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A REPORT ON TECHNICAL COOPERATION IN AFFORESTATION FOR THE PRESERVATION ON THE ENVIRONMENT IN BAHIA STATE, BRASIL

JULY 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

1. The Organization which Requested Cooperation

The Petro-chemical Complex Public Corporation of the Camaçari District under the jurisdiction of the Mining and Power Bureau of the Bahia State Government, Brazil

COPEC (Complexo Petroquimico de Camaçari)
(The organization responsible for the project)
The public corporation Coodenador: Raimundo Mendes de Brito
Chief of the afforestation group
Dorian de Souza Engenheiro Agrônomo
Chefe do Groupo de Florestamento do COPEC

2. Period of Cooperation

From October 30th, to November 22nd, 1975
Specialists dispatched to Bahia State, Brazil
Afforestation specialists:
Kyoji Doi (Forestry Experimental Station, Forestry Agency)
Masayuki Yamada (Foundation : Japan Afforestation Center)
Yasuhiro Nakajima (Forestry Experimental Station, Fukuoka Prefecture)

3. Cooperation Requested by Bahia State

1) How the request for technological cooperation came

In December, 1972, the Bahia State Government asked Japan for the dispatch of specialists on the preservation of the environment on the occasion of the construction of the Camaçari Petro-chemical Complex. In May, 1973, Mr. Masaharu Kawasaki of the Mitsubishi Chemical Industries, Ltd. visited Bahia State and submitted a letter of recommendations to the state government after joint studies and discussions with Brazilian technicians in charge of making a master plan for the construction of the projected petro-chemical complex.

The afforestation for the preservation of the environment was started on the basis of the recommendations. Since the afforestation project was the first experience for the Bahia State Government, however, it requested again the dispatch of Japanese specialists on afforestation in order to solve various problems.

The request was made in a letter from the Bahia State Governor to the Japanese Ambassador to Brazil, Mr. Uyama, in September, 1975, and a letter of request for cooperation was formally submitted to the Japanese Government by the Foreign Ministry of Brazil in March, 1976.

2) What was requested by Bahia State

COPEC (Complexo Petroquimico de Camaçari) has entrusted private companies with construction works for road, railway, waterway and waste disposal systems under execution plans based on the basic plan. However, COPEC is directly carring out the afforestation project according to the plan made by its afforestation group on the basis of the basic plan.

However, it was the first experience for COPEC, which needed to solve such problems as the choice of trees highly resistant to smokes, soil amelioration and the conservation of birds and animals. COPEC asked for Japanese cooperation in the solution of these problems because a solution could be found theoretically but the application of theories to the local situation involved difficulties.

4. The Results of Researches

1) The location of the area under survey

The site of the Camaçari Petro-chemical Complex is located about 40 km north-northeast of Salvador, the state capital of Bahia, Brazil. Its center is situated at about 12°40′ South Latitude and 38°20′ West Longitude. The area is attracting public attention as the site of a new petro-chemical complex in Brazil and it is also listed as the place most suited to such an industrial complex in the northeastern part of the country.

2) The natural environment in the area under survey

a) Topography

The area which is about 20 km inland from the coast line is a low platform in the old age. There are a flatland area and independent or continuous salient land about 50m in height. There are many accidents in the northern, eastern and southern parts of the area under survey.

The low-lying land near the center is grassy and has some shrubs. It is submerged in water in the rainy season. There are no rivers but the area is studded with lakes and swamps.

b) Geological features

Sandstones and shales of the São Sebastiao Formation belonging to the Cretaceous period are widely spread on the bedrock, and on these stones are the strata of the Marizal Formation and of the Barrierias Formation of the Tertiary period, which are spread around the salient land. There is an alternation of the strata of micro-sandstones, shales, kaolin-type clay and sandy and conglomerated rocks. At some places, there are impermeable layers of ferrous rocks.

c) Soil

The soil is generally laterite peculiar to the tropical region. But, because of geological features and topography, there are also areas of what might be called parent materials rather than soil, such as the areas of near-white sandy soil, yellow and yellowish-white weathered shales and efflorescences of soil, mainly kaoline.
Generally speaking, trees grow faster on the thick stratum of red soil than the strata of other types.

d) Weather

There are no sufficient data on weather in the area under survey since weather observation there has just started. Here are the data of weather observation by the Aviation Ministry's observatory in Ipitanga which is the observatory closest to the area under survey.

The table shows that the weather is of the tropical type and the temperature and humidity are high. But the weather is bearable because the area is close to the Atlantic coasts and under the influence of the ocean. The rainy season lasts from the end of autumn to the middle of winter, or from April to June. It might be said that the precipitation is of the winter rain type.

A table of data on weather observation (Ipitanga)

Annual average of temperatures	25.3°C
Annual average of the highest temperatures	28.7°C
Annual average of the lowest temperatures	21.6°C
Annual average of humidity	78.9%
Annual average of atmospheric pressure	1,013.9 mb
Annual total of precipitations	1,615.3 mm
Smallest monthly precipitation	45.5 mm
Largest monthly precipitation	562.5 mm
Largest precipitation in 24 hours	192.3 mm

e) Vegetation

The Salvador area has been developed for a long time since Salvador is the old capital of Brazil. There are no natural forests but the area is studded with small, secondary forests of broad-leaved trees of low quality. There are associations of low trees and taller trees along water systems down to valleys. The low-lying marshland is generally grassy. The scenery of the area is barely saved from dullness by orchards called Syacara and woody areas near villas.

(3) The method of making forests

a) An outline of afforestation

The total area for the construction of the petro-chemical complex amounts to 21,750 ha. A breakdown is shown in the table. The forestry for the conservation of the environment accounts for a little less than 40% of the total, but the ratio reaches 52%, if the area to be used for purposes yet to be decided is excluded from the total. Accordingly, the afforestation group of COPEC is in charge of afforestation of the area of more than 8,000 ha.

Table : Classification of the land to be used for the Petro-chemical Complex of the Camaçari District

Classification	Space	Ratio
Total area	21,750 ha	100%
Residential districts	2,960 ha	14%
Factory districts	4,620 ha	21%
Forests	8,260 ha	38%
Area for undecided purposes	5,910 ha	27%

The forests for the preservation of the environment are located around the site of factories totalling about 4,600 ha in area, separating the factory districts from such residential districts as Camaçari in the south and Jiastabila in the north. The forests are aimed at preventing both discharges from plants and possible accidents in the factory districts from directly influencing the residential districts. Camaçari and other towns around the industrial complex supply labor force needed by the complex, and houses for workers are being built there one after another. Jiastabila with mineral springs serves as a resort for the people in the region.

An annual plan for the afforestation of the entire 8,000 ha area has not yet been decided. But, with the completion of afforestation work in the northern Camaçari district, COPEC began work in the Jiastabila district in 1977 in accordance with the factory construction plan. The work is to be continued in the western, northeastern, eastern and southeastern parts of the area.

(b) The forest belt location plan

According to Mr. Jayme Mascarenhas Sobrinho who took part in the planning of the location of forest belts (now an executive in charge of technology at FLONIBRA), it was decided to choose and arrange trees in consideration of the direction of winds and topography.
Since the winds in the area usually blow from the notheast, they cut the ridges of salient land extending from the northwest to the southeast at right angles, Therefore, fast-growing eucalyptuses were planted on the ridgelines, pines in the middle of slopes and native broad-leaved trees at the lower parts of the slopes so that smokes from factories would be arrested by the trees as much as possible. But trees were not planted that way in some places because of varied conditions there.

(c) The kinds of trees planted and their growth

A total of 300,000 eucalyptuses, pines and native broad-leaved trees were planted at the ratios of 29%, 42% and 29% respectively.

(I) Eucalyptuses

The species most suited to the area can be chosen because they grow fast and there are many species. So far, three species --

Eucalyptus alba, E. Grandis and E. citriodora—have been picked for planting. Saplings grown in pots reaches the height of 25 cm in three to four months and, three months after planting, they grow to the height of one meter. Their growth is remarkable especially in the rainy season between April and July.

How they grew:

E. alba : Planted in December, 1974. Twelve months later, the height was 4.90 m and the diameter 30 cm above the ground was 7.0 cm.

E. citriodora : Planted in December, 1974. Twelve months later, the height was 3.79 m and the diameter 30 cm above the ground was 5.0 cm.

E. grandis : Planted in February, 1975. Ten months later, the height was 4.34 m and the diameter 30 cm above the ground was 6.5 cm.

Pines : Two species--Pinus Caribaea and Pinus hondurensis--were chosen.

They are raised in pots surrounded by plywood which rot off in three months. Raising saplings takes 50 days and they reache the height of 15 cm to 20 cm.

How they grew After planting:

Pinus caribaea: Planted in the January - February period, 1975. Twelve months later, the height was 0.70 m and the diameter 30 cm above the ground was 3.0 cm.

P. hondurensis: Planted in the March-May period, 1975. Nine months later, the height was 0.98 m and the diameter 30 cm above the ground was 2.8 cm.

(III) Native broad-leaved trees:

As shown in the table, 20 species of native broad-leaved trees have been adopted for planting. Grown in pots, they reach the height of 30 cm to 40 cm in five to six months. Their growth after planting is shown in the table. * means excellent growth.
Measured in December, 1975.

A. Species (local names) B. Period of raising C. Height of trees
D. Diameter 30 cm above the ground

(d) Quality of soil at the areas for afforestation

Burrows for soil survey were dug at five points on the slope of an existing afforested land along the line drawn from the ridge to the hollow. Red soil exists at points 1 and 2 and the upper part of point 3, but not at points 4 and 5. The point 5 submerges in water in the rainy season and the gley horizon appears there. The underground water level is 31 cm below the ground surface. When there are small stones on the land surface, they prevent the flow of soil by rainwater but when they are used for road construction, silt and clay below them are washed away leading to conspicuous soil erosion.

A Pinus Caribaea B. Eucalyptuses C. Native broad-leaved trees
D. Natural vegetation E. The height above the sea level
F. Strata of small stones G. Strata H. Depth
I. Specific characters of profiles J. Hardness
K. Many small tones down to the depth of 20 cm to 30 cm
L. The amount is very small. M. The amount is small.
N. The amount is extremely large. O. Tilled by tractors
P. Red soil Q. Stratum of small tones R. Black soil
S. Small stones on the ground. T. The amount is very small.
U. The amount is small. V. The amount is extremely large.

(e) Fertilization, planting and cultivation and control method

(I) Eucalyptuses : Holes 10 cm to 20 cm in depth and 15 cm in diameter are dug one each in an area of 2 m by 3 m, and Ca is used to adjust the PH of soil. The appropriate season for planing and cultivation is before the start of the rainy season. N, P and K are used after planing. Weed clearing is required twice a year. It is necessary to exterminate ants.

(II) Pines : Holes 20 cm in depth and 20 cm in diameter are dug one each in an area of 2 m by 3 m. On other points, the pines are treated in the same way as the eucalyptuses.

(III) Native broad-leaved trees : The treatment is the same with that of the pines.

5. Problems and Countermeasures

(a) The entire afforestation plan

The purpose of making forests around factories is to harmonize industrial activities with the neighboring local communities by having forests fulfil its functions to conserve the environment.

For that purpose, it is necessary to make forests which are resistant to diseases, injurious insects, adverse effects of weather and so forth. The best forests would be stable natural forests which attract wild birds and animals and serve the purpose of protecting the natural environment. However, the natural forests in the areas in questions have been turned to poor secondary forests of broad-leaved trees due to reckless deforestration over a long period in the past.
And most of the land is wasteland left as it is after the adoption of the slash-and-burn method of agriculture. Therefore, it takes a long time to make stable natural forests.

Meanwhile, it is hoped that the afforestation around factories will be completed ss soon as possible. Although there is no fundamental problems with the basic structure of the afforestation plan, it is necessary, for above-mentioned reasons, to complete forests with complex aspects, while carrying out the afforestation around factories speedily.

(b) The arrangmment of forest belts

The arrangement of trees in the already afforested areas is generally good, but there are the following few problems.

(1) Under the basic plan, the direction of winds is said to be north-eastery, but full weather observation has not been conducted. The direction of winds should be ascertained and the arrangement of forest belts around the areas should be re-examined so that they can stand winds from other directions.

(11) There is glassland in the already afforested areas. But it is throught to be desirable to turn it into forests, except low-lying marshland and other areas which cannot be turned into forests easily. Then, the forests will be more effective for the conservation of the environment.

(III) In the arrangement of trees, those most resistant to air pollution should be planted at the edges of forests.

(IV) Sicnce natural forests with good aspects are included in the areas covered by the afforestation plan, it is desirable to improve the forest aspectts and to make them indicator forests.

(c) The kinds of trees for planting

The choice of trees is basically all right but it is hoped to give heed to the following points.

(I) Trees with a large amount of leaves should be adopted for forests for the conservation of the environment because they will absorb floating dust and small particles from factories.

(II) Since the soil condition is bad, it is recommended to plant such trees as Acacia Melanoxylon which serves as a fertilizer.

(III) Trees highly resistant to pollution should be chosen after conducting tests to see their resistance to smokes discharged by factories.

The problems with the trees which have been adopted are as follows.

(IV) Eucalyptuses : Since seeds available are not even in quality, those of saglina and glandis, which are non-resistant to Diaporte cubensis breaking out in the Flonigra plantation in Espirito Santo State, may mingle with other seeds. Therefore, it is necessary to remove such species during the nursing of seedlings.
It is also recommended to examine the seeds of the species grown in northern Australia and Papua New Guinea which are in almost in the same latitude as Brazil.

(V) Pines : The two species of Pinus Caribaea which have been adopted are thought to be the most suited pines to the areas in question in view of their distance from the equator. Although they grow slower than eucalyptuses, they are precious in the areas where there are only a small number of conifers. Therefore, it is necessary to seek other species suited to the areas by conducting tests on the conditions in places of their origin.

(VI) Native broad-leaved trees : Since they are the most appropriate to the making of forests for the conservation of the environment, it is

necessary to adopt as many species as possible for such plantations.

(d) Methods of Soil control, planting and nursing

(I) Fertilization

There is no problem with the adjustment of PH or the giving of three elements, but it is hoped to examine the giving of such trace elements as Mg, Zn and Br as is being practiced in the above-mentioned Flonigra plantation. It is also recommended to examine the use of organic fertilizers, which is quite desirable. But it is necessary to give heed to the damage to trees by thick fertilizers.

(II) Planting and nursing control

a) Effective trees should be utilized without felling and the bringing of fire into forests should be limited to the minimum. Steps should be created on slopes to prevent the soil from being washed away. It is recommended to try planting assorted trees rather than a single sort of trees.

Weed clearing is desirable. Fertilization should be continued for the time being to smooth the circulation of nourishment.

Since the fast-growing eucalyptuses require liberation cutting, it is necessary to start now the preparations for the control of the density of the trees.

1. E Eucalyptuses 2. P Pines 3. N Native broad-leaved trees
4. Three to four trees should be planted in a group at a place.

6. Proposals for Various Sorts of Tests

1. An on-the-spot survey of growth characters of plantations

Designate specific areas in plantations and measure and record the growth of trees every year. Dig the ground in part of these areas to see the development of root systems.

Choose such areas in consideration of the differences in soil conditions and species of trees.

2. A test to compare the growth characters of trees of different places of origin.

It is desirable to introduce eucalyptuses, pines, native broad-leaved trees and others into plantations.
Compare the trees of different species and different places of origin to find appropriate trees.

3. A test to compare the trees' resistance to dryness and dampness

4. A test to compare the trees' resistance to air pollution

Plant various sorts of trees close to factories in operation and examine the effects of air pollution on them.

5. A Fumigar test

Conduct a Fumigar test by using sulfurous acid gas (SO_2), fluorine (HF), chlorine (cl), nitrogen oxide (NO_X) and ozone (O_3) to clarify the resistance of trees of different species. The test requires a special house for experiments and training of personnel on the methods of experiments.