the many problems of land management in the Northeast. They will provide some information on the behaviour of the systems under specific conditions, and probably raise additional questions to be addressed to the future. Therefore it is necessary to follow up each of the sub-projects undertaken with additional investigations to understand fully the reasons for the observed behaviour. Some of the

ancilliary lines of research are:

1. Changes in the physical, chemical, and biological properties of the soils and their effect on plant growth.
2. Interaction of plant communities - both complementary and competitive - when they are grown in close proximity.
3. The reaction of the new systems to varied climatological patterns which are likely to occur from year to year.
4. Acceptability of the systems by the farmers and the probable shifts in social patterns.
5. Determination of agroecological zones for the respective agroforestry systems adopted.

Separate series of experiments will be necessary to evaluate each of these aspects. These are planned to be initiated after the initial results of the proposed sub-projects are available and are ready to be transferred to the farmers.

IMPLEMENTATION OF PROJECT

BRAZILIAN ORGANIZATIONS

Until the creation of the National Programme of Forest Research (PNPF), research on reforestation and forest management was undertaken in Brazil by IBDF (Brazilian Forestry Development Institute). This Institute conducted forestry research in the Northeast, at experimental stations located in different ecological zones. The administrative and functional structure of agricultural research in the region was more complex, in that research was undertaken by Federal research agencies, State agricultural agencies, Regional development agencies, and Universities. Moreover, more of these agencies devoted much attention to tree crops.

The assumption by EMBRAPA (Brazilian Agricultural Research Enterprise) of the role coordinating all agricultural research in the Northeast, and the establishment of the Centre for Agrolivestock Research in the semi-arid tropics (CPATSA) at Petrolina, have rationalised the administration of research in the region, and have been a major contribution to more efficient and co-ordinated research.

There is an adequate number of well-trained scientists and researchers in the Region, in all the fields it is desired to cover, and EMBRAPA will co-ordinate the required work. The incorporation of elements of the FNPF into the network by adding the Executive Unit of Forest Research in the Northeast to CPATSA will greatly strengthen the capability for multidisciplinary agroforestry research in the project. The administrative and scientific expertise in this network will be utilized in the project (see Appendix 1).

EXTERNAL STAFF INPUTS

As Brazilian expertise is adequate for the project, there is need, permanently on the project only for a Project co-manager to act as a link between EMBRAPA and ICRAF, to assist in the general administration of the project, and to co-ordinate the activities of the various sub-projects. The job description of the project co-manager is shown in Appendix 4.

However, in addition to the co-manager provision is made for a number of consultants to assist in the final design and layout of the experiments, in tendering advice on specific aspects of agronomy, forestry, soil science and animal husbandry and in the forward planning of the project. Costings and details are shown in Appendix 1.

SUPPORT STAFF

EMBRAPA will supply all the support staff and bear the costs of their emoluments and other benefits. The needs and estimated costs are shown in Appendix 1.

The custody of project funds released by ICRAF for disbursement in this project in the Northeast of Brazil will be vested in the EMBRAPA Chief Accountant. EMBRAPA will designate at least one Assistant Accountant/ Accounts Assistant who will be responsible for the project funds under the Chief Accountant.

ICRAF INVOLVEMENT

Recruitment of Co-manager and Consultants

The recruitment of the project co-manager and consultants, as outlined in Appendix 4, will be carried out by ICRAF in consultation with EMBRAPA. ICRAF will also be responsible for paying their salaries, relocation costs

and allowance.

Project Monitoring

ICRAF's core staff, located in Nairobi, will provide technical and scientific advice and support to the field staff. Visits of ICRAF core staff will be made when necessary, to the various sites and sub-project headquarters. In addition, monitoring and evaluation exercises will be undertaken by ICRAF (in collaboration with EMBRAPA) at six monthly intervals in the first eighteen months of the project. Thereafter, evaluation and monitoring will be carried out at yearly intervals in conjunction with forward planning exercises.

Education and Training

A seminar will be organised, in the first year of the project, for professional and sub-professional technical staff engaged in the project to acquaint them with the methodologies and techniques to be employed in the project. In the third year of the project a seminar for Latin America experts working in the field of agroforestry research in areas similar to the Northeast of Brazil will be conducted. This second seminar will seek to interpret the results so far obtained in the project, to examine their extrapolability, and to discuss the research methodologies and techniques that have been used.

In addition to these seminars, provision is made in the second year for short-term training, of six months duration at selected institutions to Brazilian experts in the project, in fields identified as being of particular importance to the continuation of agroforestry research in Northeast Brazil.

These seminars and training courses will be organized by ICRAF, in collaboration with EMBRAPA.

Project Revision and Forward Planning

ICRAF will organize teams to assess project progress at one yearly intervals. Based on a study of the recommendations of the review teams, ICRAF will consult with EMBRAPA and decide on modifications and extensions.

PROPOSED BUDGET

Donor contribution

The anticipated donor contribution which will be channelled through ICRAF is US $ 1,131,400 or US $ 377,100 annually for three years. The total donor contribution includes a capital budget of US $ 25,000. The donor contribution towards personal emoluments and consultants is estimated at US $ 652,000 of which US $ 412,000 are for consultants. Training costs attributed to the donor are assessed at US $ 112,000.

Grantee contribution

The Government of Brazil will contribute US $ 862,500 or US $ 287,500 annually for three years. Capital costs are estimated at US $ 90,000; and personal emoluments at US $ 348,000.

PROPOSED BUDGET

ICRAF CONTRIBUTION

OPERATIONAL BUDGET

Salaries and allowances	YEAR 1 US $	YEAR 2 US $	YEAR 3 US $	TOTAL US $
1 Project co-manager 6 x 2 months	75,000	80,000	85,000	240,000
Consultancies	126,000	136,000	150,000	412,000
	201,000	216,000	235,000	652,000
Research Expenses				
Cultural practices	17,000	18,800	20,800	56,600
Vehicle maintenance	5,000	5,600	6,200	16,800
	22,000	24,400	27,000	73,400
Transport and Travel				
International (visits to projects, meetings etc.)	13,000	14,000	15,000	42,000
Training (including travel)				
2 x 2 weeks seminars for local and other Latin American researchers	28,000	-	28,000	56,000
Training: 2 Foresters		15,000		15,000
2 Agronomists		15,000		15,000
1 Animal Husbandry specialist		7,500		7,500
1 Sociologist/Economist		7,500		7,500
2 Publications		5,000	6,000	11,000
	28,000	50,000	34,000	112,000
	264,000	304,500	311,000	879,500
Contingencies (10 %)	26,400	30,400	31,100	87,900
Total Operational Budget	290,400	334,900	342,100	967,400

CAPITAL BUDGET

	YEAR 1	YEAR 2	YEAR 3	TOTAL
	US $	US $	US $	US $
Field Equipment	9,000	4,000	2,000	15,000
Lab. Equipment	5,000	3,000	2,000	10,000
Total Capital Budget	14,000	7,000	4,000	25,000

ICRAF BUDGET SUMMARY

Operational	290,400	334,900	342,100	967,400
Capital	14,000	7,000	4,000	25,000
	304,400	341,900	346,100	992,400
ICRAF servicing charge 14%	42,600	47,900	48,500	139,000
Grand Total	347,000	389,800	394,600	1,131,400

PROPOSED BUDGET

EMBRAPA CONTRIBUTION

OPERATIONAL BUDGET

	YEAR 1	YEAR 2	YEAR 3	TOTAL
Salaries and Allowances	US $	US $	US $	US $
2 Agronomists (50% of time)	20,000	20,000	20,000	60,000
2 Foresters (50% of time)	20,000	20,000	20,000	60,000
1 Animal Husbandry Specialist (50% of time)	10,000	10,000	10,000	30,000
1 Accountant (25% of time)	4,500	4,500	4,500	13,500
1 Accts. Asst. (50% of time)	2,500	2,500	2,500	7,500
3 Technicians, Agr.	18,000	18,000	18,000	54,000
3 Technicians, For.	18,000	18,000	18,000	54,000
1 Senior Technician	9,000	9,000	9,000	27,000
2 Secretaries/Typists	8,000	8,000	8,000	24,000
2 Messengers/Cleaners	6,000	6,000	6,000	18,000
	116,000	116,000	116,000	348,000
Research Expenses				
Surveying and Mapping	80,000	75,000	-	155,000
Nursery costs	10,000	6,000	3,000	19,000
Cultural practices (including plant inputs etc.)	15,000	16,000	18,000	49,500
Office Supplies	15,000	10,000	3,000	28,000
	120,000	107,500	24,000	251,500
Transport and Travel				
Internal travel for project personnel	50,000	55,000	60,000	165,000
Publications				
Reprints etc.	1,500	2,500	4,000	8,000
Total Operational Budget	287,500	281,000	204,000	772,500

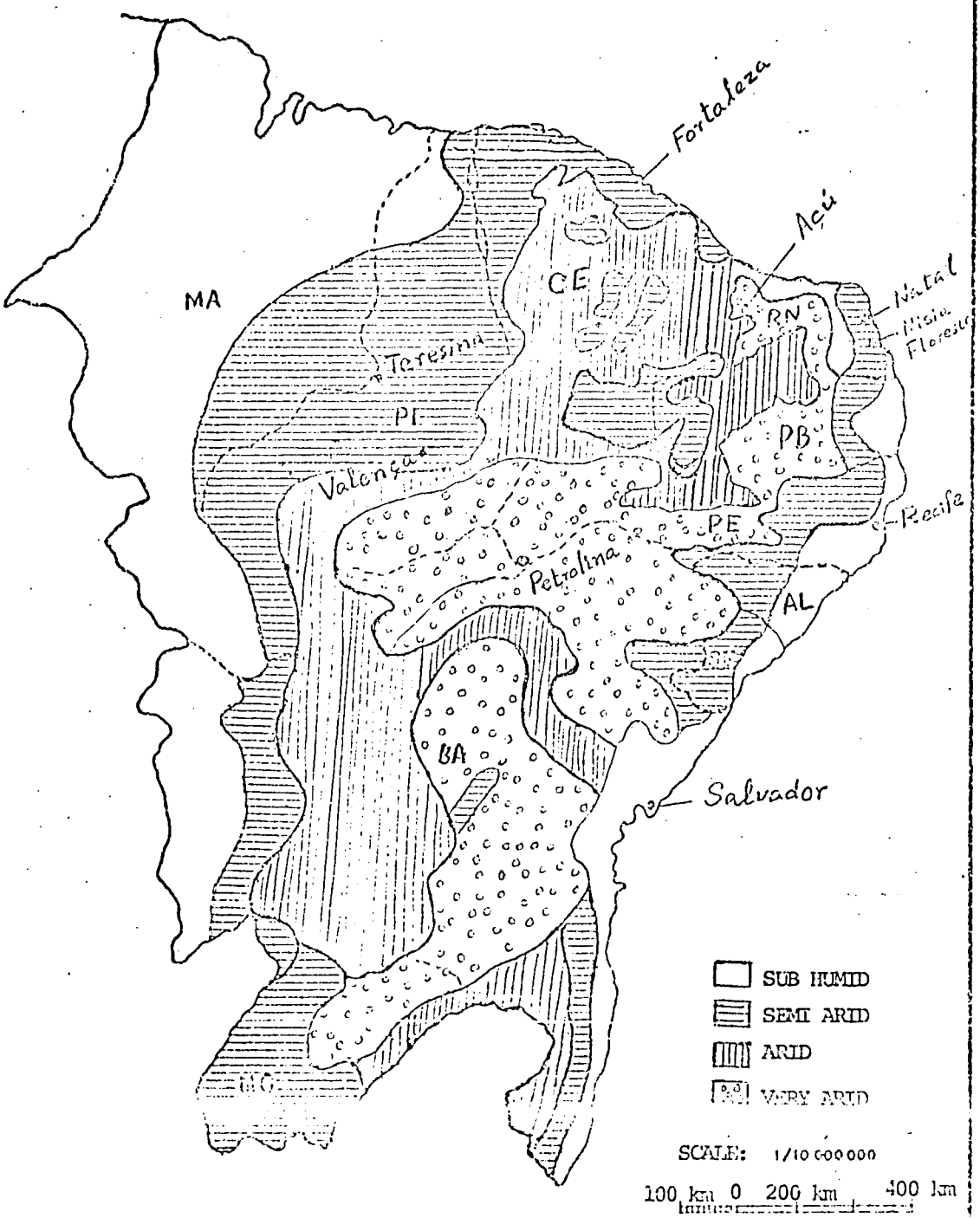
CAPITAL BUDGET

	YEAR 1	YEAR 2	YEAR 3	TOTAL
	US $	US $	US $	US $
Field Equipment	11,000	9,000	7,000	27,000
Construction (storage shed, office, field labs.)	25,000	-	-	25,000
Lab. equipment	13,000	10,000	3,000	26,000
Office equipment	7,000	3,000	2,000	12,000
	56,000	22,000	12,000	90,000

EMBRAPA BUDGET SUMMARY

Operational	287,500	281,000	204,000	772,500
Capital	56,000	22,000	12,000	90,000
	343,500	303,000	216,000	862,500

CLIMATIC ZONES OF NORTHEAST BRAZIL



SOIL MAP OF TROPICAL SOUTH AMERICA

JOB DESCRIPTION
PROJECT CO-MANAGER

Duties and Responsibilities

The Project co-manager, working under the general direction of the Director-General of ICRAF and the Director-General of EMBRAPA, will assist in the implementation of the cooperative agroforestry research programme of the Government of Brazil and ICRAF. His responsibilities will inter alia include the following:

(i) administration of the project, including the overall coordination of the planning and implementation activities of the project;

(ii) procurement of materials, equipment and supplies for the project under donor contribution funds;

(iii) accountability for all matters pertaining to fund disbursement, the custody of the funds however being with the EMBRAPA or ICRAF management, as appropriate;

(iv) preparation of detailed prgorammes of work and budget, within budgetary limits in the project agreement, and clearing the plans with ICRAF and EMBRAPA prior to implementation;

(v) preparation and submission of quarterly and annual scientific progress reports on the project;

(vi) co-ordination of the on-the-job training programmes for Brazilian cooperating scientists and support technical staff so that these effectively impart the concepts, principles and practices of agroforestry and the research methodology appropriate to the different fields of work;

(vii) advising the Government of Brazil (through EMBRAPA) and ICRAF on all matters pertaining to the project;

(viii) advising on reviews for the project and on the need for consultancies for the project; and

(ix) participating in the research activities of the project in the area of his professional competence.

Qualifications

The Project co-manager should have at least a Ph.D. in agriculture, forestry, horticulture or animal production.

He should have at least 10 years of professional experience in the development, conduct, and administration of research work at research institute or university level. A significant proportion of his research experience should have been gained in the tropics or sub-tropics and should have involved multiple cropping systems, with or without the integration of a woody species component.

The Project co-manager should have the ability to write clear and concise analytical reports.

He should have full working knowledge of English (UN level 6) and Portuguese (UN level 4).

He should also have the ability to establish and maintain effective working relationships with persons of different national and cultural background.

Duty Station

Brasilia, Brazil.

Assignment Period

3 years.