BASIC DESIGN STUDY REPORT ON THE GENETIC RESOURCES PRESERVATION AND RESEARCH LABORATORY ESTABLISHMENT PROJECT IN THE ISLAMIC REPUBLIC OF PAKISTAN

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Genetic Resources Preservation and Research Laboratory Establishment Project, and entrusted the study to the Japan International Cooperation Agency (JICA).

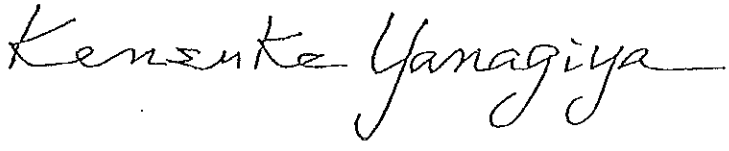
JICA sent to Pakistan a study team headed by Dr. Masahiro Nakagawara, Councilor R. & D., Agriculture, Forestry and Fisheries Council Secretariat, Ministry of Agriculture, Forestry and Fisheries, from March 21 to April 15, 1991.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft report and the present report was prepared.

I hope that this report will contribute to the promotion of the Project, and to the enhancement of friendly relations between our two countries.

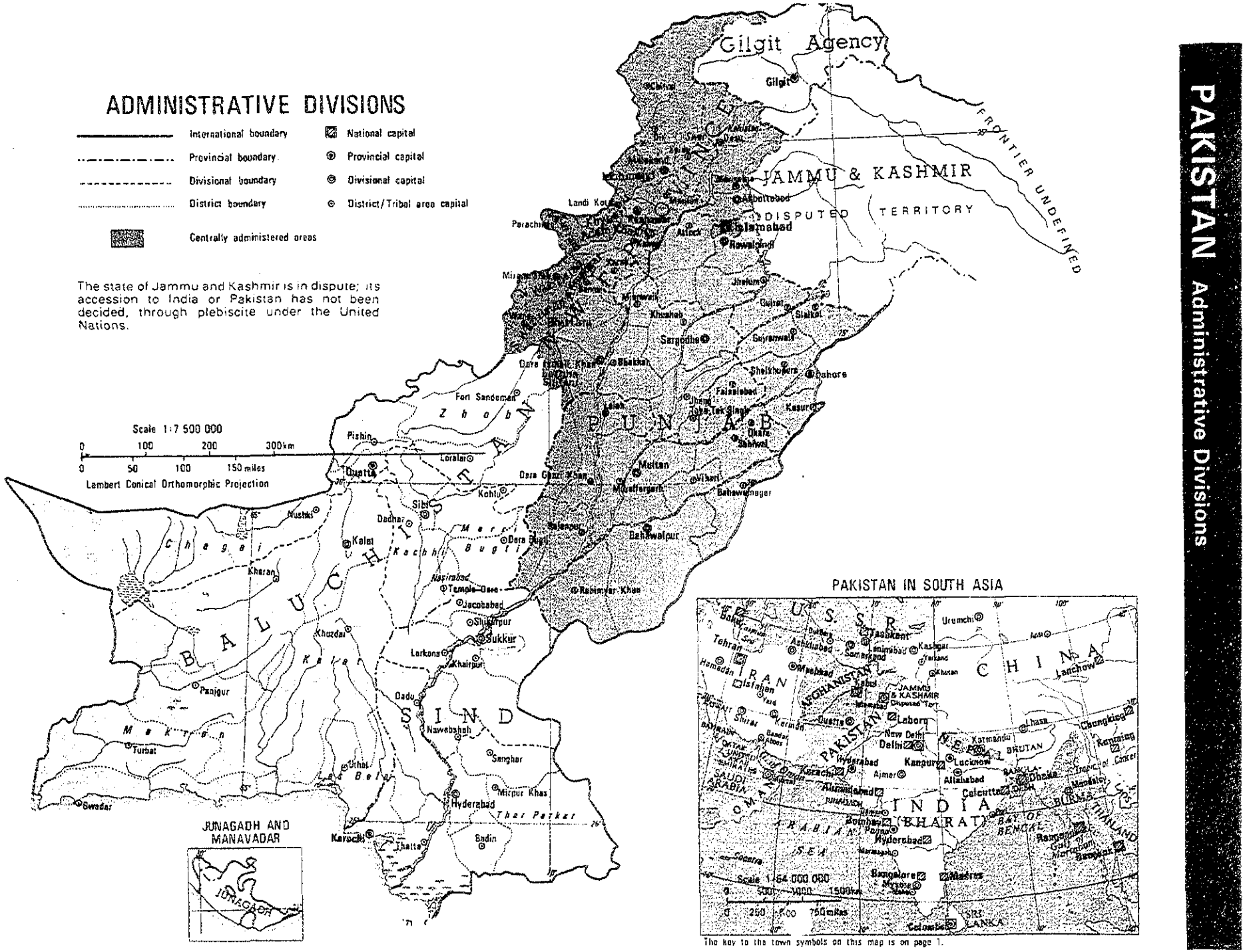
I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the teams.

August, 1991



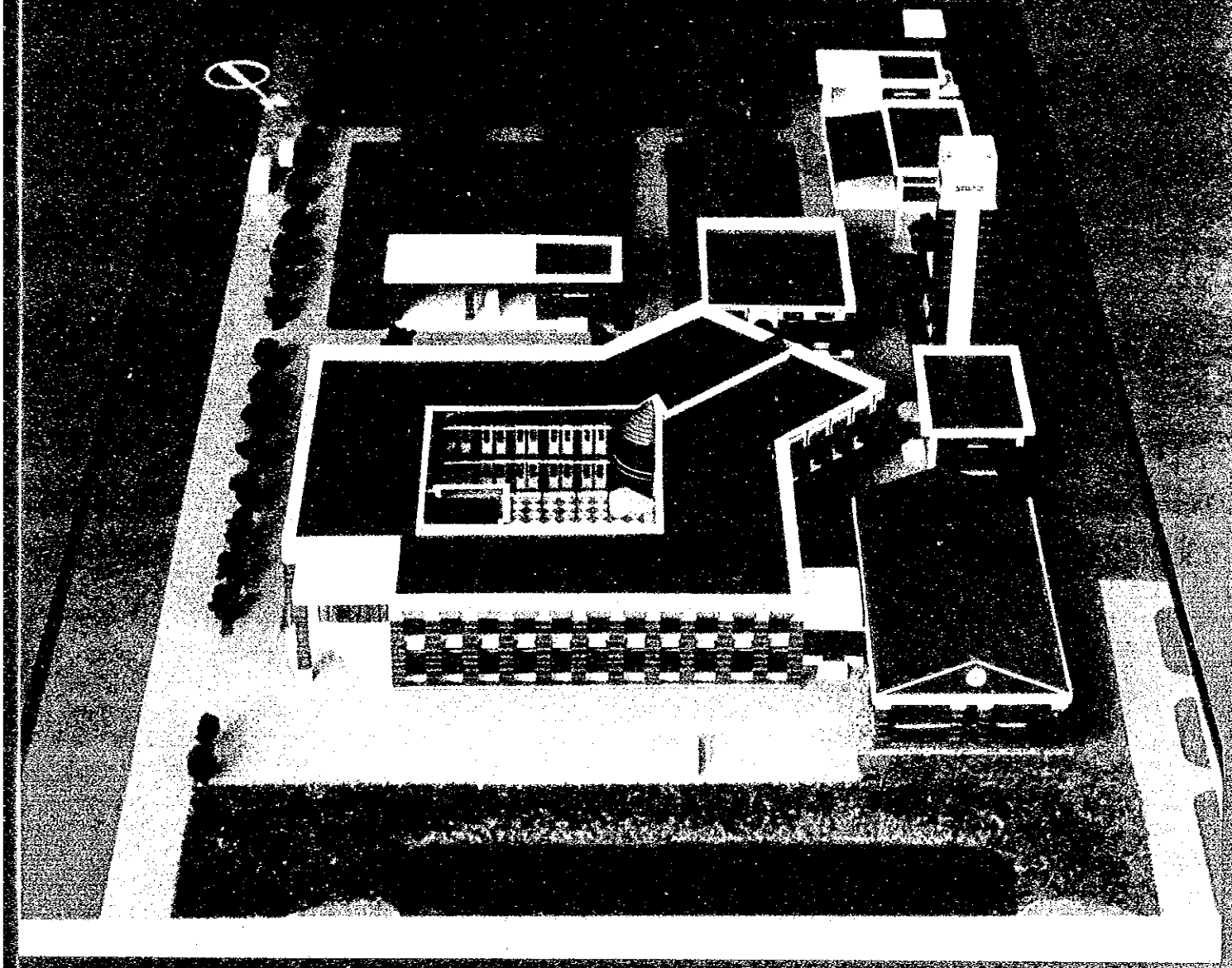
Kensuke Yanagiya
President
Japan International Cooperation Agency

PAKISTAN
Administrative Divisions



The key to the town symbols on this map is on page 1.

THE GENETIC RESOURCES PRESERVATION AND RESEARCH LABORATORY ESTABLISHMENT PROJECT IN THE ISLAMIC REPUBLIC OF PAKISTAN



SUMMARY

SUMMARY

In the Islamic Republic of Pakistan (hereinafter referred to as Pakistan), agriculture is the mainstay of the economy, accounting for 23.3 % of the GDP, employing 49.2 % of the labor force, and farm products and their processed goods represent 70 % of the total export earnings.

Pakistan, a sub-tropical country, has nevertheless many varieties of flora and crops ranging from tropical to temperate, due to its diverse climatic and topographic conditions. And it has been the origin of some crop species. Moreover, being located in a strategic point between Central Asia and India, it has witnessed, since ancient times, many different races moving and trading across the country. This has undoubtedly brought about the spread of crop species and the settlement of various introduced cultivars.

In recent years, however, Pakistan has become dependent on particular species, namely, modern species, in order to improve productivity. This has accelerated genetic erosion, replacing many locally adapted primitive cultivars and causing the loss of plant genetic resources. Such genetic erosion has been under way for all kinds of crop species throughout the world, endangering plant genetic resources.

The development of agricultural production has been stable in Pakistan, but land productivity needs improvement. The reasons fro this are a population growth rate of more than 3 % annually and the scarcity of unutilized land which could be adapted to cultivation.

The Sixth Five-Year Plan ended in 1988 had aimed to achieve the agricultural growth rate of 4.9%, but it actually only reached 3.7%. This was because the crops other than cotton, which had attained the target production with the diffusion of high yielding varieties, had failed to reach their targets. The reasons pointed out for these unsuccessful results concerned the invested materials which are directly related to productivity: failure in the development of high-yielding varieties adapted to general cultivation for sugar cane, lack of high yielding varieties of fine quality Basmati Rice, and

insufficient diversification of high value-added crops for oil seeds.

In view of these circumstances, the National Commission on Agriculture (NCA), under the Ministry of Food, Agriculture and Cooperatives, made various recommendations to the Government, aiming at full self-sufficiency in food production and improvement of crop productivity.

Based on these recommendations, in the Seventh Five-Year Plan, the agricultural sector aimed to achieve an annual growth rate of 4.7 %. The goals included the increase in agricultural production by improving land productivity, strengthening self-sufficiency in cereals, and the diversification of farm products. The means applied to attain these goals were: (1) development of high-yielding and disease-resistant varieties for sugar cane, rice and oil seeds, (2) research and introduction of improved breeds of fruits, vegetables and crops adapted to the climate, (3) diversification of high value-added fruits and vegetables adapted to the climate, (4) development of new varieties through the promotion of agricultural researches, and other means.

Accordingly, the Pakistan Agricultural Research Council (PARC) worked out the "Genetic Resources Preservation and Research Laboratory Establishment Project" (hereinafter referred to as the " Project "), to strengthen the activities of the Plant Genetic Resources Program of the Crop Science Institute, the National Agricultural Research Centre (NARC) where comprehensive research is conducted on the collection and preservation of plant genetic resources. The objective of the Project was to arrange for the effective utilization of plant genetic resources, in order to strengthen the breeding of crop species in Pakistan.

The Government of Pakistan, recognizing the importance of the Project, approved its implementation, and due to the lack of funds on hand, requested grant aid from the Government of Japan to provide the necessary facilities and equipment, as well as the transfer of technology, for its realization.

In response to the Request, the Government of Japan decided to conduct a preliminary study of the Project, and JICA sent a joint preliminary study team

on grant aid and technical cooperation to Pakistan for 12 days, from December 1 to 12, 1990.

The preliminary study team concluded that the Project was urgent and required to be executed. Given the importance of agriculture in Pakistan, the need to improve productivity, and in connection, the importance of breeding and distribution of quality breeds is vital. It is also necessary to collect and preserve plant genetic resources of the country, which has been the origin of some field crops, before they perish. Moreover, since Pakistan has been carrying out exchange and cooperation programmes with international agencies, the facilities and equipment expected to be provided under the grant aid system could be utilized in an effective and advanced manner.

But due to the need to concentrate the Project on its essentials, it was considered appropriate to limit the scope of Japanese cooperation to those related to genetic resources, and as for seed science, to the research on those seeds needed in connection with the preservation and evaluation of genetic resources.

Discussions and examinations were also made as to the propriety of the Project, of Japanese grant aid and of the possible scope of cooperation.

Following the results of the preliminary study, the Government of Japan decided to conduct a basic design study for the Project for grant aid, and JICA sent a basic design study team to Pakistan for 26 days, from March 21 to April 15, 1991.

The team discussed the contents of the Request with the officials concerned of Pakistan, studied the proposed construction site, investigated the conditions of relevant infrastructure and the circumstances of construction work, and collected information and data related to the Project. Upon returning to Japan, and after the analysis and examination of the results of the study, the team worked out a basic design of the facilities. The team also prepared a draft final report of the basic design study which includes a selection of equipment and an operation and maintenance plan.

In order to explain to and consult with the Pakistani side on the contents of the draft report, the Draft Final Report Confirmation Team was sent to Pakistan from June 30 to July 7, 1991. As a result, the present report has been prepared.

The executing agency of the Project will be PARC under the Agricultural Research Division of the Ministry of Food, Agriculture and Cooperatives, Government of Pakistan.

The main activities of the Project, decided after the consultations with the Pakistani side are as follows:

(a) Exploration and collection laboratory:
  (1) To collect and analyze plant genetic resources,
  (2) To work out exploration programmes,
  (3) To conduct collecting activities,
  (4) To compile passport data,
  (5) To carry out preliminary evaluation.

(b) Plant introduction and seed health laboratory:
  (1) To introduce seeds,
  (2) To examine seeds,
  (3) To carry out preliminary evaluation of the introduced genetic resources,
  (4) To cultivate seeds in isolation,
  (5) To grow disease-free seedlings.

(c) Seed preservation and research laboratory:
  (1) To carry out threshing, refining, adjustment, drying, germinability tests, packing, short-and medium-term storage,
  (2) To carry out rejuvenation and multiplication,
  (3) To carry out research on preservation of orthodox and recalcitrant seeds.

(d) In-vitro preservation research laboratory:
  (1) To conduct research on in-vitro preservation,
  (2) To conduct research on preservation under extremely low

temperatures.

(3) To carry out regeneration/cultivation of stored germplasm.

(e) Germplasm evaluation laboratory:

(1) To carry out detailed evaluation on the levels of fields and laboratories (confined to stored genetic resources).

(f) Data management laboratory:

(1) To receive register and control data on genetic resources.

(2) To draw up a seed catalog.

(3) To receive requests for distribution of genetic resources or their information, and to instruct their distribution to relevant research institutions.

(g) Administration section:

(1) Secretariat

(2) To coordinate research with research institutions.

(3) To coordinate the utilization of the facilities by different crop study groups of NARC.

(4) To maintain the facilities and equipment.

The proposed Project site is a flat area of 11,250m^2 located on the premises of NARC in Islamabad. Regarding the infrastructure, electricity, water supply and telephone facilities will be provided at the site. However a stable electricity facility, water supply and drainage facilities including reservoir tank, elevated tank, septic tank and soakage tank are essential and must be constructed on the site.

The facilities of the Project consist of a Main Complex (laboratories complex including different laboratories listed below), a Plant Introduction and Seed Health Laboratory building, a Garage for Exploration Vehicles and Work Shop (a tool shop for agricultural implements), Greenhouses, a Power Supply Building and other facilities.

The scale of the facilities and the outline of the essential equipment for different laboratories has been worked out by the Basic Design Team, and are listed below.

1. Scale of facilities

(1) Main Complex: ..... 1F. 1,786 m^2

2F. 1,235 m^2

Total 3,021 m²

Exploration and Collection Laboratory,

Seed Preservation Research Laboratory,

In-vitro Preservation Research Laboratory,

Germplasm Evaluation Laboratory,

Data Management Laboratory,

Administration Section,

Common Facilities and Connecting Corridor

(2) Plant Introduction and
Seed Health Laboratory Building····· 200 m²

(3) Cultivation-related facilities:

Processing Building ····· 222 m²
(for crop cleaning and threshing of seeds)

Sterilized Soil, Cultivation Material Stock Shed···· 90 m²

Greenhouses: 153.8 m² x 3 sets ····· 462 m²

230.7 m² x 3 sets ····· 692 m²

(4) Power Supply Building ····· 176 m²

(5) Water Supply Facilities(elevated tank, pump roomx 2)···· 65 m²

(6) Garage and Workshop····· 155 m²

Grand Total 5,083 m²

2. Equipment

(1) Equipment for the Exploration and Collection Laboratory

(2) Equipment for the Plant Introduction and Seed Health Laboratory

(3) Equipment for the Seed Preservation Laboratory

(4) Equipment for the In-vitro Preservation Research Laboratory

(5) Equipment for the Germplasm Evaluation Laboratory

(6) Equipment for the Data Management Laboratory

(7) Equipment for the Administration Section

(8) Equipment for Common Facilities

(9) Equipment for Cultivation and Post-harvest Treatment

The period necessary for the implementation of the Project is calculated to be 17 months after the Exchange of Notes between the two Governments. A period of 5 months proposed for Detail design, tendering and

contracting, and of 12 months for construction.

The annual operation and maintenance expenses of the facilities under the Project are estimated to be about Rs. 4 million (about 25 million yen) excluding manpower costs. These expenditures were already approved by the Executive Committee of National Economic Council (ECNEC) and will be covered by the national budget. Manpower requirements will be met from the existing research divisions or the Talent Pool (a registration system of manpower available under PARC) and will be funded by PARC.

The execution of the Project will enable Pakistan to systematically preserve its valuable plant genetic resources which are gradually being lost, and through effective utilization of these resources, to develop crop breeding programmes for agricultural production. Moreover, in the long range, the improvement in agricultural productivity brought about by the development of new varieties will, in turn, bring about such benefits as stable supply of food and expansion of agricultural product exports.

The Government of Pakistan, being fully aware of the significance of the Project, has already arranged for its implementation and operation, and the earliest implementation of the Project is earnestly desired. For these reasons, the Project is an appropriate candidate for Japanese grant aid cooperation.

If the project-type technical cooperation by the Japanese Government is implemented along with the Project, the research activities related to the germplasm preservation will be fortified, and the research technology in this field will be greatly upgraded. Eventually, the more systematic research will be able to carried out, and the facilities and equipment provided under the Project will also be utilized effectively. In order to amplify the effects of the Project, it is recommended that the project-type technical cooperation will be implemented by both Governments.

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

The government of Pakistan, in its effort to promote agricultural research operations for the improvement of agricultural productivity, one of the basic objectives of its Seventh Five-Year Plan, sets the target of the Project on the strengthening of the breeding of crop species through the arrangement of a system of effective utilization of plant genetic resources. And, in order to fulfill this objective, the Project was worked out to strengthen the activities of the Crop Sciences Institute of NARC, concerning the collection, preservation and evaluation of plant genetic resources. Then the government requested grant aid from the Government of Japan to provide the necessary facilities and equipment for the research in these specialized fields.

In response to the Request, the Government of Japan decided to conduct a preliminary study of the Project, and JICA sent to Pakistan a joint preliminary study team on grant aid and technical cooperation headed by Mr. Yoshikiyo Ohkawa, Director, Overseas Technical Cooperation Office, Economic Affairs Bureau, Ministry of Agriculture, Forestry and Fisheries, for 12 days from December 1 to 12, 1990.

The team discussed with the officials concerned of Pakistan, and conducted a field study of the basic matters including the background and the contents of the Request, the propriety of the Project, as well as the basic policy and the scope of cooperation.

In view of the results of the preliminary study, the Government of Japan decided to conduct a basic design study for the Project for grant aid, and JICA dispatched to Pakistan a basic design study team headed by Dr. Masahiro Nakagawara, Councilor R. & D., Agriculture, Forestry and Fisheries Council Secretariat, Ministry of Agriculture, Forestry and Fisheries, for 26 days from March 21 to April 15, 1991. (See the Appendix 3., 4.and 5.)

Referring to the results of the preliminary study, and explaining the Japanese grant aid system, the basic design study team fully exchanged views on the Project with the officials concerned of Pakistan, as to the contents and the

scale of the necessary and appropriate facilities and equipment to be provided. The team also conducted a field study, trying to clearly grasp the contents of the Request and those of the Project, as well as the organizational arrangement for the operation and maintenance of the Project, collected related information and data, and surveyed the Project site. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft report and the present report was prepared. The results of the study were summarized in the Minutes of Discussions, which is attached to the Appendix.

The present Report, compiled thus on the basis of the consultations with the officials concerned of Pakistan, and the analysis of data obtained through the field study, defines the objectives and the contents of the Project, proposing a basic design which would be most appropriate for the facilities and equipment to be provided, and its executing process, and lastly rendering an evaluation of the whole operation.

CHAPTER 2

PROJECT BACKGROUND

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2-1 General Conditions of Agriculture

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(1) Natural Conditions of Pakistan

Pakistan is 796,095km^2 in area, situated between 23°30" and 36°45" of North Latitude and between 61° and 75°31" of East Latitude. It faces the Arabian Sea to the south, and is bordered by Afghanistan and Iran on the north and on the west, by India on the east and by Kashmir on the northeast.

Its geographical features are diverse with the River Indus, the origin of the ancient Indus Civilization, running through the middle of the country, the northern mountains of the Great Himalayas as high as 8,611m above sea level, the fertile Punjab Plain in the central region, and the vast desert zone in the southwest.

Administratively, the country is divided into 4 provinces: North-west Frontier Province, Punjab Province, Sind Province and Baluchistan Province. In addition, there is a centrally administered area called the Federally Administered Tribal Area in the north.

The population of Pakistan was estimated to be approximately 110 million as of 1989, with the annual rate of increase remaining as high as 3.1%. Much of the population is concentrated in the Punjab Plain, and mainly engaged in agriculture.

By latitude, the country is situated in the sub-tropical zone, but its climatic conditions are as varied as its topography, and generally affected little by seasonal wind.

The weather in general is quite hot and dry, with little rainfall. It rains most from July to September, and the annual precipitation is about 1,000mm in Islamabad, about 350mm in Peshawar, and about 240mm in Karachi.

Because of the scarcity of rainfall, agriculture in Pakistan cannot be developed without irrigation facilities, except in some regions, and many regions often suffer from drought.

The lowest temperature in the plains is 4~10℃ in January in winter, and 25~30℃ in June or July in summer, and the highest is 17~20℃ in winter, and 37~41℃ in summer.

With rainfall and temperature varying by regions, the diversity of the topography has thus produced a variety of flora, so that plant ecosystems are divided into 10 categories, as shown in the Fig. 2-1.

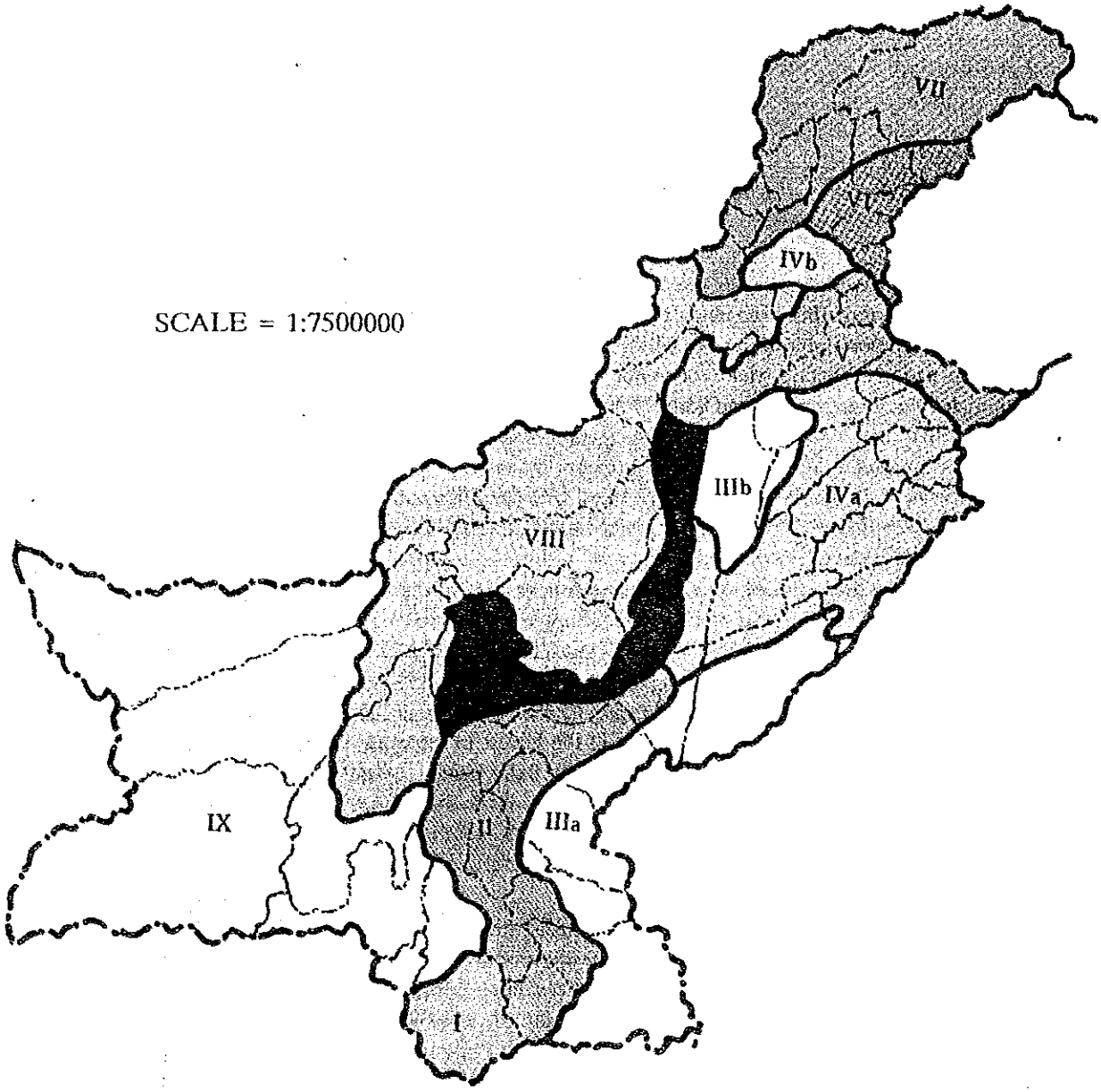
Pakistan is where the old Indus Civilization emerged, followed by a Buddhist culture flourishing in Gandhara, which lead to Mahayana Buddhism. The old trade route from central Asia to Europe passed through Pakistan. Different crop plants were introduced in the region, and under various ecological and climatic conditions, the flora was adapted and evolved over centuries of cultivation, associated with ethnic groups. Therefore Pakistan is considered as a Secondary Centre of diversity for a number of crop species.

The magnitude of genetic diversity in many crops is considered to be very high. This material must be collected and preserved before it is lost forever.

Also, according to Vavilov, a Russian botanist, Central Asia including Punjab and Kashmir is considered as one of the eight centers of origin in the world, and lentil, onion, spinach, radish, pear, apple, pistachio and grape are counted among the plant species originating in this region.

(2) Soil

Soil in Pakistan mostly contains a lot of lime and little organic matter. The color is reddish brown in the North, and red or gray in the South. The soil is utilized as farmland through irrigation. An alluvium consisting of sand and sandy soil is spread along the river. Desert soil covers wide areas of the Thar Desert and Baluchistan.



I	Indus Delta	II	Southern Irrigated Plain	III	Sandy Desert (a & b)
IV	*Northern Irrigated Plain (a & b)*	V	*Barani Lands*	VI	*Wet Mountains*
VII	Northern Dry Mountains	VIII	Western Dry Mountains	IX	Dry Western Plateau
X	Sulaiman Piedmont				

VII VI IVb V IVa IIIb VIII X II IIIa I IX

FIG 1. PAKISTAN AGRO-ECOLOGICAL REGIONS

2-1-2 Industrial structure and current state of agricultural production

(1) Industrial Structure

Since the economic basis inherited from the British colonial days was agriculture, as represented by river irrigation, cotton, rice and wheat, the agricultural sector still represents a large share of the GDP today. The agriculture sector accounted for as much as 22.6% of the GDP in 1987/88, and a review of the employed population by occupation shows that 49.2 % was engaged in the agricultural sector in 86/87.

Many of the manufacturing industries such as textile depend on the agricultural sector for raw materials. And the farm products or their processed goods account for nearly 70 % of the total exports: cotton thread 13.7%, raw cotton 12.1%(1986/87), ready-made clothes 9.6%, cotton cloth 9.4%, rice 8.0%, clothes 7.0%, carpet 5.4%, and other cotton products 3.9%, in total 69.1%. Agriculture is thus a mainstay of the Pakistan economy, which remains heavily affected by the performance of this sector.

(2) Agricultural production

Major crops cultivated in Pakistan are rice, cotton, maize, bajra (sorghum) and jowar (pearl millet) during the Kharif period, from April to October, and wheat and chickpea during the Rabi period, from October to April. Sugar cane and some crops for feed are cultivated throughout the year.

Among major crops, wheat is the most important staple food crop, and its annual production reaches 12 to 14 million tons. Except for minor variations caused by temporary bad weather, the production has been on an increasing trend in recent years. Self-sufficiency of this crop has almost been achieved today with the introduction of high-yielding varieties.

Cotton is the second major important cash crop. While raw cotton and cotton products are the first export commodities of Pakistan, cotton seed serves a great deal as a raw material for cooking oil, which is in shortage in the country, and its seed cakes are utilized as feed for domestic animals.

Rice is another major export farm product. The annual production is 3 to 5 million tons, some 40 % of which is for export.

The yield per unit area of each of those major cereals is low,

TABLE 2-1 GROSS NATIONAL PRODUCT CLASSIFIED BY SECTORS (Rs million,96)

	1984/85	1985/86	1986/87	1987/88	SECTOR96
Agriculture	108,873	120,305	128,159	143,917	23.3
Crops	72,817	80,378	82,930	91,861	(14.9)
Livestock	32,134	35,709	40,604	47,393	(7.7)
Fishing	3,544	3,828	3,914	3,958	(0.6)
Forestry	378	390	711	705	(0.1)
Mining & Quarrying	7,116	11,029	12,136	14,767	2.4
Manufacturing	73,572	81,827	94,066	108,060	17.5
Construction	26,464	29,135	34,396	39,242	6.3
Electricity & Gas distribution	8,738	11,136	12,032	13,974	2.3
Transport, Storage & Communication	34,793	39,120	43,674	48,504	7.8
Wholesale & Retail Trade	71,883	80,376	88,468	98,611	16.0
Banking & Insurance	13,370	14,855	16,334	17,476	2.8
Ownership of Dwellings	17,332	19,077	20,805	22,997	3.7
Public Admn. & Defence	36,714	42,053	51,018	58,565	9.5
Services	36,160	40,463	44,800	51,923	8.4
G D P	435,015	489,376	545,888	618,036	100.0
Net Factor Income from abroad	38,311	41,359	36,493	31,096	-
G N P	473,326	530,735	582,381	649,132	-
Population(in million)	94.73	97.67	100.07	103.82	-
Per Capita Income(Rs.)	4,997	5,434	5,783	6,252	-

SOURCE:PAKISTAN ECONOMIC SURVEY 1987/88

TABLE 2-2 AREA HARVEST, YIELD AND PRODUCTION OF IMPORTANT CROPS

	1960/61	1970/71	1980/81	1985/86	1986/87	1987/88	1988/89	AVERAGE YIELD OF ASIA IN 1989
WHEAT								
AREA HARV.	4,639	5,977	6,984	7,403	7,706	7,308	7,730	
PRODUCTION	3,814	6,476	11,474	13,923	12,882	12,675	14,419	
YIELD	0.82	1.08	1.64	1.88	1.67	1.73	1.865	2.315
RICE								
AREA HARV.	1,181	1,503	1,933	1,863	2,066	1,963	2,042	
PRODUCTION	1,030	2,200	3,123	2,919	3,486	3,241	3,200	
YIELD	0.87	1.46	1.62	1.57	1.69	1.65	1.567	3.359
COTTON								
AREA HARV.	1,293	1,733	2,108	2,364	2,502	2,568	2,619	
PRODUCTION	301	542	715	1,208	1,309	1,468	8,315	
YIELD	0.23	0.31	0.34	0.51	0.52	0.57	0.544	1.401
SUGARCANE								
AREA HARV.	388	636	825	780	762	842	877	
PRODUCTION	11,641	23,167	32,359	27,856	29,926	33,029	36,916	
YIELD	30.00	36.43	39.22	35.71	39.27	39.23	42.093	55.203
TOTAL OF AREA HARVEST	14,860	16,620	19,330	20,280	20,900	-		
CURRENT FALLOW RATE(%)	26.8	24.8	24.1	23.7	23.1	-		

NOTE: AREA HARVEST(1,000ha), PRODUCTION(1,000TONNES), YIELD(TONNES/ha)
SOURCE: NCA 1988, ES 1988/89

TABLE 2-3 IRRIGATION MEASURES AND IRRIGATED RATIO

	PAKISTAN		PUNJAB		SIND		BULCHISTAN		N.W.F.P.	
	1977/78	1986/87	1977/78	1986/87	1977/78	1986/87	1977/78	1986/87	1977/78	1986/87
AREA CULTIVATED	20.10	20.69	11.35	11.85	5.47	5.47	1.38	1.48	1.90	1.89
AREA IRRIGATED	14.22	16.48	9.78	11.82	3.18	3.30	0.52	0.52	0.74	0.84
IRRIGATION CANAL (PUBLIC)	10.06	11.71	6.76	7.95	2.64	3.13	0.34	0.32	0.32	0.31
IRRIGATION CANAL (CIVIL)	0.37	0.42	0.01	0.01	-	-	0.04	0.02	0.32	0.39
TUBEWELLS	2.79	3.71	2.67	3.51	0.06	0.05	0.04	0.10	0.02	0.05
WELLS	0.35	0.30	0.30	0.19	0.01	0.05	0.01	0.02	0.03	0.04
TANKS	-	0.06	-	0.06	-	-	-	-	-	-
OTHERS	0.65	0.28	0.04	0.10	0.47	0.07	0.09	0.06	0.05	0.05
IRRIGATED RATIO	70.7	79.7	86.2	99.7	58.1	60.0	37.7	35.1	38.9	44.4
TUBEWELLS RATIO(%)	13.9	17.9	23.5	29.6	1.1	0.9	2.9	6.8	1.1	2.6

SOURCE: PAKISTAN STATISTICAL YEARBOOK 1989

compared to the Asian average: 1,865 kg/ha against 2,315 kg/ha for wheat, 1,567 kg/ha against 3,539kg/ha for rice, and 544kg/ha against 1,401kg/ha for cotton, and 42,093kg/ha against 55,203kg/ha for sugar cane. The increase in these yields is desired.

(3) Land utilization

Pakistan has a total land area of 79,610,000 ha, out of which about 20 million ha, or approximately 26 % is utilized as farmland. Since unutilized land which could be adapted to cultivation is limited, a large-scale increase in the cultivated area will be unlikely in the future.

Wheat, which is cultivated in the area of some 8 million ha annually, accounts for nearly half of the total planted area (47.4 % in 1987/88), followed by cotton with 16.1 % (in 1987/88), and rice with 12.5 %. Sugar cane accounts for 5.4%, and bajra, jowar and barley, all cultivated in areas without irrigation, 3.1%, 2.6 % and 0.9 % respectively, and maize cultivation in the North-west Frontier Province, accounts for 3.1 %.

(4) Current state of agriculture under irrigation

Irrigation works having been carried out since the British colonial times, the irrigation rate of farmland reached almost 80% in 1986/87. Province wise, it was almost 100% in Punjab, 60% in Sind, 35% in North-west Frontier, and 44% in Baluchistan.

The irrigation facilities, however, have become too old, causing much loss of water, high salinity and water lodging. Five point eight million ha of farmland in Pakistan were damaged by salt, and some 2 million ha suffered flooding in 1986, both combined accounting for 38 % of the total cultivated land. In addition, 2/3 of those cultivated areas, 3.64 million ha, where the level of underground water is less than 6 feet, causing bad drainage, suffer from salinity damage and seem to be no longer fit for cultivation.

(5) System of land ownership and farming

Approximately 4 million families engage in agriculture in Pakistan, and the average farming scale per household is about 4.7 ha, of which 3.9

ha is the cultivated area. Yet, the land ownership system of large scale farms, which was formed under British colonialism, still remains, mainly in Sind and Punjab. Even after land reform was executed twice; the upper group of owners of more than 10 ha, representing merely 10% of all the households, own 53% of the total land. By form of land ownership, landed farmers account for 55% (52% of the cultivated land), tenant farmers 26% (22%), and landed and concurrently tenant farmers 19%.

2-1-3 State of the Economy

The economy in Pakistan, after remaining stagnant in the 1970s, became active in the 1980s, enjoying high growth over the ten years from 1978 to 88, with the average annual growth rate of the real GDP at 6.6%. Growth then to a rate of 4% annually, the results for 1988/89 being 5.1%. Per capita GNP in 1988 was 431 US dollars, which was higher than those of the neighboring countries. Yet, Pakistan is now suffering from a financial deficit, due to the shortage of tax revenue, recession in the Middle-East countries in recent years, and the fall of the amount of remittance from emigrant workers because of the Gulf War. Life of the people is not so comfortable, with the problem of unemployment and the rise in consumer prices by as much as 38%.

2-2 Outline of the plans related to agriculture

2-2-1 The Sixth Five-Year Plan

Economic development plans of Pakistan have been carried out successively since the First Five-Year Plan (1955/56～1959/60), with the exception of the Fourth Plan. During the period of the Sixth Plan (1983/84 ~87/88), while the target real GDP growth rate of 6.5% was attained, the real agricultural growth rate only reached 3.7% against the target of 4.9%. This was caused by the fact that, with the exception of cotton, which attained the target volume with the high-yielding varieties, the production of crops such as sugar cane, rice and wheat failed to meet the target. This situation was due to the unsuccessful result of the development of high-yielding varieties adapted to general cultivation for sugar cane, the shortage of the high-yielding varieties of fine quality Basmati Rice for rice, and the insufficient diversification of high value-added crops for oil seeds.

2-2-2 Recommendations of the National Commission of Agriculture and the Seventh Five-Year Plan

(1) Recommendations of the National Commission of Agriculture

In April, 1988, the Report of the National Commission of Agriculture (NCA) was submitted to the Government of Pakistan, serving as a basis of the planning of the agricultural sector of the Seventh Five-Year Plan. In this Report, the following recommendations were proposed, in view of the agricultural development to be made by the end of the Seventh Five-Year Plan, and by the year 2000:

1) Agriculture in Pakistan has almost achieved self-sufficiency in major sections, but now it must try to reach the average annual growth rate of 4.7%, assuming the key role in the economic development.
2) Until the 1980s, wheat, rice, cotton and poultry farming had been successful in the agricultural sector, while cooking oil and sugar cane failed. Pulses and milk also had some problems.
3) The expansion of cultivated land and the securing of water supply reaching their limits, emphasis should now be put on the improvement of land

TABLE 2-4 GROWTH RATIO OF GDP CLASSIFIED BY SECTORS

	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
PRODUCTION SECTORS	5.8	2.2	9.4	7.5	5.6	5.9
Agriculture	3.8	-6.0	12.2	6.4	2.7	7.1
Manufacturing	7.0	7.9	8.1	7.5	10.0	4.0
Mining & Quarrying	4.2	2.2	23.0	20.7	13.9	2.1
Construction	12.0	17.4	3.0	6.7	4.9	2.3
Electricity & Gas distribution	7.8	17.4	4.3	15.5	5.9	13.2
SERVICES SECTORS	7.9	7.9	8.9	6.3	6.8	3.7
Wholesale & Retail Trade	6.3	3.7	10.4	7.2	9.0	5.4
Transport, Storage & Communication	7.8	10.7	6.9	7.6	6.8	0.6
OTHERS	8.9	9.9	8.6	5.4	5.2	4.5
GDP	6.7	5.1	9.2	7.0	6.2	4.8

SOURCE: Pakistan Economic Survey 1987/88, 1989/90

TABLE 2-5 THE AVERAGE ANNUAL GROWTH RATE DURING THE SIXTH PLAN PERIOD AND TARGET OF THE AVERAGE ANNUAL GROWTH RATE DURING THE SEVENTH PLAN

	THE SIXTH PLAN	THE SEVENTH PLAN
Agriculture	3.7	4.7
Mining & Quarrying	11.4	8.0
Manufacturing	7.7	8.1
Construction	8.7	8.0
Electricity & Gas distribution	8.8	8.5
Transport, Storage & Communication	7.7	6.8
Wholesale & Retail Trade	6.7	6.7
Banking & Insurance	7.3	5.5
Ownership of Dwellings	8.1	5.3
Public Admn. & Defence	7.2	5.8
Services	6.6	6.6
TOTAL	6.5	6.5

(%)

TABLE 2-6 NET DISBURSEMENTS OF ODA BY DAC COUNTRIES TO PAKISTAN IN 1989

(IN MILLION US $,%)

	TECH.COOP.GRANTS		GRANTS		ODA LOANS NET		TOTAL ODA GROSS	
	AMOUNT	SHARE%	AMOUNT	SHARE%	AMOUNT	SHARE%	AMOUNT	SHARE%
U. S. A.	99.0	36.4	116.0	30.5	48.0	10.7	263.0	23.8
JAPAN	14.3	5.3	74.8	19.6	88.4	19.6	177.5	16.1
GERMANY	21.1	7.8	14.4	3.8	18.7	4.2	54.2	4.9
CANADA	6.7	2.5	39.4	10.3	-10.8	-2.4	35.3	3.2
ITALY	0.7	-	5.7	1.5	29.9	6.6	36.3	3.3
U. K.	18.8	6.9	29.5	7.7	-6.9	-1.5	41.4	3.8
OTHERS	21.7	8.0	47.2	12.4	5.6	1.2	74.5	6.8
SUB.TOTAL	182.3	67.0	327.0	85.8	172.9	38.4	682.2	61.8
IDA	-	-	-	-	-	-	90.0	8.2
ADB	-	-	-	-	-	-	217.2	19.7
UNHCR	-	-	-	-	-	-	58.5	5.3
OTHERS	-	-	-	-	-	-	73.0	6.6
SUB.TOTAL	89.9	33.0	52.3	13.7	296.5	65.9	438.7	39.8
ARB AGENCIES	-	-	1.5	0.4	-19.2	-4.3	-17.7	-1.6
TOTAL	272.2	100.0	380.9	100.0	450.1	100.0	1,103.2	100.0

SOURCE : OECD "Geographical Distribution of Financial Flows to Developing Countries 1986/1989"

NOTE:GRANTS AND TECH.COOP. ARE DIVIDED ACCORDING TO THE ALLOCATION OF JAPAN'S ONE

productivity.

4) Technology and price policies having been too much centered on the traditional major cereals, attention must now be turned to the high value-added fields including vegetables, fruit, animal husbandry and processing of farm products, in order to diversify the agricultural sector.
5) It is possible to secure employment for 65% of the increase in the labor force, which is expected to be nine million in 1988～2000, by maintaining an annual growth rate of 4.7%.
6) The employment elasticity value of the agricultural sector was 0.57 (1963/64～86/87), compared with 0.33 for the mining and industry sector, and the absolute number of employed was also higher. Therefore, in order to substitute the increase in employment (approximately 430,000 people) caused by the increase in the total agricultural production by 5%, the mining and industry sector should raise production by 30.7% annually. Since this assumption is unrealistic, priority should be given to the investment in agriculture.
7) Other problems including the provision of infrastructure in rural areas, strengthening of the self-governing bodies and of the system to support small farmers, and conservation of the environment, must also be taken into consideration.

(2) The Agricultural Sector in The Seventh Five-Year Plan

(July 1988～June 1993)

Following the recommendations of NCA, the Government of Pakistan defined the policies on the agricultural sector in the Seventh Five-Year Plan. Its target annual growth rate during the period is 4.7%, while that of the real GDP is 6.5%, the same level as in the Sixth Plan. Along with the maintenance of a high economic growth rate, the achievement of economic independence by reducing dependence on foreign assistance is regarded as the second objective. In order to fulfill this, it is considered necessary to moderate economic regulations and activate investment activities by private companies.

The following three points are the basic objectives set up for the agricultural sector:

1) To supply food and raw materials needed by the people and companies
2) To create surplus farm products to promote export
3) To create employment.

The following are the details related to the above-mentioned objectives:

1) To achieve a growth rate higher than that of the population growth rate by modernizing agriculture.
2) To increase production through the improvement of land productivity.
3) To maintain and strengthen the system of self-sufficiency, to achieve self-sufficiency in sugar, and to lower the degree of dependence on the import of cooking oil.
4) To diversify farm products and employment, by encouraging production of such high value-added products as fruit, vegetables, oil seeds, meat and milk.
5) To increase export profits by encouraging specialization of products and through the improvement of relevant systems.
6) To raise the income of small farmers through the improvement of the support price system and the market mechanism.
7) To increase the supply of animal products through the improvement of productivity of the animal husbandry and raise the income of animal farmers.
8) To solve the problem of feed shortage, to strengthen the variety improvement for domestic animals.
9) To work out a long-term general development plan to protect land, forests and water resources from environmental distruction.

The following are the details of the strategy to reach these objectives:

1) To improve the yield per unit area through proper utilization of fertilizers, the improvement of soil and the introduction of quality breeds.
2) To develop high-yielding and disease-resistant varieties for sugar cane, rice, and oil seeds.
3) To develop new varieties through the promotion of agricultural research

operations by strengthening or setting up research institutions.

4) To introduce and conduct research on the improved varieties of fruit, vegetables or export crops, adapted to the local climatic conditions.
5) To increase cooking oil products by producing non-traditional oil seeds.
6) Diversification of high value-added fruit or vegetables, adapted to the local climatic conditions.
7) Development of high-yielding and drought-resistant varieties of food and feed crops.

In this way, the Government of Pakistan recognizes in the Seventh Five-Year Plan, that it is essential for the improvement of productivity to promote agricultural research operations aiming at the breeding and distribution of quality varieties.

Moreover, the target distributions by 1992～93 of the improved breeds are stated as follows:

TABLE 2-7 REPLACEMENT, REQUIREMENT OF IMPROVED SEED BY 1992-93

CROPS	AREA(000ha)	SEED RATE (kg/ha)	SEED REQUIRED (TONNES)	REPLACEMENT RATE (PER CENT)	REPLACEMENT REQUIRED (000 TONNES)
WHEAT	7,650	91	696,150	20	139
RICE	2,185	20	43,700	20	9
MAIZE	900	40	36,000	33	12
COTTON	2,550	25	63,750	100	64
GRAM	1,060	40	42,400	20	8
OTHERS	-	-	-	-	17

2-2-3 Trends of assistance for the agricultural sector from the major countries and international agencies

Financial aid from abroad has been playing an important role in Pakistan, serving as a general development fund since the First Five-Year Plan. Its volume for the Sixth Five-Year Plan reached 11.975 billion US dollars on the commitment basis .

Early in the 1950s after the Independence, the U.S.A. and Great Britain, the former suzerain, were the two major assisting countries. Then, after the consortium was formed since 1960, they were joined by Japan, West Germany and some others.

The World Bank constitutes the key international organization assisting Pakistan. In order to help fulfill the objectives of the Seventh Five-Year Plan, it has set up a policy to support among others the projects concerning agricultural development and energy development.

The Asian Development Bank started its aid to Pakistan in 1968. Giving priority to agriculture and its related industry, and to the energy sector for providing loans, it has since been supporting the economic development.

The Agricultural Research Project-II and the Seed Industry Project are the projects in the agricultural research field, worked out under the Seventh Five-Year Plan. The former is expecting loans from the World Bank, and the latter from the Asian Development Bank.

2-3 Agricultural research activities in Pakistan

2-3-1 System of agricultural research

Agricultural research institutions in Pakistan are controlled either by the federal or the Provincial government. Among the most representative under the federal government are the National Agricultural Research Centre (NARC, in Islamabad), the Pakistan Agricultural Research Council (PARC), and the three Cotton Research Institutes (the central institute is in Multan) under the Pakistan Central Cotton Committee. There are 21 centrally controlled agriculture-related research institutes, and with those under the Provincial governments, the number of agricultural research institutes reaches 65.
In addition, there are stations, sub-stations, centres and laboratories in 162 places across the country, engaging in research works adapted to regional conditions, and three universities of Agriculture.

(1) Outline of major research institutes

1) Pakistan Agricultural Research Council

The PARC, under the control of ARD, MFAC, coordinates and monitors research activities on agriculture. It is a comprehensive research institution where over 600 specialists are working in such fields as agriculture, social sciences, agricultural engineering and so on.
It also takes charge of working out and coordinating research projects such as the Barani Agricultural Research and Development Project (BARD), and international research cooperation. PARC was founded in 1951 and it has control over five research institutes. Fig. 2-2 shows the organizational chart of PARC.

The major functions of PARC are the overall planning and coordination of research including project studies, promotion of effective utilization of the research results, arrangement of research systems, training of scientists and technicians, and documentation and dissemination of scientific information.

The PARC cooperates with CIMMYT, CIP, IBPGR, ICARDA, ICRISAT, CIAT, IITA, IRRI, etc. among the 13 institutions of the Consultative Group of International Agricultural Research (CGIAR), and the Chairman of PARC is a member of the Board of Directors, Asia and Far East Division of CGIAR,

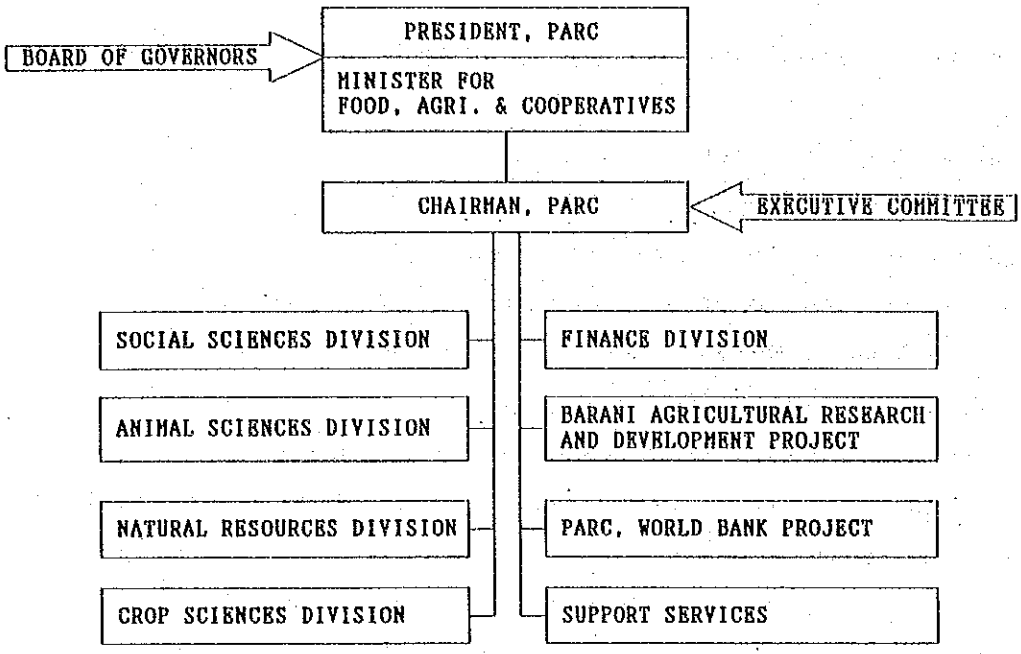


FIG. 2-2 ORGANIZATIONAL CHART OF PARC

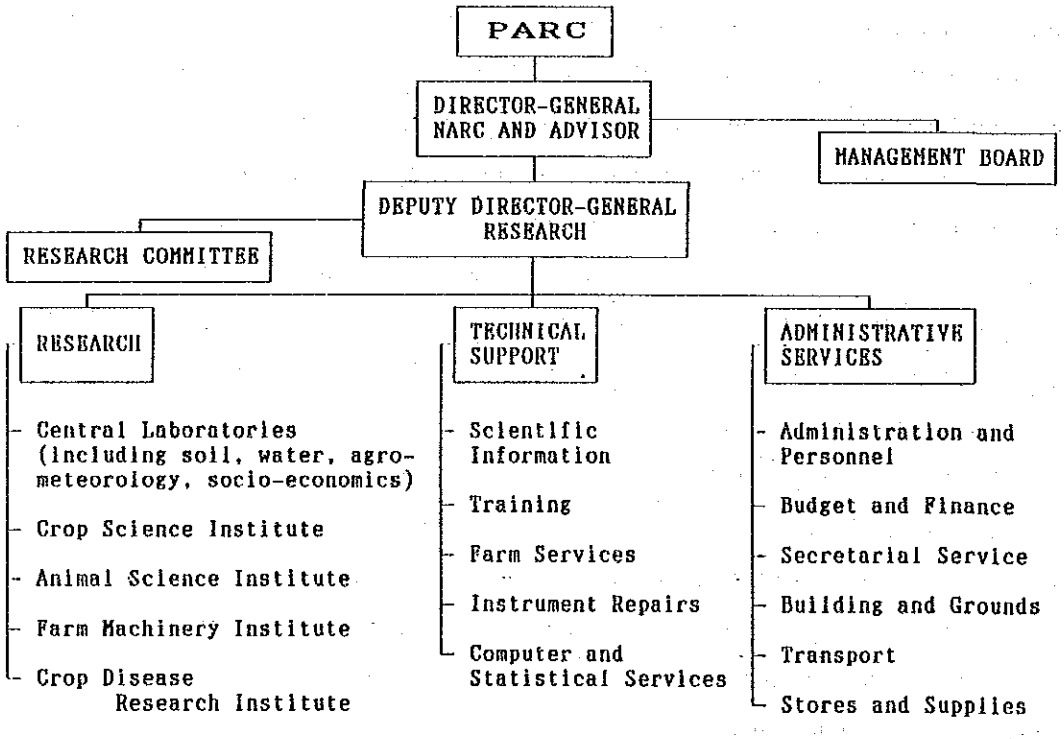


FIG. 2-3 ORGANIZATIONAL CHART OF NARC

and Member of the Board of ICARDA.

2) National Agricultural Research Centre

The NARC was established in 1975 on an area 565ha, 6km to the south-east of Islamabad.

In addition to its activities as the central agricultural research institute in Pakistan, NARC serves as a genetic resources centre, and conducts technology guidance and training of researchers from the Provinces, as well as providing information services to the scientific community in the country.

The NARC's research division is composed of the Crop Sciences Institute (CSI), the Central Laboratories, the Natural Resources Institute, the Crop Diseases Research Institute, the Animal Sciences Institute (ASI) and the Social Sciences Institute. Fig. 2-3 shows the organization of NARC.

The researchers at NARC include 53 Ph.Ds, 275 M.Sc. and 20 B.Sc.. NARC's budget for the fiscal 1990/91 was Rs.1,094,180,000 in total, out of which Rs.547,210,000 was appropriated for ordinary research, Rs.316,970,000 for research and development, and Rs.230,000,000 for special research.

At CSI, testing and research are carried out on breeding, cultivation, prevention and control of insect pest, and soil management on various crops including wheat, barley, triticum, rice, maize, sorghum, millet, sugar cane, beat, oil seeds, pulses (lentil, mungbean, chickpea, cowpea), vegetables, potatoes and fodder crops.

Testing of wheat and related species is focused on the breeding of disease-resistant or drought-resistant varieties, and the development of production technology adapted to the Barani regions. About 7,000～12,000 strains are tested every year at CSI in collaboration with CIMMYT, ICARDA and FAO.

The NARC Farm Operation & Services was founded in 1982, and 35 staff members are working there today. They supply fertilizers and other support service facilities to the researchers: land preparation or irrigation facilities to researchers, and maintenance services for farm machinery.

The NARC Training Institute was founded in 1983, and 28 staff members

are currently working there. The Institute provides training to scientists and field workers and laboratory technicians. Up to December 1988, they had organized 138 training programmes in which 3,752 persons were trained. They now organize training programmes in cooperation with international organizations including CIMMYT, FAO, USAID, CIDA and ICARDA.

At the Agricultural Machinery Institute, development of agricultural machinery and examination of the adaptability of imported instruments are carried out. Moreover, NARC, emphasizing the importance of the development of Barani agriculture, is organizing its research and development project, for studies on the improvement of planting strength by catch cropping or double-cropping, the development and utilization of water supply systems, and the development of agricultural machinery.

In addition, the Crop Disease Research Institute was founded in 1954. 49 researchers at this institute are conducting research on diseases affecting wheat and other crops such as sugar cane, maize, potato, sunflower, etc.

2-3-2 Current state of crop breeding

(1) Institutions conducting breeding and their objectives

Research on breeding is carried out in closely between federal and Provincial-controlled research institutes. Breeding of major crops such as wheat and related species, pulses and maize are conducted at NARC, while those of rice, cotton or sugar cane are done by other institutes. Examinations on insect resistance or on adaptability are carried out by standardized methods suitable to each objective of breeding.

Table 2-8 Breeding objectives of major crops

Wheat	: high-yielding varieties resistant to rust disease, salinity, drought, cold and heat.
Rice	: high-yielding varieties resistant to stem borer, blast, low temperature and high temperature.
Maize	: high-yielding varieties resistant to blight, root-rot, and borer.
Pulses	: high-yielding varieties resistant to blight, yellow mosaic virus, and fast-growing or little susceptible to the day length

Oil seeds : high-yielding varieties resistant to salinity, drought, and aphid.

Vegetables: high-yielding varieties resistant to root-rot, Powdery mildew, blight, TMV, and Aphid, and fast-growing.

(2) Results of breeding

Variety improvement of wheat and related species in Pakistan started with the systematic selection of local germplasm, and breeding of several varieties has been conducted since 1919. Crossbreeding was also introduced and has been carried out. A lodging-resistant and fertilizer-resistant variety of wheat was introduced from Mexico around 1965, and yielded more than twice that of the local varieties: 740 kg/ha in 1970. Inspired by this result, the government of Pakistan actively promoted research on the variety improvement, enabling the breeding programmes to be more efficient and well organized.

Since then, using the Mexican varieties as a mother species, improvements in the high-yielding, fast-growing and disease-resistant varieties evolved, and many good-quality varieties such as Mexipak-65 and Chenab-70 were bred and widely distributed, especially in the Punjab Plain. Today, efforts continue to varieties superior to those. Short duration varieties are evolving through radiation and conventional breeding.

Those varieties spread in the plains of the Northeast are Mexipak-65, Chenab-70, SA-42, and Blue-Silver, all of which are similar to Mexipak but more resistant to diseases and are fast-growing. Other varieties which have been successively bred, distributed and adapted to the local conditions of the Northeast include Potohar, Lyallpur-73, Sundar, and PARI; to the Northeast, Triple Dwarf (introduced from Australia), Khushal, Tarnab-73, and to the Southwest, Local Mixture, Local White and Mexipak-70.

High-yielding varieties of rice have also been developed such as IRRI-Pak (IR-8) and IR-6 and are now grown in wide areas of Pakistan.

The following varieties have been developed over past few years.

Rust resistant wheat germplasm : Faisalabad-83, Barani-83, Pirsabak-85, Faisalabad-85, Punjab-85, Chakwal-86,

	Sutlej-86, Rawal-87, khyber-87, Hyderabad-88, Panjnad-88, Shalimar-88.
Early matured groundnut varieties	: Vard-699
Early matured lentil	: Precoz
Early matured and cold resistant maize	: Gauhar
Early matured and high-yielding maize	: Pool-10, Pool-20, Pool-70
High-yielding sorghum varieties	: ICSV-107, ICSV-219, CSH-6
High-yielding millet varieties	: ICMS-7704, Ugandi
High-yielding millet for feed	: Bajra MB-87.

(See Appendix 6-4 for the results of the breedings conducted in Pakistan over the recent years.)

2-3-3 Current state of the research on plant genetic resources

The research on the plant genetic resources under the Government of Pakistan started in the 1970s, with the genetic resources collection project carried out with the cooperation of SIDA and IBPGR. In 1980, the Genetic Resources Preservation Laboratory was set up at the Crop Sciences Institute (CSI), NARC, and activities including the exploration and collection, introduction, evaluation, preservation, distribution and data management were conducted there.

(1) Exploration and collection

Exploration and collection were carried out in the country, and 5,993 samples were collected through 21 plant collecting expeditions. (see Table 2-8)

(2) Introduction and Exchange of genetic resources

By 1988, 4,700 accessions were introduced. The exchange of genetic resources has been done with Federal and Provincial Research Institutes and foreign national genebanks, genetic resources centers and international research institutes. The germplasm material of different crops was

TABLE 2-8 NUMBER OF SAMPLES BY COLLECTING EXPEDITION(1981～1990)

S.NO.	Collecting Expedition	Area	Year	No.of Samples
1.	PARC/Netherlands, Cereal expedition.	Baluchistan.	1981	794
2.	Fruits genetic variability.	Baltistan.	1982	96
3.	Chickpea & lentil.	Punjab & Sind.	1982	660
4.	Cereal germplasm.	Azad Kashmir.	1982	136
5.	Mung & Mash germplasm.	Punjab.	1982	419
6.	Fruit genetic diversity.	Northern Area.	1983	257
7.	Lentil germplasm.	Punjab.	1983	212
8.	Vegetable germplasm.	Nothern Area.	1983	80
9.	SINO/PAK Cereal germplasm.	Punjab, NWFP. & Azad Kashmir.	1983	78
10.	Rice genetic variability.	NWFP.	1984	144
11.	Chickpea germplasm.	Sind & Punjab.	1985	356
12.	Rice genetic diversity.	Baluchistan.	1985	200
13.	Aegilops and Triticum.	Baluchistan.	1986	105
14.	Triticum germplasm.	Northern Area.	1986	150
15.	Fruit genetic diversity.	NWFP.& Kashmir.	1987	205
16.	Rice germplasm.	Sind.	1987	205
17.	Millet & related wild apecies.	Northern Area.	1987	250
18.	Temperate fruit & nuts.	Northern Area.	1988	450
19.	Cereal collecting exp.	NWFP.,Punjab & Northern Area.	1989	705
20.	Pearl Millet.	Punjab.	1989	262
21.	Fibre crops.	Punjab & NWFP.	1990	229
			TOTAL :	5,993

TABLE 2-9 GERMPLASM STATUS

S.NO.	Crop	No.of Accessions
1.	Wheat & related species.	1,538
2.	Rice.	3,296
3.	Barley.	392
4.	Maize.	342
5.	Sorghum.	492
6.	Millet.	725
7.	Chickpea.	2,597
8.	Pulses.	1,588
9.	Oilseed crops.	2,847
10.	Vegetable.	335
11.	Spices.	99
12.	Oats.	112
13.	Fruits.	801
14.	Medics.	114
15.	Misc. crops.	484
16.	Fibre crops.	229
	TOTAL :	15,991

TABLE 2-11 CHARACTERIZATION & PRELIMINARY EAVALUATION

S.NO.	Name of Crop	No.of Accessions
1.	Wheat.	1,298
2.	Barley.	312
3.	Oat.	93
4.	Lentil.	179
5.	Vigna.	1,088
6.	Chickpea.	2,489
7.	Groundnut.	125
8.	Rice.	2,005
9.	Brassica.	199
10.	Maize.	230
11.	Vegetables.	64
12.	Sorghum.	258
13.	Millet.	388
14.	Lathyrus.	30
15.	Faba beans.	10
16.	Wheat	313
17.	Millet & Sorghum	350
	TOTAL :	9,431

supplied to the U.S.A., Japan, India, Taiwan, Bangladesh, Syria, Egypt and several other countries.

(3) Plant quarantine and examination

Plant quarantine is conducted by the Plant Protection Department, MFAC, and it has limited facilities for insects (Entomology) but no facility for testing diseases. Plant genetic resources introduced from abroad need to be examined to avoid the introduction of foreign diseases into Pakistan.

(4) Preservation

The number of conserved accessions of each crop is indicated in Table 2-9. Collected plant germplasms are preserved in the genebank at 4℃, and their numbers have reached 15,991 as of April, 1991. The seed samples are put in tin cans or aluminium bags, and then piled on the storing shelves. The present facility was constructed years ago, so that the equipment is now too old for use, and almost no more space is available to accommodate more samples.

As for cotton, 1,200 samples of different origins are stored in the Central Cotton Research Institute in Multan under the Pakistan Central Cotton Committee.

The procedures of germplasm storage carried out at the Genetic Resources Lab., NARC, are as follows:

Reception of seeds from related research institutes → seed threshing and cleaning → germination test: those with the germinability of over 85% are considered proper seeds → seed drying → packing → preservation → germination test → rejuvenation/multiplication.

(5) Distribution of genetic resources

The germplasm of different crops is distributed to the local and foreign research institutes, and so far, as many as 11,035 germplasms of cereals, pulses, fruits, etc. have been distributed. (see Appendix 6-6)

(6) Vegetatively propagated plants

Studies on vegetatively propagated plants such as potato, date palm and sugar cane are conducted not only at NARC but also at the Nuclear Institute for Agriculture and Biology, Faisalabad and the Atomic Energy Agricultural Research Centre, Tandojam. A virus-free potato was produced by tissue culture at NARC, and multiplied at a station in the northern area. Research is being carried out on the cellular propagation of date palm.

(7) Evaluation and rejuvenation

Preliminary evaluation, characterization and rejuvenation of 9,431 strains of genetic resources of different crops were accomplished by 1990 (see Table 2-11). The evaluation is based on Table 2-12. The crop coordinator for each of the major crops provides cooperation for testing at NARC and other research institutions in the provinces.

(8) Utilization of genetic resources (breeding and production of seeds)

Wheat and barley germplasms received from abroad are tested for their resistance to rust-disease, salinity and drought. The promising lines are used in the breeding programmes for development of high-yielding improved varieties. Testing is also carried out for the identification and utilization of the superior genotypes of wheat, oat, millet, sorghum, legumes and so on.

(9) Data management

A data base has been established for the storage and management of genetic resources information. Collection and passport data, evaluation and characterization data, accession record data and gemplasm exchange/distribution data, is being maintained and computerized for efficient retrieval and utilization of the information. The germplasm catalogues for different crops will be published after all the data is computerized.

2-4 Circumstances which led to the Request and its contents

2-4-1 Circumstances which led to the Request

The Seventh Five-Year Plan, setting the targets of the agricultural sector on the increase in production by improving land productivity, strengthening of self-sufficiency in cereals, and the diversification of farm products, aimed to achieve the annual agricultural growth rate of 4.7%. The means to be applied to attain this goal were :
(1) development of high-yielding and disease-resistant varieties for sugar cane, rice and oil seed, (2) research and introduction of improved varieties of fruits vegetables and other crops adapted to local conditions, (3) diversification of the high value-added fruit and vegetables adapted to the local climate, (4) development of new varieties through the promotion of agricultural research operations, and so on which concerned productivity.

Accordingly, PARC worked out the Project to strengthen the activities of NARC, where comprehensive research is to be conducted on the collection and preservation of plant genetic resources, through arranging a system of effective utilization of plant genetic resources, in order to strengthen and support the breeding programmes in Pakistan for different crops.

The Government of Pakistan, recognizing the importance of the Project, planned its implementation, but lacked the requisite funds for its execution. Therefore, the Government of Japan was requested to provide the necessary facilities and equipment, as well as the transfer of technology for the Project.

In response to the Request of government of Pakistan, the government of Japan decided to conduct a preliminary study on the Project, and JICA sent a joint preliminary study team on grant aid and technical cooperation to Pakistan in December, 1990.

Based on the results of this preliminary study, the Government of Japan decided to conduct a basic design study of the Project for grant aid, and JICA dispatched a basic design study team to Pakistan in March, 1991.

2-4-2 Contents of the Request

The comparative list of the contents of the Request and the results of the preliminary study is shown on the next page.

TABLE 2-12 CONTENTS OF THE REQUEST FROM THE GOVERNMENT OF PAKISTAN AND THE RESULTS OF PRELIMINARY STUDY

	Contents of the Request	Results of Preliminary Study
1. Name of Project	Genetic Resources Preservation and Seed Research Laboratory Establishment	Elimination of "Seed"
2. Execution Agency of Project	Pakistan Agricultural Research Council (PARC), Agricultural Research Division (ARD), Ministry of Food, Agriculture & Cooperatives	
3. Project Site	On the Premises of National Agricultural Research Centre (NARC)	To pay attention to the Rebuilding Plan of Crop Science Institute and any overlap with the existing facilities
4. Outline of Research Activities	(a) Examination and Research on Plant Genetic Resources (b) Examination and Research on Seed (Evaluation, Preservation, Breeding, etc.) (c) Production and Distribution of Good Quality Seed	(a) To eliminate the research activities on Breeding and Seed Production (b) Regarding the Seed Research, to limit it to that necessary for Evaluation and Preservation of Genetic Resources (c) To limit Vegetative Propagation Research to Research on In-vitro Preservation
5. Execution Structure of Activities, Provision of Budget, etc	A. Following 5 Laboratories and other related Rooms (a) Exploration, Collection and Seed Processing Laboratory, (b) Seed Physiology and Seedling Establishment Laboratory, (c) Evaluation and Seed Health Laboratory, (d) Data Management & Seed Ecology Laboratory, (e) Plant Introduction & Vegetative Propagation Laboratory B. Personnel Allocation: 46 persons (under consideration) C. Maintenance & Operation Cost: 4,000,000 Rupees/Year (Spares, Electricity, Water, Gas and Consumables)	According to above Research Activities, following 6 Laboratories to be better: (a) Exploration & Collection, (b) Plant Introduction & Seed Health, (c) Seed Preservation, (d) Germplasm Evaluation, (e) In-vitro Preservation Research, (f) Data Management. Confirmation of budgetary provision and examination of whether it is proper amount or not, to be necessary.
6. Facilities and Equipment		
(1) Building	Lab Complex & Office Accommodation (2 Stories, 23,000ft²) [21,768,500 Rupees]	Regarding the Vegetative Propagation Research, to limit its Facilities to those necessary for Research on In-vitro Preservation
(2) Phytotron	1 set (50m²) [23,761,200 Rupees]	Due to heavy Maintenance Cost and Difficulty in Management, to eliminate from Requested items. Instead of it, to procure necessary amount of Growth Chambers
(3) Green Houses	(a) Environmental Controlled Green House: 2 sets (350m²/1set) [7,761,200 Rupees] (b) Green House for Production of Distribution Seeds: 4 sets (350m²/1set) [12,447,800 Rupees]	(a) Examination of Scale and Grade, Cooling System, Operation and Maintenance Cost, etc., to be necessary. (b) To Examine availability of Mesh House, to be necessary.
(4) Seed Storage & Related Facilities	(a) Seed Storage (Maximum: 50,000 items) [34,328,300 Rupees] ・Medium-term Storage: Temperature +5℃, Relative Humidity 30~40% ・Short-term Storage: Temperature +10℃, Relative Humidity 40% (b) Cooling System for Seed Storage and Air-conditioning for a Lab., etc.	(a) Medium-term: 10 years, Short-term: 1 to 3 years (b) Examination of Humidity Conditions, Packaging of Seeds, Proper Amount of each Sample for Storage, to be necessary.
(5) Electrical Facilities	High Voltage Receiving System and Wiring, Back-up Generator, etc. [12,686,600 Rupees]	
(6) Scientific Equipment	(a) Seed Storage, (b) Seed Viability Testing Lab., (c) Seed Preparation & Processing Lab. (d) Vegetative Propagated Plant Lab., (e) Lab. for Data Management, (f) Lab. for Exploration & Collection, (g) Lab. for Evaluation & Seed Health, (h) Facilities for Administration, etc. (i) Eq. for Common Facilities, (j) [74,414,800 Rupees]	(a) Regarding the Vegetative Propagation Research, to limit its Equipment to that necessary for research on In-vitro Preservation. (b) Careful Discussion on Items, Quantity, Specification, etc., to be needed.
(7) Training for Facility Operation and Supervision	180 man-days [1,343,300 Rupees]	
(8) Spares for Item (2) to (6)	@10% of their cost (165,399,900 Rupees) [16,540,000 Rupees]	
Total	[221,469,600 Rupees]	
(9) G.O.P. Contribution	Provision of Electric, Gas and Water Connections [2,000,000 Rupees]	Confirmation of Undertakings covered by G.O.P. and Budgetary Provision, etc., to be necessary.
7. Technical Cooperation	(a) Term of Cooperation: 5 Years (b) Sector of Experts: Genetic Conservation Expert, Seed Pathologist/Quarantine Expert, Seed Technologist (c) Acceptance of Trainees: in Genetic Conservation and Seed Science Course, 3~4 persons/year, 3~6 months (d) Procurement of Equipment: those necessary for execution of Project, but excluding those procured within Japan's Grant Aid program (e) Imposition of a part of G.O.P. Contribution	(a) Definite scope of Technical Cooperation to be decided in future discussion between both sides. (b) Arrangement of Undertakings and Contribution covered by G.O.P., to be necessary. (c) Dispatch of Japanese Experts: in the fields of Seed Preservation, Seed Pathology/Quarantine, and other fields if needed.

2-4-3 Results of the preliminary study

As a result of the preliminary study, the Project was considered to be very important for the development of agriculture in Pakistan. It was realized that distribution of germplasm to breeders is imperative. It is essential to collect and preserve the plant genetic resources which are threatened with extinction. These resources must be properly conserved and collected before they are lost forever.

The feasibility of the Project was also confirmed, since the existing facilities and equipment for genetic resources research at NARC were judged to be too inadequate to fulfill the role to provide appropriate and sufficient quantities of breeding materials to the institutes throughout the country and abroad.

Moreover, various exchange and cooperation programmes have been carried out in collaboration with Japan, U.S.A. and international agencies such as the International Board for Plant Genetic Resources, ICARDA, ICRISAT, IJO etc., therefore the scientists and technicians are capable of handling the Project. Therefore, according to the conclusion of the study, by conducting the transfer of the applied technology, the facilities and equipment to be provided under the grant aid system will be utilized in an effective and advanced manner.

The contents of the Request covered both genetic resources and seed science, but the items of these activities were found to be too many to be executed within the limited budget and personnel of the Pakistani side. Therefore, it was decided more appropriate to concentrate on research related to genetic resources aspects. Seed science being a basic study, therefore it was suggested to limit the scope of Japanese aid to those related to the genetic resources, and to confine the study of seed research to the preservation and evaluation of the genetic resources, and preservation of the vegetatively propagated plants.

As a result of their discussions, the preliminary study team and the Pakistani officials agreed to the following activities to be carried out under the Project.

a) Exploration and collection of the plant genetic resources.

b) Health examination of the germplasm or seeds of the introduced plant genetic resources, and study on its procedures.

c) Storage of 50,000 accessions under low temperature conditions. The storage will be for short-term (1~3 years) and medium-term (5~10 years).

d) To conduct research on the dormancy and germinability of seeds, and examine the seed invigoration of the stored genetic resources.

e) To conduct characterization and preliminary evaluation of germplasm for agromorphological and genetic traits, and evaluate the genotypes for utilization in breeding. (Table 2-13)

f) To conduct basic and applied development work on seed physiology and seed biochemistry

g) In-vitro preservation research

h) Studies on more reliable biochemical and physiological procedures for varietal identification.

i) Data management on plant genetic resources.

j) Distribution of germplasm to local and foreign breeding research institutes for crop improvement programmes.

The facilities proposed in the Request were : 5 laboratories (exploration, collection and seed processing lab., seed physiology and seedling establishment lab., evaluation and seed health lab., data management and seed ecology lab., plant introduction and vegetative propagation lab.), seed storage-related facilities, crop threshing and cleaning room, seed drying room, seed preparation and packing room, office accommodation for research professional and staff, library, machine room, phytotron, greenhouses for environmental control, greenhouses for insect/pollen control and for maintenance of seed purity.

Based on the above-mentioned activities, however, the preliminary study team consulted the Pakistani side, and the need of the following facilities became clear. The name of each laboratory is understood as indicative of the research division, and the actual composition of the rooms matched to the flow of the activities, and the required size of each room were to be defined in the basic design study.

a) Exploration and collection lab.

b) Plant introduction and seed health lab.

c) Seed preservation lab.

d) Germplasm evaluation lab.

e) In-vitro preservation research lab.

f) Data management lab.

g) Medium-term storage

h) Short-term storage

i) Germplasm preparation room

j) Crop threshing and cleaning room

k) Seed preparation and packing room

l) Greenhouses

m) Mesh houses

n) Other required facilities: conference room, documentation room, sample identification room, administrative facilities, office accommodation, machine room, storehouse, and other rooms.

Regarding equipment, it was concluded that it should be relevant to the agreed upon activities, and the details were to be defined in the basic design study. However, the replacement of the phytotron by growth chambers, and the need of equipment for both seed health testing and for in-vitro preservation research were confirmed.

Table 2-13 Detail evaluation to be carried out at Genetic Resources Preservation Lab.

CROP	EVALUATION PARAMETERS
Wheat, Barley & Oat	- Screening for Pest and Diseases(Leaf rust, Stem rust, Stripe rust, Root-rot, Powdery mildew and Aphid) - Evaluation for Lysine (Protein ratio) - Stress susceptibility(for heat, drought and salinity) - Identification of gene marker through gel electrophoresis
Food Legumes & Pulses	- Screening for blight - Evaluation for yellow mosaic virus - Evaluation for protein content - Evaluation for stress factors(drought, temperature and salinity)
Oil seeds	- Screening for aphid resistance - Evaluation for oil contents - Evaluation for salinity, drought, etc.
Rice	- Screening germplasm for blast and stem borer - Evaluation for salinity.
Maize, Sorghum & Millet	- Screening for borer, root-rot and blight - Evaluation for salinity.
Fruits & Nut species	- Identification of cultivars/land races through gel electrophoresis and to eliminate the duplicate.

CHAPTER 3

CONTENTS OF THE PROJECT

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3-1 Objectives of the Project

In order to accomplish the most important aim of the Seventh Five-Year Plan, and the enhancement of its agricultural productivity, the Government of Pakistan is endeavoring to promote agricultural research work which will contribute to breeding operations such as the development and distribution of good quality seeds. For the promotion of projects like the production and distribution of the seeds, however, the genetic resources preservation facilities have not yet been sufficiently prepared. In addition, as the spread of HYV (high yielding varieties) is now threatening to eliminate the old cultivars and species which have valuable genes, it is necessary to preserve them. It is also necessary to streamline the system to utilize those genetic resources for the purpose of strengthening crop breeding in the country.

The Government of Pakistan recognizes that it is necessary to preserve plant genetic resources internationally and utilize them by exchanging seeds at national and international levels.

It was thus decided to establish the Genetic Resources Preservation and Research Laboratory, in order to solve those problems, and arrange a system to efficiently utilize plant genetic resources, by strengthening the activities related to the collection, preservation and evaluation of food crops having useful genes including cereals, pulses, tubers, fruits and vegetables.

3-2 Review of the Contents of the Request

For the purpose of the review of the Project Outline and the execution of the Basic Design, under eventual Japanese grant aid, the contents of the request were examined whether the Project was appropriate to be implemented under the Japanese Grant Aid System, in connection with its desired effects, the actual conditions and the executing capacity of the recipient country.

3-2-1 Review of the Validity and Need of the Project

Prior to the present study, the objective of the Project, as confirmed by the preliminary study, was to establish the Project to strengthen the activities of collection, preservation, and evaluation of plant genetic resources conducted by NARC, which is now solely responsible for their collection and preservation in the country: that is to prepare a system to effectively utilize plant genetic resources, to strengthen the activity of crop breeding in Pakistan. This objective is considered appropriate, since the contents of the Project are now focused on the research on genetic resources, seed science being excluded from the original request.

In the preliminary study, the validity of the contents requested was examined. In the basic design study, therefore, the validity and need of the Project were reviewed with the Pakistani side. Moreover, the detailed contents of the Project were discussed with the Pakistani side.

3-2-2 Review of Implementation Plan of the Project

As a result of the discussions between the Pakistani side and the preliminary study team, the Project will include six laboratories;
1: exploration and collection, 2: plant introduction and seed health, 3: seed preservation, 4: in-vitro preservation research, 5: germplasm evaluation, 6: data management, and other relevant facilities.

In this study, after the above laboratories were confirmed, the administration section was added to the organizational structure as a section to conduct general management, coordination of the research activities, and maintenance of the facilities. The concrete contents of their activities and the mutual relationships among the laboratories, and the major activities are as follows:

(1) Exploration and Collection Laboratory:

To conduct the exploration and collection of plant genetic resources and to carry out the preliminary evaluation of the germplasm.

1. exploration and collection of genetic resources
2. planning of exploration programmes in collaboration with national and

international agencies

3. implementation of activities for collection
4. production of passport data
5. preliminary evaluation and characterization of crop germplasm

(2) Plant Introduction and Seed Health Laboratory:

To conduct the introduction of seed/plant material and to study its acclimatization in the country, the cultivation of introduced seeds in a quarantine nursery in terms of epidemic prevention, the detection of diseases and pests, the breeding of virus-free seedlings through an apical meristem culture method, the introduction of germplasm of under-exploited crops and the health inspection and study of its method.

1. introduction
2. seed inspection
3. the preliminary evaluation of introduced material
4. cultivation in isolation of introduced material
5. identification of diseases and pests and treatment of the infected or infested seeds

(3) Seed Preservation Laboratory:

To perform the activities for preserving 50,000 accessions of genetic resources of low temperatures. The storage periods will be divided into two kinds: short-term (1 to 3 years) and medium-term (5 to 10 years). During storage, the seeds of genetic resources are going to be examined for viability, and rejuvenated and multiplied according to their conditions. In addition, the dormancy and germination of the seeds will be studied here.

1. threshing, cleaning, preparation, drying, germination test, packing, and short- and medium-term storage
2. rejuvenation, and multiplication
3. study on the methods of the preservation of orthodox seeds and recalcitrant seeds which are difficult to preserve under low temperatures

(4) In-vitro Preservation Research Laboratory:

To conduct the study of the preservation methods for vegetatively propagated crops.

1. study on preservation method by tissue culture
2. study on cryopreservation using liquid nitrogen
3. acclimatization and cultivation of preserved material

(5) Germplasm Evaluation Laboratory:

To conduct the detailed evaluation of stress factors such as drought, heat, salinity, insect pest and diseases; to study the physiological and biochemical aspects of the germplasm; identification of cultivars and species through biochemical studies and to remove duplicates in the collection; the identification of the superior genotypes and the utilization of promising germplasm in the crop improvement programmes.

1. detailed evaluation of genetic resources in the field and at the laboratory

(6) Data Management Laboratory:

To manage data on plant genetic resources; to distribute preserved genetic resources to the breeding research institutions both in the country and abroad.

1. reception, registration, and management of data on genetic resources
2. production of the seed lists/germplasm catalogues
3. distribution of genetic resources and their data, and instruction of their distribution to the relevant laboratories/institutions, upon request

(7) Administration Section:

1. general administrative matters
2. coordination of training courses on genetic resources
3. coordination of the utilization of the Project facilities by the scientists of Crop Sciences Institute, NARC
4. maintenance and management of facilities and equipment
5. coordination with national and international research institutions for research and germplasm material

3-2-3 Review of Existence of Similar Projects, Relationships with Assistance Programs of the Other International Agencies

In Pakistan, various projects are being planned, and the loans from the World Bank and the Asian Development Bank are expected for the implementation of them. The projects related to this Project are the Agricultural Research Project-II and the Seed Industry Development Project, and their relationships with the Project are as follows.

(1) Agricultural Research Project-II (ARP-II)

(expected to get a loan from the World Bank)

This is a project which is being planned and executed by PARC, and a sum of 400 million Rs. is allocated out of 744 million Rs. approved in the budget of the Seventh National Five-Year Plan.

The implementation period of the project is seven years, and its plan was put up to the Government of Pakistan in February, 1990.

This project is going to be executed at twelve places including NARC/PARC, agricultural research institutes in each province, and agricultural universities in Faisalabad and Sind.

The aims of this project are: 1. to consolidate and complement the advances achieved under the Agricultural Research Project-I; 2. to give assistance to research programmes in the provinces; 3. to strengthen the ties with foreign research institutes; and 4. to promote post-graduate education and studies in social sciences at agricultural universities.

This project includes the rebuilding of the NARC Crop Sciences Institute (CSI). The total space of the new building will be 3,402.48m^2 (36,624ft^2), and will consist of the rooms for a director, principal senior researchers of each crop section, researchers, administration personnel, laboratories and seed processing facilities, and others. A sum of 22,529 thousand Rs. has been allocated for this project. The building site is not decided yet, but the new CSI is likely to be built either at the present site after demolishing its existing buildings or at the neighboring site of the facilities of the Project. It was confirmed with the Pakistani side that, since the institute would complement some of the activities of the Project, its facilities would not duplicate those of the Project.

(2) Seed Industry Development Project (loan from the Asian Development Bank)

The Project has an important role which will reflect the results of breeding research on the enhancement of agricultural productivity. The contents of this project are as follows:

1. comprehensive review of the seed industry and execution of the assessment
2. clarification of the disparity between supply and demand of good quality seeds and of the constraints on the supply, and assessment of the short- and medium-term demand for seed both in quality and quantity
3. review of the application of the current system to the seed industry, and proposal for its improvement
4. to clarify whether seed identification and other processes are consistent with their international standards
5. to set up the order of priority for the development the seed industry in Pakistan and cooperate with public/private sectors
6. preparation for the proposal of detailed programmes

The total fund for this project is estimated as US$ 371,000, and the executing agency will be the Seed Certification Division of the Ministry of Food, Agriculture and Cooperatives. The formal request is now being submitted in to the Asian Development Bank.

3-2-4 Functional Roles Sharing between the Project and Existing Research Facilities

The scope of the activities of the Project and its collaboration with other research institutes for the rejuvenation, evaluation, and distribution of explored and collected germplasm as well as the functions of the Project were discussed with the Pakistani side, and it was clarified and concluded as follows.

(1) Relationship with the other research institutes regarding the activities of exploration and collection:

Crop Advisory/Technical Committees are going to be established, and the activity of exploration and collection will be performed in cooperation with the institutes both at home and abroad according to the guidelines set by the committees.

It will consist of the PSO of the Project, researchers of each crop group of NARC, and one researcher from each province, and will be divided into 13 Germplasm Advisory/Technical Committees such as wheat and barley, rice, pulses and food legumes, oilseed and other crops. The institutes related to each of the committee and the List of Related Agricultural Institutes in Pakistan are shown in the reference data.

For the wheat and barley Advisory Committee, researchers from the following stations will participate: PARI-Panjub, Research Centre for Atomic Energy and Agriculture in Sind, Agriculture University of Faisalabad, Nuclear Institute for Agriculture and Biology (NIAB) of Faisalabad, AARI-Baluchistan, AARI-Sind and AARI-Peshawar.

(2) Relationship with other agencies regarding plant introduction:

The Plant Introduction Center, Karachi, is introducing tropical plants for commercial purposes.

The Project on the contrary, will concentrate on research activities, introducing sub-tropical and temperate plants as research materials.

At the the Department of Plant Protection, the Ministry of Food Agriculture and Cooperatives, is responsible for quarantine of commercial plant material imported to Pakistan. The Department of Plant Protection has facilities mainly for insects(Entomology) and limited facilities for diseases identification. There are other diseases caused by organisms such

as viruses, bacteria, and nematodes associated with imported plant materials. Post-entry quarantine facilities exist nowhere in Pakistan. As a result, the country has to rely on the quarantine certification issued by exporting countries and serious diseases and pests might be introduced into Pakistan which may cause severe damage to the relevant crops. This is a very critical situation, therefore, the Project facilities will also serve as a quarantine centre for the seeds and germplasms required for the introduction and distribution of plant genetic resources.

(3) Relationship with the department of tissue culture in NARC:

The existing department of tissue culture will not conduct the study of the preservation of germplasm. In the Project, only the study of the methods of preservation will be conducted. The research on culture technology will be done with the cooperation of the existing department of tissue culture.

(4) Relationship with other laboratories regarding evaluation activities:

In the Project, comprehensive evaluation in the field and laboratory will be conducted. The evaluation for resistance to drought, heat, and salinity will be conducted in cooperation with the Crop Sciences Institute. For the resistance to diseases and insect pests, some researchers will be assigned to the Project. More detailed evaluation, however, will be done in cooperation with the researchers of the Crop Diseases Research Institute (CDRI), NARC.

(5) Relationship with other laboratories regarding the utilization of cultivation facilities:

For field study under the Project, the Farm Operation and Services, NARC, will prepare the necessary farm land.

The purposes of using the greenhouses in the Project are: acclimatization, cultivation of vegetatively propagated plants; isolated cultivation; rejuvenation/multiplication and evaluation. For the purpose of the evaluation research, the greenhouses will be used commonly with the other laboratories of the Crop Sciences Institute.

(6) Relationship with NARC's Maintenance and Repair Unit:

While only the inspection of equipment and investigation of the causes of their trouble will be performed in the Project's facilities, the actual repair work will be done by NARC's Maintenance and Repair Unit. The unit consists of 13 personnel at present, and is performing all kinds of work ranging from setting up to maintenance of all of the equipment in NARC. The major equipment they have repaired number more than 500 items and include a growth chamber and fume hoods as well as precision machines such as an atomic absorption, plasma emission photometers, and an X-ray diffractometer. It is considered that NARC's Maintenance and Repair Unit has sufficient technology and the system to perform quick repair services.

(7) Relationship with NARC Training Institute regarding training activities:

The training for a large number of people will be held in the existing facilities, while the Project's conference room will be used for small-scale training on Plant Genetic Resources.

(8) Relationship with the existing facilities in NARC regarding printing and bookbinding:

The developing and printing of photo films will be performed in the existing facilities, but the simple printing and bookbinding, which is not performed at the NARC, will be done in the Project.

3-2-5 Review of Contents of Requested Facility and Equipment

As stated in 3-2-2 Review of the Project Implementation, the contents of the activities of the Project were finalized at the field survey, in accordance with the results of the preliminary study. As for the scale and contents of the facilities, and the contents of the laboratory equipment, it was agreed that they should be adapted to the actual conditions of Pakistan and NARC, related to the contents of research activities and their mutual relationships, and appropriate for the objectives of a grant aid project.

In the original Request, the main building of the research facilities had an area of about 2,140m^2, and the annex facilities which contained greenhouses, mesh houses and phytotron had a total area of 2,100m^2. While the offices for the PSO, SSO's and others were as many as 19 rooms with a total area of about 500m^2, the experiment room of each laboratory had an area of only about 40m^2. In addition, some rooms required for each laboratory's research activities were neglected, which would cause problems for the smooth functioning of the Project. The facilities which were lacking included: an exploration preparation room and a storage area for original seeds, in the Exploration and Collection Laboratory; a test room for bacteria, viruses, and fungi in the Plant Introduction and Seed Health Laboratory; a distribution preparation room and a seed reference room in the Seed Preservation Laboratory; a clean bench room and a incubation room in the In-vitro Preservation Laboratory; and a room for printing, bookbinding, and compiling data, in the Data Management Laboratory. An administration section, a tool and implement room, an experimental room for common use, rooms for experts for technical cooperation, and a garage for exploration vehicles were also lacking. All in all, it seems that the facility plan shown in the Request gave too much priority to preparing the offices for personnel, and did not pay enough attention to the flow of the activities of the Project. Regarding the green and mesh houses, the requested scales were considered too large for the number of accessions to be cultivated for different crops and the conditions of the utilization of existing facilities.

It was the same with the manpower allocation plan, in which the number of researchers, lab. attendants, and administration clerks was too small in comparison with that of senior researchers, and likely to create problems in the execution of research activity and the management of the facilities. And the

list of requested equipment contained many pieces with the type of specifications which would require great cost and skill to operate and maintain, and therefore, would be considered not suitable for the Project. They include a phytotron, a gas chromatography, an amino acid analyzer, a prometer among others.

(1) Review of facilities

According to the the organization of the Project decided on the basis of the results of the preliminary study, the contents of facility of each laboratory were examined in view of the contents of the research and the mutual relationships of the laboratories. An appropriate scale will be calculated for each facility in accordance with the number of researchers and that of the items of the genetic resources to be collected and preserved, the layout of research equipment, and the space necessary to conduct the work.

1) Exploration and Collection Laboratory

This laboratory will perform mainly the activity of exploration and collection of genetic resources. In the Request, this was indicated as an exploration and collection laboratory with an additional function of seed preparation. The need was recognized to separate the function of seed preparation from this laboratory's activities, and in order to secure the necessary space for the equipment layout and activities, to increase the area of its experiment room to more than requested, and to include an exploration preparation room, an original seed stock room, a lab. equipment room, and a storage for glassware and other materials.

2) Plant Introduction and Seed Health Laboratory

This laboratory will conduct principally the health inspection and health studies of plant genetic resources imported from abroad as well as the preliminary evaluation and seed production. The research contents which were classified under the Evaluation and Seed Health Laboratory and the Plant Introduction and Vegetative Propagation Laboratory in the Request are put together here. In addition, it was proved necessary for the Plant Introduction and Seed Health Laboratory to serve as a quarantine center

against viruses, bacteria, fungi and nematodes, besides the introduction activity. Therefore, a seed health experiment room, a bacterial and viral inspection room, a fungal inspection room and a lab. equipment room will be needed in this laboratory. Moreover, as it will also carry out isolated cultivation, it will have to be situated next to the greenhouses, and have a sowing preparation room.

3) Seed Preservation Laboratory

This laboratory will perform principally work necessary for the preservation and distribution of seeds, and studies on relevant preservation methods. In the original Request, the activities of seed preservation and germination testing were indicated under the Seed Physiology and Seedling Establishing Laboratory, and the seed preparation, drying/ packing and preservation under the Common Facilities for Genetic Resources and Seed Research. The necessity was recognized to set up an annex facility, which would contain space for seed cleaning/ preparation as well as fumigation, storage areas for fertilizers and agricultural chemicals, and a seed drying area. It also proved necessary to install, in its vicinities, an independent seed storage facility which would contain rooms for drying/packing, germination test, and a original seed stock, in addition to the short-, and medium-term storage area. In order to secure the space needed for the studies of preservation methods, the lab.'s experiment room should be expanded, and the rooms for lab. equipment, seed reference and distribution preparation, and a storage area should be added.

Regarding the short- and medium-term storage areas, the requested storing method requires a huge maintenance cost and advanced technology. The necessity was recognized to adopt a storage method with cheaper operation and maintenance costs, and to limit the number of the accessions to be stored to 50,000, in accordance with the result of the preliminary study. An air-conditioned anteroom attached to the storage areas should also be necessary to avoid the sharp change of temperature in and the heat shock to the seeds, when they are brought in and out of the storage areas.

As for the drying/packing room, it was considered appropriate, since the

drying method (a temperature-humidity-controlled room system) defined by the International Board of Plant Genetic Resources (IBPGR) would be very expensive and difficult to operate and maintain. It was decided to adopt the mechanical drying system. This system has often been adopted in the similar grant aid projects, and its operating and maintenance cost would be very low, if used along with the sun drying system. Therefore a sun drying area and a drying/packing room are to be built.

4) In-vitro Preservation Research Laboratory

In the original Request, this department was included in the Plant Introduction and Vegetative Propagation Laboratory, and the details of its research contents were not clearly stated. It was decided that this laboratory would conduct research on in-vitro preservation of germplasms, which would require the facilities to perform research on tissue culture and cryopreservation. Therefore, it was considered necessary to provide an experiment room, an equipment room, a clean bench room, a dark room, a culture room, and a storage room.

5) Germplasm Evaluation Laboratory

This laboratory will conduct principally detailed evaluation. In the Request, the research functions of the laboratory were included either in the Evaluation and Seed Health Laboratory, or in the Seed Physiology and Seedling Establishment Laboratory. It was therefore considered better, to carry out these research activities in the Laboratory, and increase the area of the experiment room to more than requested, to secure the necessary space for the layout of the equipment and the conduct of work, and add a lab. equipment room and a storage area.

6) Data Management Laboratory

In the request, this laboratory was referred to as the Data Management and Seed Ecology Laboratory, covering diverse areas of research.

It was considered better for this laboratory to carry out; (1) acceptance, registration, and management of data on genetic resources; (2) production of the seed lists/germplasm catalogues; (3) distribution of genetic resources and their data, and instruction of their distribution to the

relevant laboratories/institutions.

Accordingly, the Data Management Laboratory would require a computer room, a printing and book binding/compiling room, a data management office, and a room for a SSO.

7) *Administration Section*

Among the Other Facilities indicated in the Request, those related to the Administration Section included an office of a PSO, a library, staff rooms, and a seminar room. It was concluded that it would be appropriate for the section to be composed of an office of a PSO, an administration office, a central control room, a conference room, a reception room, and a library. The installation of a central control board and an automatic telephone switch board, covering the whole building, would be possible in the central control room. As for the requested seminar room, since only small-scale seminars are to be held in the Project facility, the conference room could be used for this purpose.

8) Offices of SSO's

In the Request, all of the offices for SSO's and SO's were planned to be situated at the same site away from the laboratories, which would make the researcher's movement to and from their laboratories rather complicated. To solve this problem, it would be appropriate to place each SSO's office at the location of each of the respective laboratories and let SO's work in their own experiment rooms or lab. equipment rooms.

9) Common facilities and rooms

It was concluded that it would be necessary to also have a herbarium, a centrifuge room, a growth chamber room, a lounge, a meeting room for researchers, and others (an entrance hall, an exhibition corner, toilets and pantry) as common facilities in the main complex. Moreover, in the annex buildings, it would be necessary to have a workshop for equipment maintenance, a garage for exploration vehicles, spaces for sterilized soil and cultivation material stocks, a machinery shed and an incineration shed, facilities for power supply (a substation room and a stand-by generator room), and crop processing facilities.

The reasons for the necessity of the common facilities and rooms are as follows:

Common facilities and rooms in the main complex

(Herbarium)

It will be necessary to have a herbarium for the evaluation and identification of materials by the Exploration and Collection Laboratory, the Plant Introduction and Seed Health Laboratory, and the Germplasm Evaluation Laboratory.

(Growth chamber room)

According to the results of the preliminary study, a phytotron was deleted from the equipment of the Project and replaced by growth chambers because of the maintenance and operational cost.

(Lounge and exhibition corner)

The lounge was considered to be necessary, due to local customs, and would be used by researchers as a place for having tea, a rest and discussions. As part of public relations, it would be necessary to design a exhibition corner in the entrance hall to show the outline of research activities and accomplishments.

(Meeting room for researchers)

This will be necessary for holding discussions among researchers including foreign experts.

Common facilities in the annex buildings

(Garage for exploration vehicles and workshop)

As a result of the discussion on the activities of the Exploration laboratory and the Administration Section, four vehicles and a garage for them would be necessary. It would also be necessary to provide a maintenance room for the related equipment, next to the garage.

(Sterilized soil and Cultivation material stock shed)

Though not included in the original Request, in order to supply soil and equipment to cultivation facilities, and incinerate used materials and diseased plants, a building would be necessary for placing soil sterilization machines, sterilized soil, cultivation machinery, and an

incinerator.

(Facilities for water and power supply)

Though only a power supply facility was planned in the Request, the discussion on the mechanical systems of the facilities led to the conclusion that it would be necessary to have reservoir tanks, an elevated tank, a septic tank, rooms for a substation and a stand-by generator.

10) Foreign experts' room

As indicated in the conclusion of the preliminary study, technical cooperation would be necessary for the implementation of the Project. It will therefore be necessary to prepare an office for the foreign experts.

11) Greenhouses

In the original Request, six large greenhouses with a total area of 2,100m^2 containing an air-conditioned greenhouse and greenhouses for cultivation and evaluation were required, but their uses were not specified. Based upon the contents of the research to be conducted in each laboratory and the number of plants to be cultivated, it was considered appropriate to construct six greenhouses with a total area of 1,500m^2: one for preliminary evaluation and multiplication by the Exploration and Collection Laboratory, one for isolated cultivation by the Plant Introduction and Seed Health Laboratory, two for rejuvenation and multiplication by the Seed Preservation Laboratory, one for acclimatization and cultivation by the In-vitro Preservation Research Laboratory, and one for detailed evaluation by the Germplasm Evaluation Laboratory.

(2) Review of equipment

Based on the results of the preliminary study, and according to the results of the discussions on the research activities in each laboratory, the requested equipment was reviewed as follows:

1) Major equipment excluded from the Request

Sophisticated skills and knowledge are required to operate the following six pieces of equipment, and specialists should be assigned to handle them. Moreover, they have low priority from the viewpoint of the research activities of the Project. Therefore, it is appropriate to exclude them from the list of the requested items.

a) Amino acid hydrolysis tube (with vacuum pump)
b) Amino acid analyzer
c) Computerized gas chromatograph
d) Vertical electrophoresis apparatus
e) Gel scanner
f) Photosynthesis meter

However, it would be necessary to replace the gas chromatograph with an oil content analyzer, and the electrophoresis apparatus by a simplified horizontal apparatus.

2) Major equipment reduced in number

a) High speed and super high speed centrifuges: from 4 to 2.

Two sets of the high speed centrifuge were requested for the Plant Introduction and Seed Health Laboratory, and one set of the super high speed centrifuge for this Lab. and for the Germplasm Evaluation Laboratory respectively. In view of the vibration problem and the practical utilization, one set of each model will be required in a room for common use.

3) Equipment confirmed by the preliminary study

a) A set of equipment for the In-vitro Preservation Research Laboratory

As a result of the preliminary study, the equipment for the in-vitro preservation research was judged necessary.

b) Growth chamber

As a result of the preliminary study, a phytotron was eliminated from the equipment of the Request. Instead, one set of the growth chamber will be installed respectively in a common room, the Evaluation Lab. and the Plant Introduction and Seed Health Laboratory.

4) Major equipment with specifications changed

a) Vehicle for exploration and collection

As the exploration team is dispatched three times a year and two teams might be on mission simultaneously, and in order to improve mobility in the rainy season, the one 4WD pickup truck requested should be replaced by two 4WD service wagons. One is short-bodied for the mountainous area, and the other long-bodied for the flat land. The pickup truck for administrative use should also be utilized for exploration and collection activities.

5) Major equipment added

a) Equipment for inspection and research: 1 set.

One set of equipment required for the inspection of and research on fungi, viruses and bacteria should be prepared for the Plant Introduction and Seed Health Laboratory to be able to perform quarantine operations.

b) Tiller and tractor for greenhouses: 1 each.

The tiller will be used for soil preparation in the greenhouses, and the tractor is for cultivation of the fields for preliminary evaluation. One each will be necessary for the Exploration and Collection Laboratory and the Plant Introduction and Seed Health Laboratory.

c) Soil burning and soil steam sterilization equipment: 1 set each.

Soil burning equipment for the pot cultivation in greenhouses, and a soil steam sterilization machine for the direct sterilization of soil will be provided. Both will be small and portable types.

d) Administrative transportation vehicle

The activities of the Project will include training and seminar programmes held on the average once every two weeks. For the transportation of the trainees as well as for the shuttle service between the Project's facilities and existing NARC buildings, an additional microbus of 15 passengers will be required.

e) Reagents: 1 set.

For the electrophoresis apparatus as well as for the seed health inspection and the detail evaluation, it will be necessary to add a set of the reagents and chemicals, for it takes time to purchase them in Pakistan.

f) It will be necessary to add two motorcycles for work in the field and transportation of small tools and seeds.

3-2-6 Review of Operation, Maintenance, and Management Plan

(1) Personnel allocation plan

In the preliminary study, the Pakistani side indicated a plan to assign 46 persons. After the review of: 1) technological capability of personnel; 2) personnel assignment according to the Project contents; and 3) availability of personnel, and after the discussion on the need to reinforce manpower, it was judged necessary to deploy 66 persons for the operations of the Project.

(2) Budget treatment

The expenses for the construction of roads, water, gas, power supply, etc. to be borne by the Government of Pakistan and for the operation and maintenance of the facilities will be covered by the national budget.
The budget of PARC consists of Non-Development Funds, Development Funds, and Special Funds, and the Non-Development Funds were 105,392 Rs. thousand in the Fiscal year (F.Y.) 1988/89, 114,000 thousand Rs. in F.Y.1989/90, and 137,000 thousand Rs. in F.Y.1990/91. The Non-Development Funds in NARC are gradually increasing as follows: 54,721 thousand Rs.(7.7% up from the

previous year) in the 1990/91 fiscal year, and 50,823 thousand Rs.(6.5% up) in F.Y.1988/89. Out of these Funds, 1,069 thousand Rupees in F.Y.1990/91, 1,529 thousand Rupees in F.Y.1988/89, and 1,129 thousand Rs. in F.Y.1988/89 was respectively allocated for the genetic resources research in the Crop Sciences Institute. The future budget was decided as follows, and its content was discussed.

1) Expenses for construction to be borne by the Government of Pakistan

In the Request, two million rupees was allocated. This has already been approved by ECNEC (Executive Committee of National Economic Council). The expenditures for the preparation of infrastructure such as the source of the water supply to the greenhouses, the distribution of electricity, gas, water, and telephone to the Project site, leveling the site and for the payment of the comission based on the B/A are estimated to total about two million rupees. Therefore, the above mentioned allocation should be sufficient to cover the whole cost excluding that of general furniture and equipment.

The Pakistani side has understood that it will have to bear , to ensure the tax exemption and custom clearance of the materials and equipment for the Project, to accord Japanese nationals whose services will be necessary for the Project their entry into and stay in Pakistan, and to exempt Japanese nationals whose services will be necessary for the Project from custom duties, internal taxes and other fiscal levies in Pakistan.

2) Operation and maintenance cost

The Pakistani side has estimated a budget of four million rupees per year for the operation and maintenance expenses of the Project. These expenses do not include the personnel costs in the Project, but consist of the costs for the purchase of expendable parts, electricity, gas, fuel, communication, and maintenance of the facility and equipment. The personnel expenses do not need to be newly allocated, because the staff will be transferred from NARC and PARC to this Project.

The expenditures for electricity and fuel, and operation and maintenance of the facilities and equipment being estimated on the above mentioned conditions, the Project should be able to be operated and maintained within the allocated budget.

3-2-7 Review of Need of Technical Cooperation

In the preliminary study, nothing was mentioned beyond the explanation of the concept of Japanese technical cooperation and the confirmation of the request, but the need for technical cooperation was mutually recognized.
The basic design study team has understood that, judging from the result of the field study, the Pakistani standard of research in this area has already advanced to a certain stage as some of the past accomplishments show. Moreover, the team supposes that a great contribution could be made to Pakistan, if the technical cooperation is provided from Japan after the implementation of the grant aid assistance to the Project. Thus, the team considers technical cooperation very essential to the Project.

3-2-8 Principle Guidelines for Implementation of Cooperation

Due to the feasibility and outcome of the Project, the Pakistani ability to execute it has been confirmed, and its anticipated meeting of the requirements of the Japanese grant aid system, it is deemed appropriate to implement the Project. Accordingly, on the presumption that Japanese grant aid assistance will be given, the team will review the outline of the Project and draft its basic design in the following sections. As stated in Review of the Project Implementation and Review of Requested Facility and Equipment, it is appropriate that part of requested contents of the Project should be changed.

3-3 Project Outline

3-3-1 Executing Agency and Administration System

(1) Executing agency

The Pakistan Agricultural Research Council under the control of the Agricultural Research Division of the Ministry of Food, Agriculture and Cooperatives is the executing agency. The Project will be established within National Agricultural Research Centre (NARC) under PARC. The staff of NARC is 247 persons in total, 79 of them belong to the Crop Sciences Institute.

(2) Organizational chart of the Project

The organizational chart of the Project is shown in Fig. 3-1.

(3) Manpower plan

The 66 persons who are going to be allocated to the Project will be made up of one PSO, six SSO's, nine SO's, one AAO, one photographer, one maintenance manager, two typists, six clerks (one each for library, general administration, training, and secretary, and two persons for data management laboratory), 26 assistants (15 scientific assistants, nine lab. assistants, and two lab. attendants), two gardeners, five field workers, and three drivers. Each laboratory will be allocated the necessary staff who will work under the control of a SSO. The SO's allocation is one each for the research of preservation methods and the management of storage areas in the Seed Preservation Laboratory; one each for the evaluation of drought/heat resistance, salinity resistance, disease/insect resistance, and biochemical analysis in the Germplasm Evaluation Laboratory; one each for each of the other laboratories. To each of these SO's, three assistants (two scientific assistants and 1 lab. attendant) will be allocated. The Administration Section will consist of a PSO who will supervise the Project, an AAO who will be in charge of support staff, and an engineer who will be in charge of management and maintenance of facilities.

Out of these 66 persons, 23 are already participating in the genetic resources research which is now being conducted at NARC, and another 12 have already been assigned to duties elsewhere at NARC. The 23 persons consist up of one PSO, two SSO's, two SO's, one typist, one clerk, five assistants, two gardeners, five field workers, two peons and two drivers. It was confirmed that the remaining 31 persons would be allocated from either existing laboratories or the Talent Pool (a registration system of transferable talented people in PARC) before the completion of the Project. It was judged that this manpower plan was realistic, and that the facilities of the Project would be able to be administered quite properly. The staff assignment plan for the Project is shown in Table 3-1.

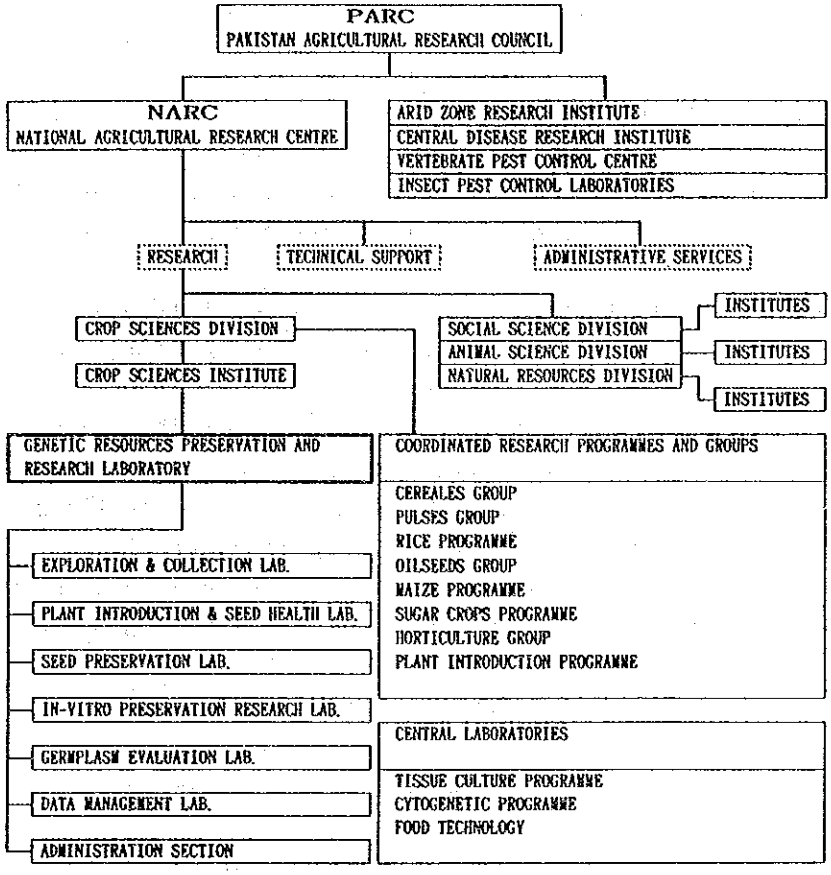


FIG. 3-1 ORGANIZATION OF THE GENETIC RESOURCES PRESERVATION AND RESEARCH LABORATORY

TABLE 3-1 STAFF ALLOCATION OF THE GENETIC RESOURCES PRESERVATION AND RESEARCH LABORATORY

POSITION / NAME OF LAB.	PSO	SSO	SO	AAO	Photo-grapher	Stock-Keeper	Steno-typist	Office Asstt.	Sci. Asstt.	Tech. Asstt.	Hall	Lab. Attdt.	Field Man	Peon	Driver	Total
Exploration & Collection Lab.		1	1						2			1			2	7
Plant Introduction & Seed Health Lab.		1	1						2			1	2			7
Seed Preservation Lab.		1	Lab. 1 Prsv.1						4			2				9
In-virto Preservation Research Lab.		1	1						2			1				5
Germplasm Evaluation Lab.		1	4						4			2				11
Data Management Lab.		1	1		1			2	2			1				8
Administration Section	1			1		1	2	Library G. Aff. Seminar Secretary		2	3			2	1	12
Cultivation Facilities													3			3
STAFF Allocation	1	6	9	1	1	1	2	6	15	2	3	9	5	2	3	66
Present working staff	1	2	2				1	1	2	2	2	1	5	2	2	23
Assigned staff from other section		4	2		1		1	1				2			1	12

3-3-2 Activity Program

In order to draft the basic design of the Project, the basic design team discussed with the Pakistani side the functions and roles of each laboratory, the concrete and practical relationships among them, and the contents of their research according to the preliminary study, and agreed with them as follows. (See Fig.3-2)

The NARC has, at present, 15,991 accessions of genetic resources (as of April, 1991), and they are going to be stored in the facilities of the Project. In the Project, about 2,000 accessions will be collected through exploration in the country and about 1,000 introduced from abroad every year, which means that the number of the accessions collected will amount to 50,000 in some 12 years. While NARC is now distributing 1,200 accessions of seeds per year, NARC plans to increase it to 2,000 per year after the completion of the Project. As described in "2-3-3, current state of research on plant genetic resources, "NARC has been collecting and storing more than 1,000 accessions a year for the past several years with limited manpower, facilities and equipment. The Project will improve these unfavourable conditions and facilitate the wider and more systematic collection, storage and distribution of genetic resources. The collection, storage and distribution plans of plant genetic resources in the Project are realistic and appropriate.

The contents of the activities of each laboratory to accomplish the aims are as follows.

(1) Exploration and Collection Laboratory

Contents of activity: collection/analysis of information on genetic resources, planning of exploration programmes, execution of collection activities, production of passport data, and preliminary evaluation

The Exploration and Collection Laboratory plans exploration and collection programmes according to the exploration guidelines set by the Crop Advisory/Technical Committees, and executes the activities of exploration and collection in collaboration with the research institutes both within the country and abroad. Exploration teams are organized three times a year, and it is possible that the three of them may be on missions simultaneously.

The passport data of the genetic resources collected are recorded. In addition, preliminary evaluation, if necessary, is be conducted by this laboratory. Out of the collected genetic resources, vegetative plants are taken to the In-vitro Preservation Laboratory, and seeds to the Seed Preservation Laboratory. And the passport data and the results of the preliminary evaluation are sent to the Data Management Laboratory. (See Fig.3-3)

FIG.3-2 MUTUAL RELATIONSHIPS

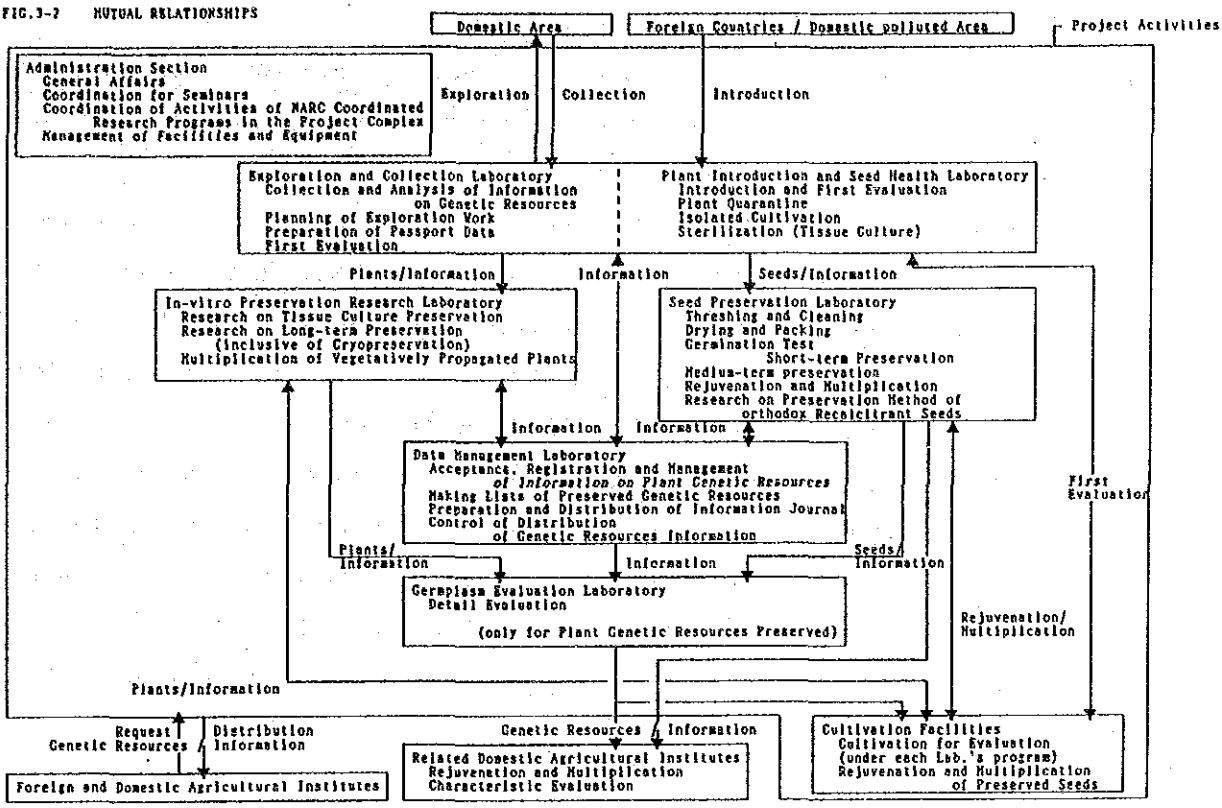


FIG.3-3 EXPLORATION AND COLLECTION LABORATORY

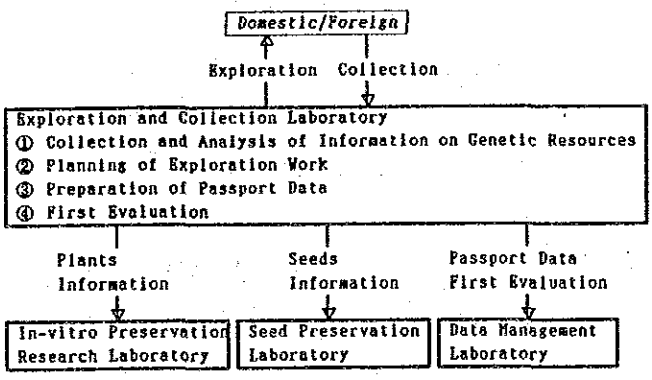
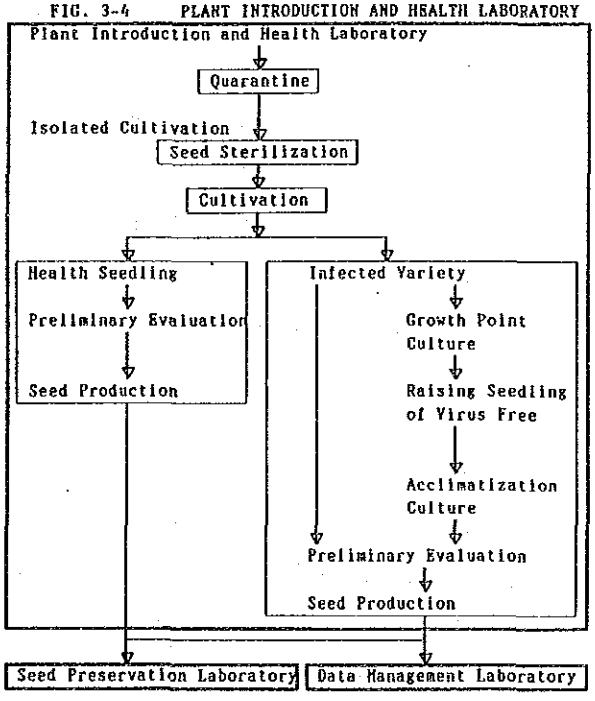


FIG. 3-4 PLANT INTRODUCTION AND HEALTH LABORATORY



(2) Plant Introduction and Seed Health Laboratory

Contents of activity: introduction, seed inspection, preliminary evaluation, isolated cultivation, sterilization treatment

Genetic resources introduced from abroad at first are quarantined. After that, if they are healthy, they are cultivated and harvested in isolation, if they are infected plants, they are cultivated after a sterilization culture, raising of virus-free seedlings, and acclimatization cultivation. Preliminary evaluation is conducted in this process. Since the Plant Protection and Inspection Division does not have enough facilities to inspect plants contaminated with viruses, bacteria, fungi, and nematodes, this laboratory also plays the role of a quarantine centre to prevent these diseases from being imported and spread in the country.

Under the Project, it studies sub-tropical and temperate plants, but not tropical ones. (See Fig.3-4)

(3) Seed Preservation Laboratory

Contents of activity: threshing, cleaning, drying, germination test, packing, medium-term and short-term preservation, rejuvenation, multiplication, study of the preservation methods for orthodox and recalcitrant seeds

The preservation programme is carried out in two stages: medium-term preservation for 10 years at 5℃; and short-term preservation for 1-3 years at 10℃. The Seed Preservation Laboratory conducts not only research on the seeds which can be dried and stored under low temperature, but also studies on recalcitrant seeds, which can not to be dried beyond certain limits and loose viability under low temperature. The seeds received from the Exploration and Collection Laboratory and the Plant Introduction and Seed Health Laboratory are tested for germination after being cleaned and dried. And the seeds which have reached a certain standard of germination are preserved in the medium-term storage and in the short-term storage.

The seeds preserved in the medium-term storage are tested for germination every two or three years. When it is confirmed that their germination rate has declined, or their consumption has been high, they are

rejuvenated or multiplied in the fields, greenhouses, or at local related research institutes, and will again be returned to the Seed Preservation Laboratory. (See Fig.3-5)

(4) In-vitro Preservation Research Laboratory

Contents of activity: studies of the preservation methods by tissue culture and cryopreservation, acclimatization/ cultivation/regeneration of in-vitro preserved material

The In-vitro Preservation Research Laboratory develops the proper methods to preserve the genetic resources of vegetatively propagated plants and perennial crops.

Plant tissues are extracted from the vegetatively propagated plants after they are cleaned, prepared and disinfected. They are set and transplanted, and cultured (culture and regeneration).

Studies on preservation methods are conducted in two ways: culture under various conditions in a incubation room; and cryopreservation with liquid nitrogen. As nitrogen can be easily obtained in Pakistan, there will be no problem in the cryopreservation study. (See Fig.3-6)

(5) Germplasm Evaluation Laboratory

Contents of activity: detailed evaluation in the fields and laboratory (only for stored genetic resources)

This laboratory performs various detailed evaluations (resistance to drought, heat, salinity, disease, and insect pests, and identity of biochemical traits). The attributes of preserved genetic resources should be evaluated for utilization in the breeding. Since the evaluation of crop gemplasm is carried out in cooperation with the institutes in NARC and related research laboratories, the evaluation is done according to the priorities set by the utilization values of each crop species for breeding. For example, the evaluation of the resistance to drought, heat, and salinity is conducted in collaboration with the Crop Sciences Institute. As to the resistance to disease and insect pests, though specialist researchers are assigned to the facility of the Project, more detailed studies are performed in cooperation with the laboratories of the Crop

FIG. 3-5 SEED PRESERVATION LABORATORY

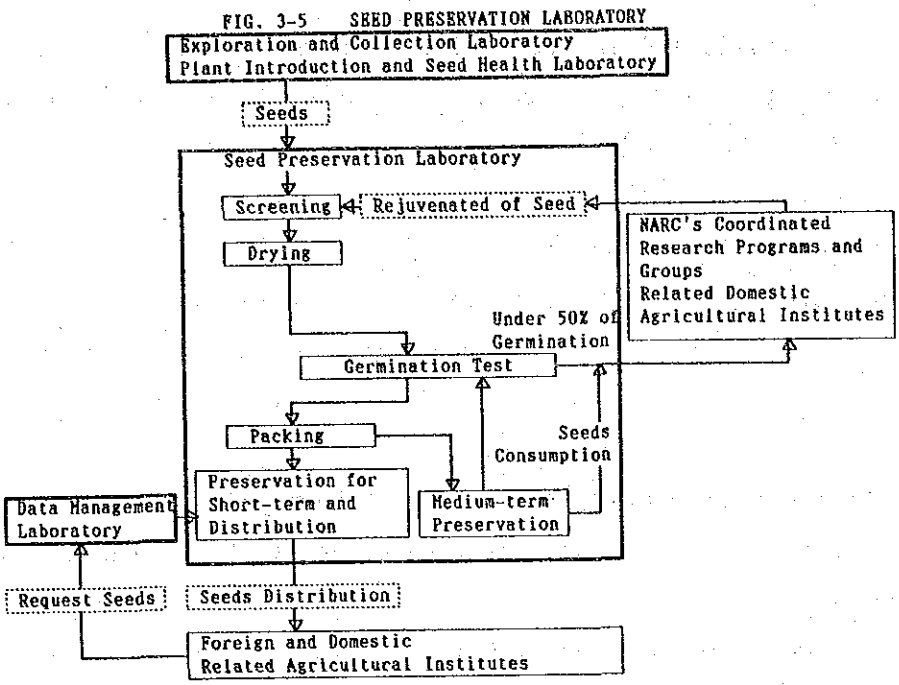
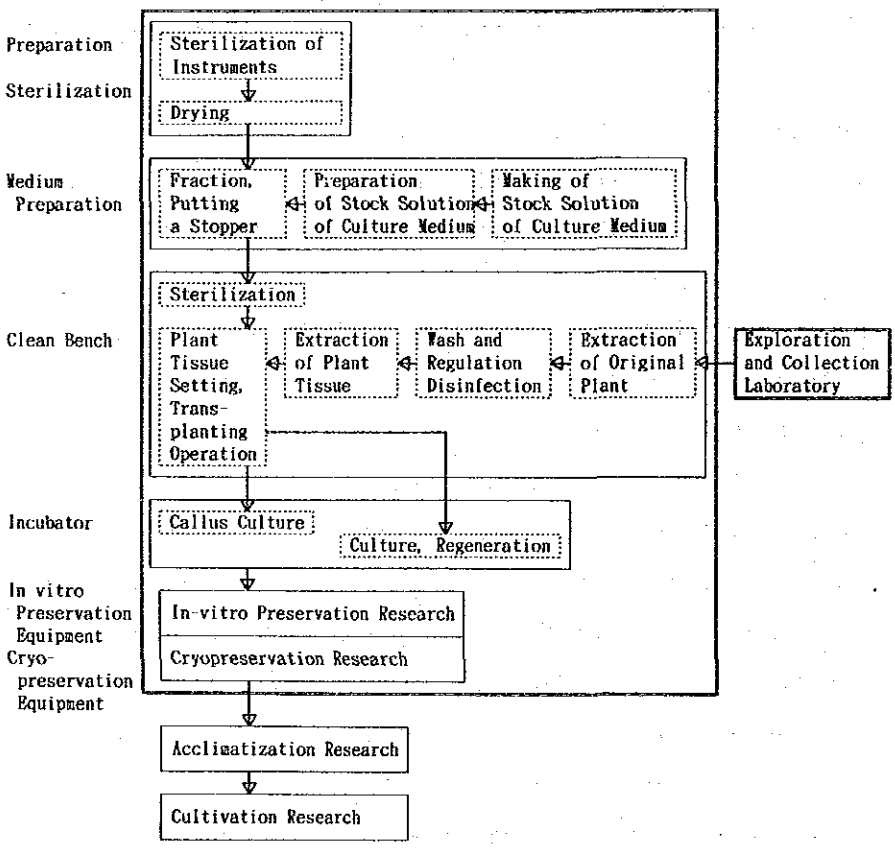


FIG. 3-6 IN-VITRO PRESERVATION RESEARCH LABORATORY



Diseases Research Institute. The Germplasm Evaluation Laboratory conducts the comprehensive evaluation activities ranging from the research in the fields to biochemical analysis, and the information obtained here is sent to the Data Management Laboratory. (See Fig.3-7)

(6) Data Management Laboratory

Contents of activity: acceptance, registration, and management of information on plant genetic resources, making lists of preserved genetic resources, acceptance of requests for distribution of genetic resources and their information, and instruction of distribution of seeds by Seed Preservation Laboratory

The Data Management Laboratory will input all the information of preserved genetic resources such as passport data and the results of evaluation, and establish a data base.

To promote the utilization of the data in each laboratory, the Lab. will systematize both the output and input of the data. This laboratory will also accept requests for the distribution of genetic resources and their information from various research institutes both in the country and abroad, and distribute them through the Seed Preservation Laboratory and the In-vitro Preservation Laboratory. (Fig.3-8)

(7) Administration Section

Contents of activity: general administration, management of training programmes, management of the use of the facilities of the Project by each crop research unit in NARC, and management and maintenance of facilities and equipment

The Administration Section performs the activities of general administration, management and maintenance of the facilities and equipment, management of training programmes of related scientists for technology transfer and enhancement of the level of technology, and management of use of the facilities of the Project by each crop research unit in NARC.

FIG. 3-7 GERM PLASM EVALUATION LABORATORY

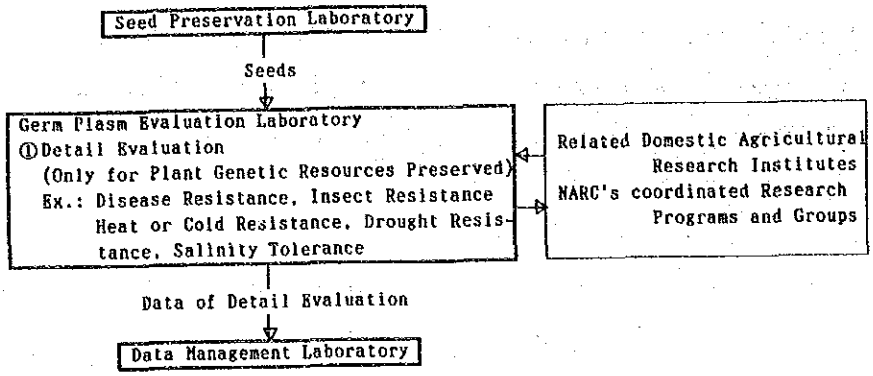
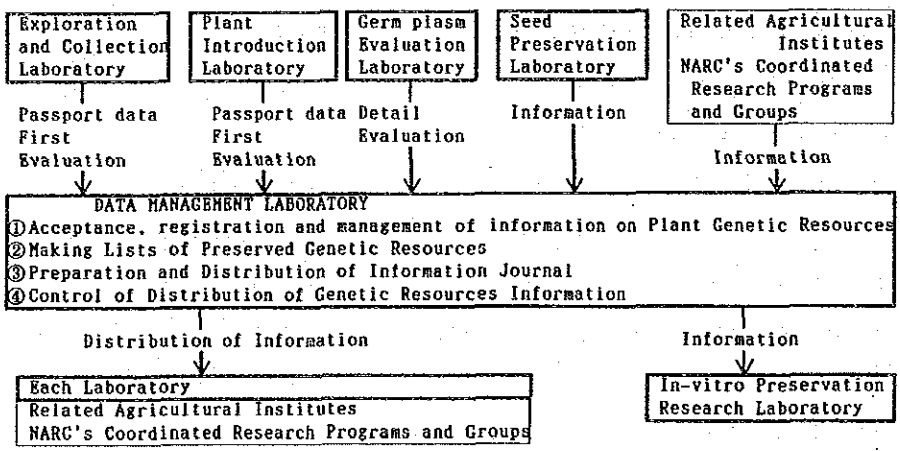
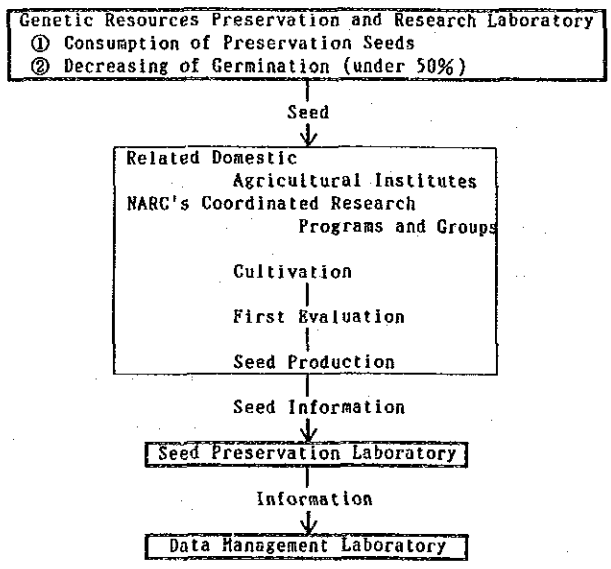


FIG. 3-8 DATA MANAGEMENT LABORATORY



RELATIONSHIP AMONG RELATED DOMESTIC AGRICULTURAL INSTITUTES ON PROPAGATION



3-3-3 Site of the Project and its Conditions

(1) The Project's site and the conditions of its surroundings

The NARC owns a huge site with an area of about 565ha (rain-fed fields with a total area of 451 hectares and irrigated fields with that of 114ha) in the city of Islamabad (about 6km southeast of its downtown). About 11,250m² of the land has been allocated to the Project as its site.

The NARC is situated here, because of "Location of NARC at Islamabad provides an easy access to the international visiting elites to interface with the national scientists. By virtue of optimum rainfall and irrigation facilities from Rawal lake NARC provides an excellent site for research both under irrigated and rainfed conditions"(FACTS ABOUT PARC, 1986).

As to the rejuvenation, multiplication, and evaluation of seeds in the Project, it is, therefore, thought imperative that the activities for many of the accessions may be performed in the existing experimental fields. The Project is not only going to be both a collector and a distributor of genetic resources and their information, and play a principal role in their exploration and collection, but will also collaborate on research with the existing institutes in NARC, and will act as an international laboratory and cooperate with international institutes. The project site at NARC's compound satisfies the conditions for the location of the Project.

(2) Natural conditions

The weather conditions of Islamabad observed by NARC are as follows.

(1982 to 1988)

1) Temperature	highest (monthly average):	39℃	(Jun. 1984, Jun. 1985)
	highest :	45℃	(13, 14, Jun. 1986)
	lowest (monthly average):	2℃	(Jan. 1984, Jan. 1986)
	lowest :	-2℃	(10 Jan. 1983, 25 Dec., 26, 29, Jan. 1984)
2) Relative humidity	highest (monthly average):	86%	(Dec. 1982, Feb. 1982)
	lowest (monthly average):	21%	(May 1988)
3) Rainfall	yearly maximum :	1,350mm	(1985)
	monthly maximum :	718mm	(Jul. 1988)
	daily maximum :	134mm	(Jul. 1985)
	monthly minimum :	0mm	(Jan., Oct. 1984, Nov. 1983, Jan. 1987)
4) Wind velocity	maximum :	297km/day	(Jul. 1987)

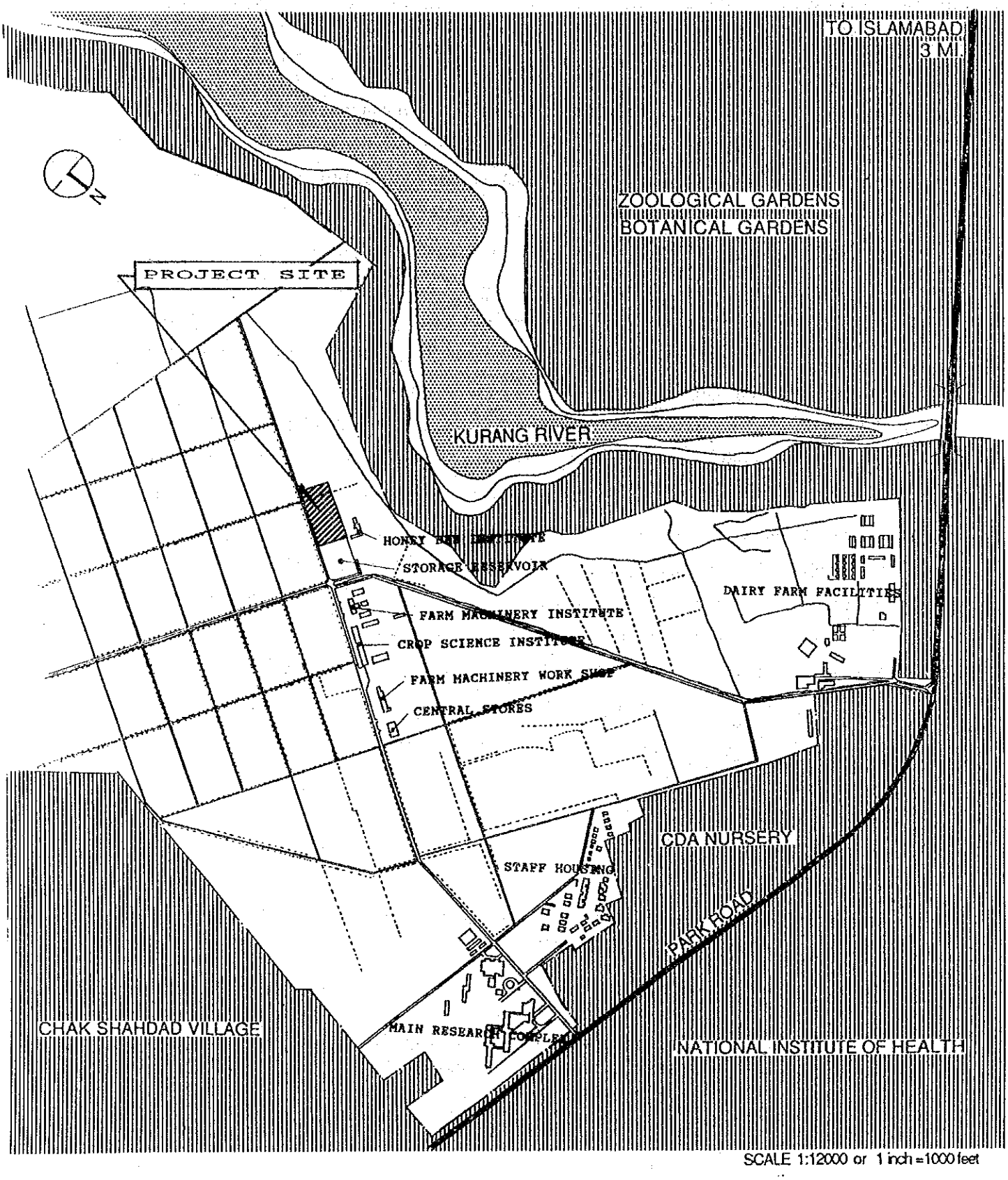


FIG.3-10 LOCATION MAP OF THE PROJECT SITE

(3) Earthquake and geological features

1) Earthquake

Islamabad belongs to the Eurasia Earthquake Belt, has an earthquake with the magnitude of 5-6 every one or two years, and belongs to Zone VII of the Modified Mercalli Seismic Intensity Scale according to the Building Standards Act of Pakistan. Accordingly, it is necessary to consider an earthquake resistant design when planning the structure of the Project facilities.

Fig.3-11 shows the distribution map of the Modified Mercalli Seismic Intensity Scale in Pakistan.

2) Geological features

The surface stratum of the site is a silt layer of about three meters, and under it is a gravel layer.

(4) Conditions of Infrastructure

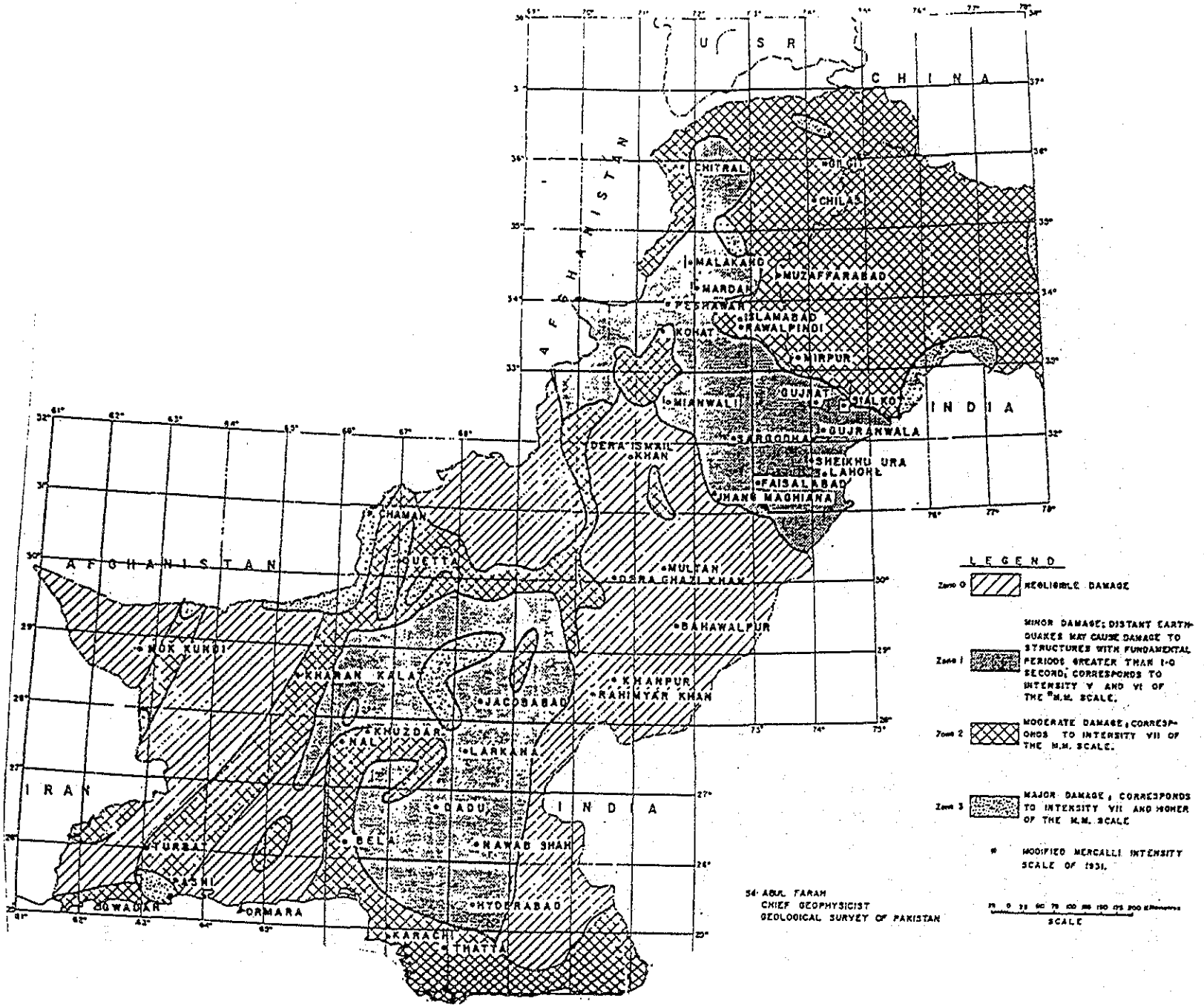
The Project's site is on the premises of NARC, and at present the site is a fallow field. It has an area of about 11,250m^2 (150m x 75m), and is rectangular with a natural incline from north to south. There is no need of reclamation for construction.

Power, water and drainage, gas, and telephone are available at the site, and the study had confirmation of supply of power, water quality, and preparation of telecommunication facilities for the Project needs as follows:

Power: The power source of 50Hz/11kv will be installed at the site by WAPDA (Water and Power Development Authority). The power from it will be transformed to low tension three-phase, four-wire 50Hz/440v and be distributed to the facilities.

Telephone: Two circuits from the existing central switch board (PABX) of NARC will be extended, and two circuits of outside lines (one for an outside line; and the other for a facsimile) will be newly installed. For inside lines there will be 25 circuits.

Gas: 1000BTU/Cft8PSI gas pipe will be led into the site.



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CHIEF GEOPHYSICIST
GEOLOGICAL SURVEY OF PAKISTAN

FIG. 3-11 MODIFIED MERCALLI INTENSITY SCALE IN PAKISTAN

Water supply: The 6-inch water main pipe in the road fronting the site will be branched off, and the water will be sent to an elevated tank through an underground reservoir tank to be distributed to the facilities.

Drainage: Waste water will be drained through a soakage tank constructed at the site after being passed through a septic tank as a rule. Rainwater will also be drained through the soakage tank.

As to the water supply to the greenhouses which need environmental conditioning, it was judged that the supply of public water was not sufficient. So a reservoir tank for well water will be built on the site, from which the water will be pumped to the greenhouses. The branching and extension of the well water pipe will be performed by NARC.

3-3-4 Outline of Facilities and Equipment

(1) Outline of facilities

According to the structure of the facilities of the Project in view of the results of the preliminary study, the discussion on the contents of research in each laboratory and their mutual relationships led to the conclusion that each of them would need the following rooms.

1) Main Complex 1F: 1,786m², 2F: 1,235m², Total: 3,021m²

a) Exploration and Collection Laboratory:

Experiment Room, SSO's Room, Lab. Experiment Room, Exploration Preparation Room, Original Seed Stock Room, Storage for equipment and camping material

b) Seed Preservation Laboratory:

Drying and Packing Room, Short-term Storage, Medium-term Storage, Germination Test Room, Distribution Preparation Room, Seed Reference Room, Experiment Room, Lab. Equipment Room, SSO's Office, Storage Area for glassware and chemicals

c) In-vitro Preservation Research Laboratory:

Experiment Room, Lab. Equipment Room, Clean Bench Room, Dark Room, Incubation Room, SSO's Office, Storage Area

d) Germplasm Evaluation Laboratory:

Experiment Room, Lab. Equipment Room, SSO's Office, Storage Area

e) Data Management Laboratory:

Computer Room, Printing and Bookbinding/Compilation Room, SSO's Office, Data Management Office

f) Administration Section:

PSO's Office, Administration Office, Central Control Room, Conference Room, Library, Reception Room

g) Common Facilities:

Herbarium Room, Centrifuge Room, Growth Chamber Room, Lounge, Meeting Room, the Others: Entrance Hall, Lobby, Exhibition Corner, Pantry

h) Other Necessary Rooms:

Rooms for Foreign Experts

i) Connecting Corridor:

Connecting Corridor between Main Complex and Plant Introduction and Seed Health Laboratory Building

2) Plant Introduction and Seed Health Laboratory Building; 200m²

Plant Introduction and Seed Health Laboratory, Seed Health Experiment Room, Bacterial and Viral Inspection Room, Fungal Inspection Room, SSO's Office,Lab. Equipment Room, Sowing Preparation Room, Storage Area

3) Garage and Work Shop; 155m²

4) Cultivation Facilities:

a) Processing Building; 222m²

Pre-drying Floor, Threshing, Cleaning and Preparation Room, Vegetable Seed Preparation Room, Fumigation Room, Fertilizer Room, Pesticide Room

b) Sterilized Soil and Cultivation Material Stock Shed; 90m²

Incineration Room, Cultivation Material and Equipment Stock Room, Sterilized Soil Stock Room

c) Greenhouses

Exploration and Collection Laboratory :

Ordinary Greenhouse(for Preliminary Evaluation, Multiplication) 154m²

Plant Introduction and Seed Health Laboratory :

Cooling and Heating Greenhouse 231m²

(for Isolated Cultivation of Introduced Genetic Resources)

Seed Preservation Laboratory :

Ordinary Greenhouse(for Rejuvenation, Multiplication) 231m²X2buildings

In-vitro Preservation Research Laboratory :

Cooling and Heating Greenhouse(for Acclimatization Cultivation) 154m²

Germplasm Evaluation Laboratory :

Ordinary Greenhouse (for Detailed Evaluation) 154m²

5) Facility for Power Supply; 176m²

Sub-station, and Stand-by Generator

6) Facility for Water Supply and Drainage 65m²

Reservoir Tanks, Elevated Tank, Pump Rooms, Septic Tank, and Soakage Tank

Grand Total of Floor Area 5,083m²

(2) Outline of equipment

As a result of the discussions on the mutual relationships of the contents of the research and the role of each laboratory, it was determined that the major equipment listed in the attached Appendix would be needed.

3-3-5 Maintenance and Management Plan

The basic design study team discussed the method and system of maintenance and management of the Project. In the facilities of the Project, only the inspection of equipment and facilities and the inquiry into failure causes will be made, and actual repair will be done in the existing repair department at NARC. As shown in 3-2-6 Review of Operation, and Maintenance Plan, the staff assignment, and budget allocation are appropriate.

The budget for the maintenance and management of the Project will be disbursed from the national budget. The Pakistani side has estimated four million rupees per year for the operation, maintenance and management expenses necessary for implementation of the Project, excluding the personnel expenses which are included in the operating expenses of NARC.

Of these expenses, the ones for maintenance and management are principally divided into the expenses for expendable and exchangeable parts, electricity and fuel, communication, and maintenance and management of facilities and equipment.

A trial calculation of the upkeep/management expenses was made, and a discussion was held on Pakistani ability to bear them. The rough estimation in Rupees per year is respectively, 1,761 thousand for electricity; 15 thousand for water; 140 thousand for gas; 244 thousand for maintenance/management of facilities; 238 thousand for maintenance/ management of equipment; 48 thousand for telephone and communication; 384 thousand for transportation; and 1,170 thousand for expendable and miscellaneous goods. The total is about 4,000 thousand Rs., which is to be financed by the budget of PARC and the Government of Pakistan.

However, in consideration of the fact that the executing budget for the Plant Genetic Resources Programme of the Crop Sciences Institute of NARC was 1,069 thousand Rs. in 1990/91, and 1,529 thousand Rs. in 1989/90, facilities

and equipment which do not cost much to maintain and manage shall be selected.

The expenses for operation and upkeep/management of the facilities of the Project are roughly estimated in the reference data.

TABLE 3-5 THE BUDGET OF NARC PLANT INTRODUCTION CENTRE AND PLANT GENETIC RESOURCES (000Rs.)

FISCAL YEAR	OBJECT	PLANT INTRODUCTION CENTRE	PLANT GENETIC RESOURCES	TOTAL
	SALARY AND ALLOWANCES	270	686	956
1990/91	RESEARCH EXPENDITURE	30	76	106
	CAPITAL COST	7	0	7
	TOTAL	307	762	1,069
	SALARY AND ALLOWANCES	282	742(600)*	1,024
1989/90	RESEARCH EXPENDITURE	60	430(303)	490
	CAPITAL COST	0	15(15)	15
	TOTAL	342	1,187(918)	1,529
	SALARY AND ALLOWANCES	216	636(498)*	852
1988/89	RESEARCH EXPENDITURE	102	167(97)	269
	CAPITAL COST	5	3(3)	8
	TOTAL	323	806(598)	1,129

NOTE : () THE WORLD BANK ASSISTANCE

SOURCE: National Agricultural Research Centre, Pakistan

CHAPTER 4

BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4-1 Basic Design Policy

The Genetic Resources Preservation and Research Laboratory, conceived of as the central institution for research and conservation of plant genetic resources in Pakistan, shall be designed to have such facilities and functions as befitting its position.

The following basic policy was adopted to make the most effective project under the consideration of the project site and the contents of the project.

(1) Facilities taking into account natural conditions and agreeable appearance

Comfortable living conditions should be secured, which will cope with great climatic changes such as the torrential downpours and high temperatures of June and July. And the facilities should be designed to have a functional sequence from existing facilities and an agreeable appearance which is suited to the environment.

1) To secure a comfortable environment through natural ventilation and to the minimize electricity charges the rooms shall be surrounded by a corridor facing an inner court. However a skylight will be adopted where the center corridor type is considered to be preferable for the function of the rooms.

2) Eaves will be constructed to reduce direct sunlight.

(2) Facilities taking into account functionality

The facilities of the project should be arranged in due consideration of the research activities in each laboratory and the natural and smooth relationships between the facilities.

(3) Facilities taking into account economy and durability

1) The local materials and construction methods will be adopted to enable ease of repair when needed.

2) Mechanical and electrical equipment installed in the facilities shall have enough compatibility to minimize spare parts. And such systems shall also be selected from the viewpoints of easy maintenance and good operability.

3) Research equipment shall be selected from the viewpoint of long durability and the availability of after-sale maintenance services.

(4) Facilities taking into account future expansion

With due regards to the future growth potential of the seed preservation facility, the building and equipment systems shall be designed so that they can be easily expanded without major remodeling.

(5) Facilities with reasonable contents and scope

The facilities will be designed with duly reasonable contents and scope from the standpoint of the project implementation system and future prospects and the Japanese grant aid.

4-2 Study and Examination of the Design Criteria

As the basic design criteria, the functions and scales of the project facilities shall be determined on the basis of the research activities, the number of staff as described in 3-3-1, scales of the existing facilities, and layout of the equipment.

4-2-1 Factors Determining the Scale of the Facilities

(1) Factors determining the scales of the seed storage areas

Some methods seemingly suitable for the project were discussed from the viewpoint of preservation conditions and operating expenses. As a result, it was decided that the following methods would be adopted:

1) *Short-term storage*

In short-term storage 50,000 accessions can be preserved in an environment of 5℃ and proper humidity without condensation. The storage requested in PC-1, whose area was 100m^2, will be segmented into two storage areas of 40m^2, and movable shelves will be installed to decrease the area. Seeds will be stored in hermetic wide-mouthed bottles with packed silica gel (See Fig.4-1 and Table 4-1). Bottles of two different capacities will be

provided for storage according to seed size: 500g, 75% of total, and 250g, 25% of total.

2) Medium-term storage

The storage requested in PC-1, whose area was 50m² at 5℃ and 30% to 40% relative humidity, will be segmented into eight storage areas which are controlled to 5℃ and proper humidity without any condensation. Therefore 50,000 accessions can be preserved without consuming much power.

One accession will be packed in 2 envelopes of laminated aluminum, and each envelope can contain 100g of seeds. Envelopes will be kept in drawers on shelves installed in the storage area.

The scale was determined by the following factors:

a) Sample volume

The volume of seeds to be distributed at one time should be large enough to be able to grow individuals to represent the plant group, for example, about 300 seeds each for cereals. The number of distributions is estimated to be 5 to 10 times an accession, the basic number of seeds for reproduction has to be enough for 10 reproductions. Therefore, it is thought that 50g to 10kg of seeds of each accession will be needed for distribution and will be kept in short-term storage, and approximately 100g for reproduction will be kept in medium-term storage. The sample volumes were discussed and determined in accordance with these figures and the conditions of existing NARC storage:

One sample volume for short-term storage:
500g bottle, 75% of the total preserved for distribution
250g bottle, 25% of the total preserved for distribution
One sample volume for medium-term storage:
100g envelope× 2 per accession, seeds preserved for reproduction

b) Packing and Storage System

The seed preservation method requested in PC-1 was to keep the entire storage area cool and dry, but its maintenance will be costly. To make it

TABLE 4-1 CASE STUDY OF COLD STORAGE METHOD

SHORT-TERM STORAGE

STORAGE TYPE	TYPE	PRESERVATION TEMPERATURE	PRESERVATION HUMIDITY	AIR-CONDITIONED AREA	DESCRIPTION
ROOM TYPE	TYPE A	10℃	40%	100㎡	The requested type. Humidity of storage is strictly controlled. Fixed seed storage racks are introduced.
	TYPE B	10℃	Condition without condensation	80㎡	Hermetic containers keep seeds from humidity. Movable racks are introduced in order to save on the running cost by decreasing the effective air-conditioned area.
	TYPE C	10℃	Condition without condensation	40㎡ × 2ROOMS	TYPE B is divided into 2 rooms to save running cost. Only the room in use can be air-conditioned. Running cost saving type. -DECIDED TYPE-

MEDIUM-TERM STORAGE

STORAGE TYPE	TYPE	STORAGE TEMPERATURE	STORAGE HUMIDITY	AIR-CONDITIONED AREA	DESCRIPTION
ROOM TYPE	TYPE A	5℃	30～40%	50㎡	The requested type.
	TYPE B	5℃	Condition without condensation	50㎡	Hermetic containers keep seeds from humidity. Humidity of storage rooms are controlled weakly.
	TYPE C	5℃	Condition without condensation	6.5㎡ × 8ROOMS =52㎡	TYPE B divided in order to save on the running cost. Air-conditioning can be stopped for the empty storage. Walk-in type. -DECIDED TYPE-
CABINET TYPE	TYPE D	CABINET 0～5℃ ROOM: 25℃	Condition without condensation	SIZE OF CABINETS 800x1200x1800mm x40CABINETS ROOM AREA:120㎡	Hermetic containers keep seeds from humidity. Only the cabinets in use consume electricity. Running cost saving type. Reach-in type. Cabinets shall be replaced in the future. (Lifetime of cabinets is only 10~15years.)

FIG.4-1 CASE STUDY OF CONSUMPTION OF ELECTRICITY OF EACH COLD STORAGE METHOD

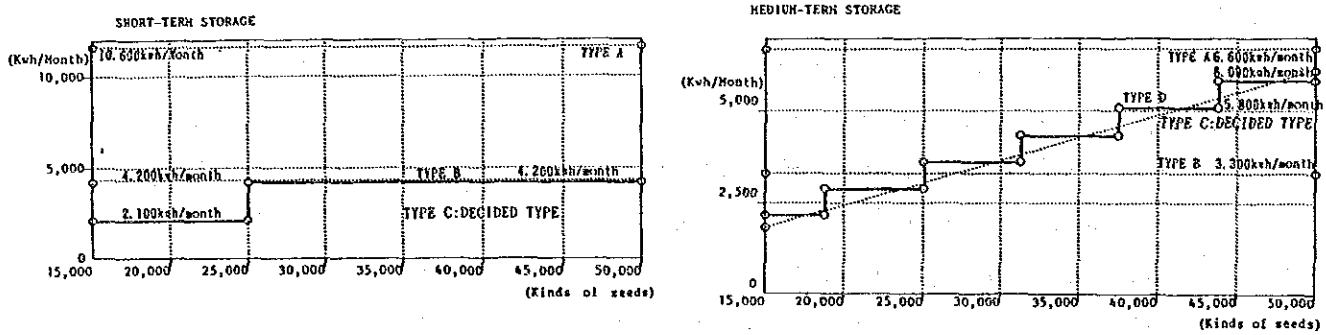

TABLE 4-2 CASE STUDY ON THE PACKING METHOD WITH HERMETIC CONTAINERS

MEDIUM-TERM STORAGE	TYPE A	ONE ENVELOPE TYPE One envelope(100g)(laminated foil packet) vacuum sealed. If the envelope has pin holes, the humidity of the seeds changes.
	TYPE B	TWO ENVELOPE TYPE(3 LAYERS LAMINATED FOIL) Two envelopes(100g× 2env./accession) vacuum sealed in order to avoid accidents of increases in humidity.
	TYPE C	CAN TYPE (100g metal can) For infrequent use of getting seeds.
	TYPE D	5 SHALL ENVELOPE AND CAN TYPE TYPE A is divided into 5 envelopes(one envelope for 20g) in order to avoid accidents of increases in humidity. And seeds in envelopes are kept in a can. For infrequent use of seeds.
	TYPE E	5 SHALL ENVELOPE AND A PLASTIC BOTTLE TYPE TYPE A is divided into 5 envelopes(one envelope for 20g) in order to avoid the accidents of increases in humidity. And seeds in envelopes are kept in a plastic bottle with silica gel which shall be changed periodically.
SHORT-TERM STORAGE	TYPE A	ENVELOPE TYPE Seeds are kept in 2 envelopes(250g) vacuum sealed. Seeds are divided into 2 envelopes (one envelope is for 250g) in order to avoid accidents of increases in humidity.
	TYPE B	PLASTIC BOTTLE TYPE Seeds are kept in a plastic bottle(500g)directly.Normal plastic bottles have a high risk of increases in humidity.
	TYPE C	PLASTIC AIR-TIGHT BOTTLE WITH SILICA GEL PACKAGE TYPE Seeds are kept in a plastic bottle(500g, 250g) directly. Air-tight bottles are introduced in order to avoid accidents of increases in humidity.
	TYPE D	TYPE (A) WITH SILICA GEL IN A PLASTIC BOTTLE TYPE 2 envelopes are kept in a plastic bottle with silica gel. Seeds are divided into two envelopes same as TYPE A. Silica gel adjusts the humidity in the plastic bottle and shall be changed periodically.

practical within the maintenance requested by the Pakistani side, the method was reviewed from the viewpoint of conditions such as local power fluctuations and the ability of maintenance and management according to the level of technology as well as (1) maintenance expenses, (2) operability, (3) service ability, and (4) protection from power failure and facilities faults. As a result, the preservation method above shall be suitable for the project.

As to the packing method, after considering the need for stable humidity for seeds, the frequency of taking seeds in and out, and the availability of procurement of expendables, the method mentioned above was selected.

3) Seed drying

Stored seed will have to be dried to a water content of about 7% to 8%, depending on the seed type, before packing. As to the drying method, it is decided that the system which has been adopted in many other grant aid projects and does not have high management and maintenance costs shall be adopted. The water content will be reduced first by drying in the sun, and then by a seed dryer.

(2) Factors determining the scales of laboratories and administration section

The scales were determined according to the Area Calculation Standard and based on the personnel assignment plan (66 persons) and the equipment layout.

Large-scale training related to the Project shall be held at the existing NARC Training Centre, and small-scale ones at a conference room in the Project facilities.

(3) Factors determining the scale of the In-vitro Preservation Research Laboratory

This laboratory consists of an experiment room for medium preparation and related work, a clean bench room, and cultivation rooms. Cryopreservation shall be realized by adding equipment.

The number of samples which will be used for the determination of the scale of the cultivation rooms are as follows:

(4 kinds of crops) × (10 kinds of varieties／each crop)
× (10 samples／each variety) × (5 stages／each sample) = 2000.

Those samples will be cultivated in two separate rooms, which are at 20℃ and 25℃ respectively, so that the preservation research can be carried out under different conditions.

(4) Scales and system of the greenhouses

The scale of each greenhouse was determined by the number of cultivated accessions, types of crops, and pot cultivation.

The greenhouse for the Exploration and Collection Laboratory is used for the preliminary evaluation of seeds that can not be cultivated enough or can not be grown in the environment in the existing fields. Four hundred of the 2,000 accessions collected will be grown in the greenroom.

The greenhouse for the Plant Introduction and Seed Health Laboratory will be used to grow about 2000 accessions introduced from overseas. Three types of pots will be used according to the growth stages of the plants. The greenhouse shall be cooled and heated as required for isolated cultivation.

The greenhouse for the In-vitro Preservation Research Laboratory is going to have sufficient scale to acclimatize and cultivate about 2000 samples for preservation research and to test optimum preservation methods. Three types of pots shall be used according to the growth stage of the plants. The greenhouse shall be cooled and heated to create the proper environment to perform acclimatization/cultivation of vegetatively propagated plants.

The greenhouse for the Seed Preservation Laboratory shall be used to cultivate about 1,000 accessions which will be one-fourth to one-third of the accessions rejuvenated and multiplied every year. For the cultivation of cross-fertilizing plants, steel frames with mesh will be used to isolate these plants from others so that the greenhouse can be used for general purposes.

The greenhouse for the Germplasm Evaluation Laboratory will be used for seedlings of 1,000 accessions which will be about a half of the accessions studied each year.

Under the above conditions, the outline of greenhouses were determined as follows:

Greenhouse for first evaluation:

Ordinary greenhouse	1 building

Greenhouse for introduced genetic resources:

Cooled and heated greenhouse*	1 building

Greenhouse for in-vitro acclimatization and cultivation:

Cooled and heated green house*	1 building

Greenhouse for rejuvenation and propagation:

Ordinary greenhouse	2 buildings

Greenhouse for detailed evaluation:

Ordinary greenhouse	1 building

(*: with cooling and heating system)

The pad and fan evaporation cooling method is used in the existing greenhouses of NARC. The method will be used this time because it can not only produce the necessary cooling effect but will also be easy to operate and maintain.

For heating, kerosene heaters with fans and vinyl ducts will be used because they do not require high equipment costs or operating expenses.

The necessity for mesh houses was found in the preliminary study. So steel frames with mesh, which are collapsible and movable, will be installed in the greenhouses in order to utilize them as both ordinary greenhouses and for isolated cultivation.