The Testing Fields

Research and Agriculture in Bangladesh

A.I.D. Science and Technology in Development Series

Agency for International Development

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Contents

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List of Sidebars

Chapter 7

Foreword

As the world's population continues to grow—the current 5.13 billion will double in about 40 years—we must grow more food. Feeding the human family may become the most important task in this and future generations.

For those involved in American agriculture, the task does not seem very difficult. We have always managed to produce enough food for our own people and have at times grown huge surpluses of agricultural commodities. Our assumption is that better farm machinery, crop varieties and management practices ensure intensive production and ever-bigger crops. To prove our point, we pay farmers *not* to grow food on much of their land.

In most Third World countries, the story is quite different. They have less fertile and more fragile soil. They may have torrential downpours rather than the nuturing, gentle rains often prevalent in the temperate zones. And the tropical countries have constant heat that keeps alive insect pests and diseases that do not thrive in milder environments. They rarely grow too much food; they often grow too little. Many of these countries—and Bangladesh is a prime example—have exhausted much of their most fertile lands and farmers now cultivate marginal and sloping areas, which produce low yields for the ever-increasing numbers of mouths that must be fed.

How can these countries increase yields on lands already under cultivation? How can they grow economically through more productive agriculture?

One answer is research. Research on soil—how to husband and replensih valuable soil nutrients while overcoming acidity, salinity, and other soil characteristics that reduce or prohibit production. Research on farming systems that conserve scarce water resources. Research to develop hardier crop varieties that will produce well in harsher environments. Research on the sociological aspects of rural agriculture to ensure that the methods we deem appropriate also fit a country's culture and social structure.

Successful agriculture is a key component of economic development. Recognizing this, the United States Agency for International Development (A.I.D.) has supported agricultural research for decades. A.I.D. has been in the forefront of agricultural progress in developing countries, supporting national and regional research institutions as well as the international agricultural research centers, both inside and outside the Consultative Group on International Agricultural Research.

The reasons for turning to agricultural research in Bangladesh were perhaps more acute than anywhere else in the world. Faced with a burgeoning population living off a fixed amount of land, much of it unsuited for agriculture, this country has made great strides in growing enough food, particularly grain, to feed itself. A.I.D. is happy to share with the readers of its Science and Technology in Development series the insights, concepts, and sheer persistence that have paid off so well for Bangladesh.

Nyle C. Brady
Senior Assistant Administrator for Science and Technology
United States Agency for International Development
September 1988

Preface

Field research in a Third World nation cannot be done adequately without dedicated local support. In this connection, I would like to particularly express my appreciation for the help I received from Kevin Rushing, agricultural project officer, and Habibur Rahman, a Bangladeshi national, of the A.I.D. mission in Dhaka.

I would also like to thank the hundreds of scientists and other professionals in research institutes and stations throughout Bangladesh who were willing to take time away from their offices and laboratories to show me their testing fields.

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Edwin L. Cobb

1

Beyond the Basket: Bangladesh Struggles for Development

A scant 15 years ago, Bangladesh was the "basket case" of the developing world. With a war behind it and famine ahead, it appeared that no amount of foreign aid or local effort could prevent this luckless nation from drowning in its own poverty and population growth. But while Bangladesh has not yet prospered—it is still the world's second poorest country—the struggle for development is going on, and its multitudes at least have a future.

Prominent among its triumphs are achievements in agricultural research.

With a little help from its friends, the U.S. Agency for International Development (A.I.D.) prominent among them, the basket case may yet become a food basket. To understand the significance of these achievements, however, it is necessary to understand the land, the people, and their agricultural heritage.

Land of Rivers

Two of the world's mightiest rivers, the Ganges and the Brahmaputra, define the character of the land. Flowing from India into Bangladesh, they change their names to the Padma and the Jamuna before colliding in the center of the country near Dhaka, the capital. Joined by two other rivers, the Meghna and the Teesta, and fed by countless tributaries, the fragmented rivers reach like fingers toward the Bay of Bengal to the south. They carry millions of tons of silt each year and flood large areas during the rainy season, spreading the rich silt over the land. The constant flooding and

erosion of the land change the paths of rivers, alter the landscape, and shape the course of agriculture.

Bangladesh encompasses about 55,000 square miles—about the size of the American state of Wisconsin or of England and Wales combined. The rivers are easily the most prominent topographic feature. Most of the country is an alluvial plain, rarely more than a few feet above sea level. The greater part of the coastline is actually the mouth of the Ganges, the largest estuarine delta in the world. This coastal belt is a mosaic of small islands and tidal rivers; from the air, it is hard to tell land from water. Only in the east is the flatness relieved as gentle hills rise in the Sylhet region bordering India and in a strip of land near Burma known as the Chittigong Hill Tracts. Given the flatness of the terrain, only modest development of hydroelectric power can be expected.

The rivers are both a boon and a barrier to transportation. Goods and people move from north to south on the waterways, but the same streams often stymie east-west traffic. Bridges are few and ferries are both slow and dangerous; frequently overloaded, they have been known to capsize in bad weather. Not surprisingly, both the railroad and highway networks in Bangladesh are poorly developed.

Pride of the Sundarbans

To much of the world, the symbol of Bangladesh is the Royal Bengal Tiger. Although the country has other wildlife attractions—elephants in Chittigong, for example, and a variety of deadly snakes—it is the Bengal Tiger that is the principal attraction.

This magnificent animal, once seemingly headed for extinction, is now making a comeback in the Sundarbans, which has been designated a wildlife park. Growing to 5 feet in length and with about a 16-year life span, the tiger preys mostly on deer and other animals stranded on river beds by the receding tide. However, the older beasts sometimes turn man-eater and prey on workers in the area.

A particular target is the honey-gatherers, called *mauals*, who roam the Sundarbans looking up at the trees.

There is increasing interest in Bangladesh in wildlife protection and management as a part of agro-forestry, a fact that should please the regal tigers if not the unfortunate *mauals*.

Even where roads exist, they are narrow and not well maintained. The 120-mile trip by road from Jamalpur to Dhaka takes an axle-shattering 5 hours, assuming no major traffic tie-ups in villages or at key bridges.

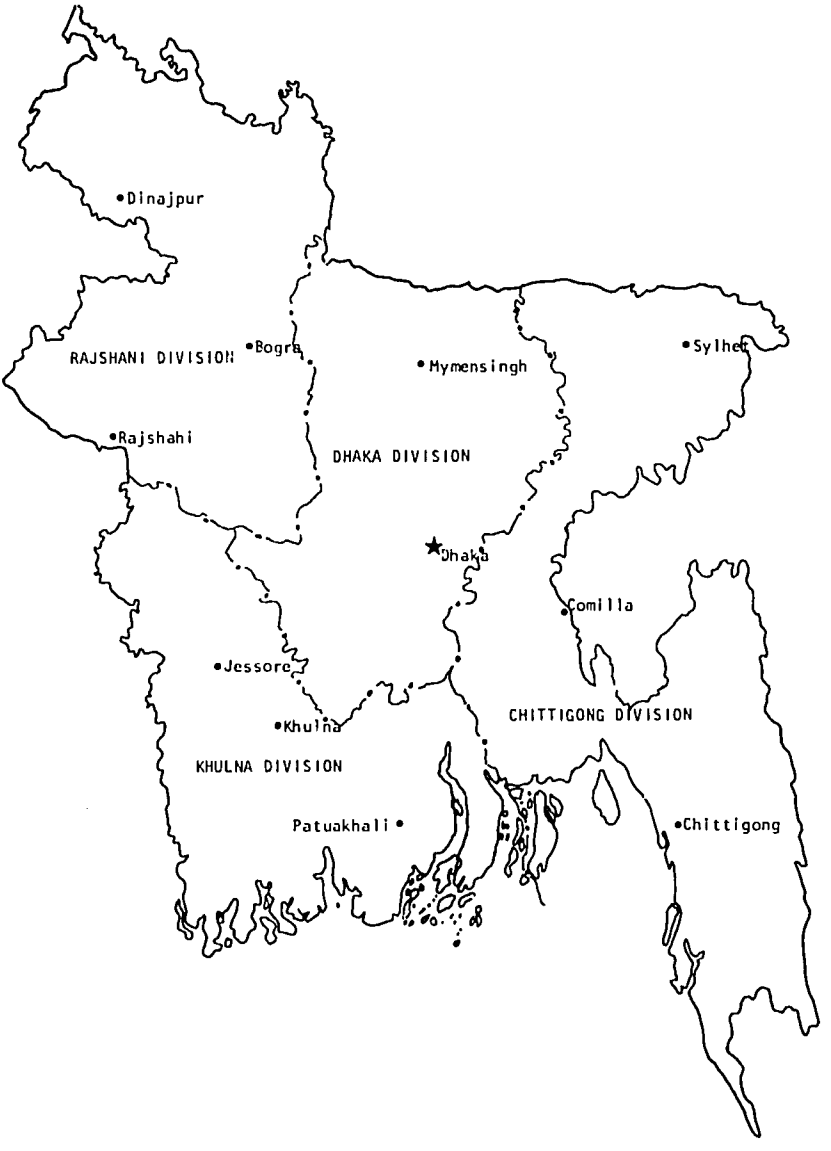
The rivers also form the rough boundaries of the country's political divisions—Chittigong, Dhaka, Khulna, and Rajshahi—each named for its capital city. The ecological differences in the divisions are not great, consisting mainly of variations in rainfall. Rajshahi, with an average of 55 inches of rainfall a year, is considered the dry region; Chittigong may get 130 inches in the same year. The heaviest rains occur in the monsoon months from May to October and the lightest from December to March.

Throughout the country, the climate is warm and humid, ranging from lows in the 40s and 50s Fahrenheit to highs above 100. The combination of climate and rainfall means that agriculture can be a year-round activity with multiple cropping.

Forests still cover about 15 percent of the country. They are mostly in the Chittigong Hill Tracts, where tropical and semi-tropical evergreens predominate, and in the Sundarbans, a vast jungle in the southwest where the mangrove tree shares the billing with the famous Royal Bengal Tiger. However, most of the interior of the country has been drained and planted with crops.

Apart from the forests and substantial deposits of natural gas, Bangladesh has few natural resources other than its soil and water. The soil is basically

General Map of Bangladesh



The Brahmaputra at Mymensingh. Rivers are the major transportation arteries of Bangladesh.

fertile, though it lacks nitrogen and sometimes other essential minerals. (It is also characterized by an absence of stones, which makes construction difficult in many places.)

Water for irrigation may be pumped directly from rivers, which discharge 5 million cubic feet per second at peak periods, twice the flow of the Mississippi River. With river pumping, the water is easily obtained and little energy is required to lift it to the land. In addition, plentiful underground sources can be readily tapped. With tubewells, water is commonly available at less than 20 feet and is rarely at depths greater than 40 feet, although deep wells are sometimes sunk hundreds of feet.

The agricultural potential provided by Bangladesh's combination of fertile land and ample water is thus enormous. However, nature also causes its share of destruction; the same flooding that brings rich silt to the delta causes heavy erosion and other damage elsewhere. With rainfall unevenly distributed, drought is frequent. Powerful cyclones churning out of the Bay of Bengal take both property and lives. Still, the possibility of agricultural productivity exists if the people of Bangladesh are in a position to exploit it. Unfortunately, they have not long had the opportunity.

Unkind Fates

Just outside the small town of Savar, near Dhaka, is a huge monument somewhat reminiscent of a spacecraft. Towering above landscaped grounds, it commemorates those who died in the fight for freedom against Pakistan in 1971. The monument will seem overstated to some, but the exuberance of the builders is understandable because liberation was a long time coming and much blood was shed for it. Over the centuries, the fates have not been kind to the Bengal nation as far as independence is concerned.

Probably the region's first appearance in history, in the Hindu *Mahabharata* (9th century B.C.), is the story of Prince Bhima's conquest of Varendra, a kingdom in what is now Bangladesh. As the tides of power ebbed and flowed in India over the centuries, the Bengal area gradually created a separate political identity and found at least intermittent prosperity, particularly under the Pala dynasty.

At the turn of the 13th century A.D., Muslim power swept over the entire area and brought a new era to Bengal. Cities were founded, palaces built, gardens laid out, roads constructed, and a new cultural life enjoyed. However, the Moghul Empire ousted the Muslims in India in 1526, and 50 years later made Bengal a province as well.

The Moghuls extended the benefits of their "golden age"—art and literature, overland and world trade—to Bengal, but the empire itself ultimately crumbled before the British. The first wave came with the activities of the East India Company, centered in Calcutta. The onslaught concluded, after the Indian Mutiny in 1857, with the *raj* itself—the British government. British rule was a mixed blessing for India. By introducing an efficient administrative system, judicial bodies, and educational institutions, the British brought order to the warring subcontinent. Infrastructure throughout the country improved, and Calcutta became a major commercial and cultural center. At the same time, British goods destroyed local industries, and the institutions that were established had a remarkedly British flavor.

The Muslim Bengalis were particularly discontent. Hindus tended to resign themselves to British ways, learning English, sending their children to London for university training, and staffing the bulk of the administrative posts. The Muslims, on the other hand, preferred to remain farmers and merchants, and every economic downturn tended to manifest itself as resentment toward the British.

When Bengal province was partitioned in 1905, creating the new provinces of East Bengal and Assam, the Muslims perceived it as a religious division. Although the Indian National Congress had served both Hindu and Muslim interests until then, the wary Muslims now established the Muslim League

The Tribal Challenge

Bangladesh has its own secessionist problem. The hilly eastern region of the country has a tribal population of about a million people who do not identify with Dhaka. Originally nomads from Burma and eastern India, the Hill Tribes (the Chakmas being the largest group) are Buddhist and animist in religion, and their culture is quite distinct from that of the flatland Bengalis.

The Hill Tribes resist all efforts by Dhaka to settle Muslim immigrants from other parts of the country. Since the 1970s, the central government has been faced with an armed movement, the Shanti Bahini guerrillas, and there have been raids on Muslim settlers and Bangladesh army camps. Bengali workers have also been kidnapped and killed by one extremist faction of the Shanti Bahini.

Central government reprisals have forced many of the tribal people to flee to India, creating a refugee problem for that country and a potential source of tension between Delhi and Dhaka. So far, the Bangladesh government has responded in moderation to the tribal challenge and is working to solve the problem peacefully.

as their own organization. Even when the split Bengal province was reunited in 1912, the Muslims continued to press for autonomy.

The final insult came when the British moved the imperial capital from Calcutta to Delhi. Calcutta remained an important city, but the rest of Bengal was neglected. As the days of the British *raj* drew to a close, a united Bengal became less important than a Muslim state separate from India.

By the end of World War II, even the most die-hard colonialists realized that the days of the British Empire—on which "the sun never set"—were numbered. Nowhere was this more evident than in India. Gandhi rallied both Hindus and Muslims to the cause of independence. With single-minded determination, the aging Mahatma traveled throughout the land, exhorting all Indians to the vision of a free and united India.

Hindus and Muslims alike revered Gandhi, but they did not trust each other. Jawaharlal Nehru's Congress Party and Muhammad Ali Jinnah's Muslim League agreed only in their opposition to the British, and all Gandhi's pleadings for brotherhood could not bridge the gap between them.

Faced with mounting violence between Hindus and Muslims, the British viceroy, Lord Mountbatten, saw no alternative but to partition the country. The question was where to draw the line. Muslims were concentrated in the two opposite sides of the subcontinent, in Punjab and Bengal, and Bengal itself was divided between Hindu-controlled Calcutta and its hinterlands

A Common Language

It is widely believed that possession of a common language is a strong factor in building national unity. If so, Bangladesh is better off than many developing nations. The official language is Bangala (also called Bangla or Bengali). Sanskrit-based and similar to Hindi, it is spoken by most of the population.

In the days of the British *raj*, of course, English was widely spoken, but this is no longer true. Outside the modern commercial areas in the major cities, both English speech and signs are relatively rare. However, many Bangladeshis received their university educations in the United States and the United Kingdom and are fluent in English. This includes a high percentage of the people involved in agricultural research. Numerous newspapers, magazines, and books are printed in English.

and Muslim-dominated East Bengal. Calcutta was a major commercial center while East Bengal was a poor agricultural land.

The solution devised by the British, and accepted finally, if grudgingly, by all parties, was partition—an India where Hindus would have the majority and a Pakistan ruled by Muslims. Pakistan itself, however, was divided into two territories; in 1947, Bengal became East Pakistan.

The arrangement was probably doomed from the start. Except for opposition to the British (no longer an issue) and religious solidarity, the two Pakistans had little in common. The West was thinly populated, earned little export income, spoke Urdu (and several other languages), and ate wheat and meat. The East was heavily populated, produced cash crops, spoke only Bengali (Bangala), and ate primarily rice and fish. Separated by these cultural differences as well as a thousand miles of Indian territory, it was unlikely that the two Pakistans could merge into one nation.

From the beginning, government policy—defense, foreign affairs, the economy—was controlled by West Pakistan in its own interest. Even in East Pakistan, the administrative service was manned by the better-trained West Pakistanis; they took over from the fleeing Hindus who had held the jobs before. Most trade, commerce, and banking was also controlled by the West. Bengali discontent was deep and abiding.

It erupted when the government of Pakistan decreed that Urdu would be the only official language. The Bengali Language Movement soon blossomed into a political party, the Awami League, devoted to self-government for East Pakistan. When the government answered with martial law and prevented the Awami League from taking power after an election it had apparently won, violence broke out.

In March 1971 the independent state of Bangladesh was declared. When the government of Pakistan sent troops to put down the rebellion, Bangladeshis took to the streets, and the War of Liberation was on.

The liberation monument at Savar. The war for independence disrupted the social and economic life of the country.

The war lasted less than a year, but it took a frightful toll in Bengali lives. Estimates vary, but it may have been as many as three million. Another ten million fled to India. Reports of atrocities by Pakistani soldiers against Bangladeshi civilians were numerous, and eyewitnesses confirmed many of the reports.

The Bangladeshis had only captured guns at the beginning and were forced to fight a guerrilla war as the Pakistan army occupied the major cities, visiting a reign of terror on the populace in the process. However, India had its own quarrels with Pakistan and soon began to arm and train the Bangladeshis.

Even then, the force was by no means equal on the two sides, and Pakistan might have prevailed had its leaders not decided to launch an air strike against Indian forces. The Indian army invaded and the end came quickly. Faced with Indian troops from the west, freedom fighters from the north, and an enraged civilian population from all directions, Pakistan surrendered in Dhaka on December 16. Bangladesh was liberated and independent at last.

But the scars of war were everywhere. The economy lay in ruins, transportation and communications systems had been destroyed, food was scarce, and famine loomed. Even worse, the educated class whose help was needed in solving these problems had been gutted by Pakistan's vendetta against the

intellectuals. It was at this time that the "basket case" term was first used for Bangladesh.

The years since independence have been troubled as a new nation has groped toward popular government and economic viability. Coups and assassinations have alternated with elections in the unstable mix of Bangladeshi politics.

In the early years, the government was committed to central control of the economy. Major industries, banks, and insurance companies were nationalized, and a number of businesses previously in the private sector were placed under public corporations. Under President Ziaur Rahman, however, the country moved its orientation more toward the West and began to be more receptive to private sector initiatives. Western aid thus poured into the country, the economy began to improve, and meaningful development seemed possible for the first time. Still, the political situation remained unstable.

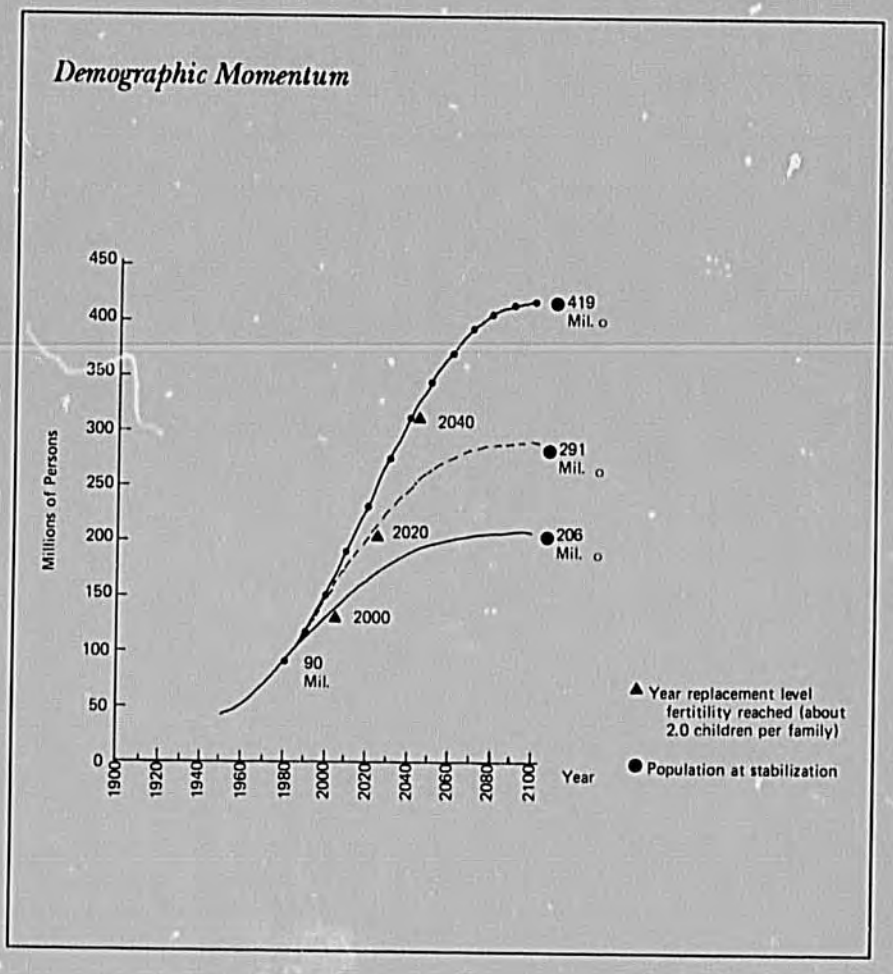
In March 1982 a bloodless coup brought General Hossain Mohammad Ershad to power, and Bangladesh was again placed under martial law. However, the Western orientation has remained and the commitment to development seems strong. President Ershad has generally received high marks for his management of the economy, the acid test of any leadership in Bangladesh. He has also attempted to build a popular base through the Jatiya Party, and has pledged an eventual return to democratic rule; martial law was lifted in November 1986.

The country has come a long way since it first unfurled the bottle-green flag with the red disc in the center, and it still has further to go. With a large population to feed, it must make the best use of its limited resources.

The People, Yes

In 1970, a cyclone roared out of the Bay of Bengal and smashed into Bangladesh. By the time the winds had quieted, an estimated 350,000 people had been killed. In the United States, such a loss of life due to weather conditions is unthinkable, but in Bangladesh, it was inevitable. The vast delta that covers the southern part of the country is in the path of every storm and every flood. People must live there because there is nowhere else to go in this overpopulated nation.

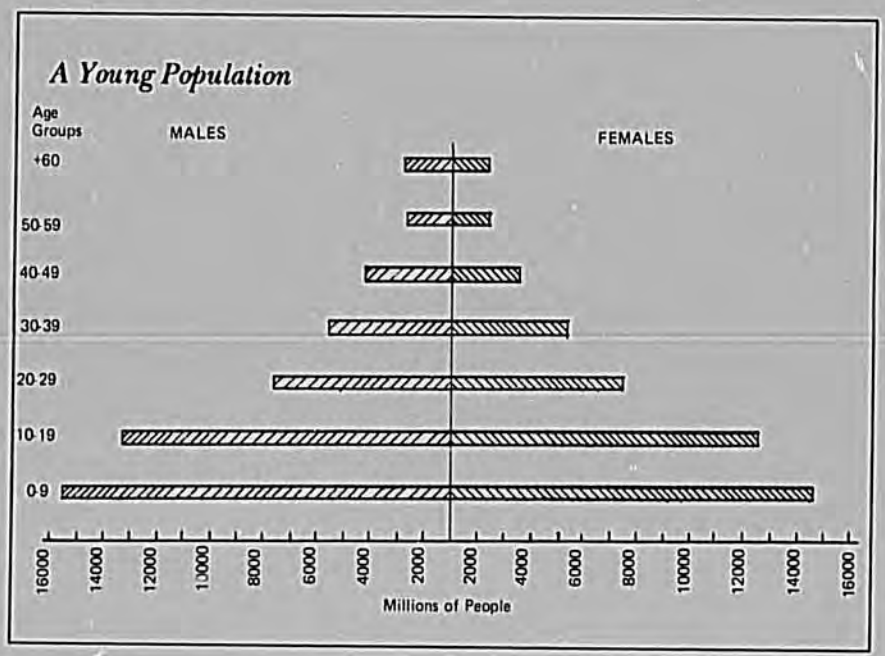
Censuses were conducted in 1974 and 1981, the latter reporting the total population as 89 million. However, these enumerations are not regarded as completely reliable, particularly the 1974 effort, and both official and unofficial updates have been issued from time to time. Many reports in 1986



estimate the population as at least 100 million. Whatever the precise count, it is a staggering number of people for so small a country to support.

Bangladesh has the highest population density of any agrarian country in the world, its ratio of people to area topped only by urban enclaves such as Singapore. And the density is increasing. The 1981 census reported 1,618 people per square mile, up from 1,374 in 1974.

Led by Dhaka, with about 5 million inhabitants, the cities literally teem with pedestrians, bicycle-rickshaws, and automobiles vying for rights of passage in the crowded streets. Every public bus is overflowing; every train is heavily loaded (with some passengers riding on the tops of the boxcars); every ferry is jammed.



To be sure, New York and London have their traffic problems, but overcrowding in Bangladesh is not just the urban phenomenon it is in many countries; it extends to the countryside as well. In terms of cultivated acreage only, the density in 1981 was 2,536 persons per square mile—about four people per acre. The rural areas do not have the suffocating closeness of Old Dhaka, but they are hardly wide open spaces, and small towns on market days resemble Old Dhaka. The forested and coastal areas are the least densely populated, but they, too, must bear their share of human life—and death—in times of natural disaster.

The problem, of course, is a fixed land area in the face of an increasing population. Between 1961 and 1974, the annual growth rate was estimated at 2.70 percent; it was estimated at 2.59 percent between 1961 and 1981. The overall annual compound rate since 1974 was 2.36 percent, which reflects a declining trend. This would be welcome news if correct, because the future of Bangladesh seems to hinge on lowering the growth rate of its population. At the present rate, the population will double in 28 years or so.

Even if a zero growth rate (2.0 children per family) is achieved soon, the numbers will continue to increase because of the size of the population that is of child-bearing age. Nearly three-fourths of the population is age 30 or under; only about 5 percent are over 60. If the two-child family is not

Street scene in Dhaka. A burgeoning population puts tremendous pressure on Bangladesh's food supply.

achieved in a short time, the total population in a hundred years will be well beyond the capacity of the land to support.

From an agricultural perspective, the geographic distribution of the population may be as important as its total size. If the people are concentrated in certain regions, or if there is massive migration to the cities, imbalances strain food resources. Neither of these possibilities seems to be a serious problem in Bangladesh yet. It is an overwhelmingly rural nation; only 14 percent of the population was classified as urban in 1981.

The population is fairly well distributed geographically. Dhaka division is the most populous area, with about 30 percent of the total population. Khulna division, which includes the Sundarbans, is the most thinly populated of the regions—20 percent of the total. The Chittigong and Rajshahi divisions each has about one-quarter of the population.

Within the divisions, the Chittigong Hill Tracts are the least densely-populated region. This part of the country has also experienced the greatest percentage increase in population in recent years. Partly to cope with unrest among the Hill Tribes, the government of Bangladesh built a number of roads into this area, and a significant amount of internal migration resulted.

Otherwise, internal migration between rural areas has been a minor factor in Bangladesh demographics. Given the homogeneity of the people and the lack of variation in the land, little rural-to-rural migration is likely in the future. Some 98 percent of the people speak Bengali; 85 percent are Muslims (most of the rest are Hindu); and rice is grown in all regions.

Some shifts in population meet agricultural requirements for seasonal labor, but these do not involve movement of large numbers of people from one division to another; most seasonal requirements are met from local labor resources.

Many developing nations are plagued by migration from the rural areas to the cities in search of greater economic opportunity. Third World cities are often ringed with shanty towns that offer few jobs and fewer services—exurban squalor that fosters discontent. So far, Bangladesh has not suffered this problem to an alarming degree, although the potential exists. As noted, the 1981 census classified about 85 percent of the people as rural, but this represented a decline from 95 percent in 1961. The annual population growth rate has been substantially higher for cities than for rural areas.

Though some of the movement to cities may be temporary as farmers seek seasonal work in urban households or on the bicycle rickshaws, it appears that many migrants are staying there. A widening gap between rural and urban wage rates makes city life a powerful attraction, even though employment opportunities in the city are not expanding rapidly enough to accommodate the millions of new job-seekers.

At the moment the problem has not reached crisis proportions, and improvements in agriculture combined with development of non-agricultural employment could stem the tide. In any case, unless the growth rate of the population as a whole is lowered, it may be some time before urban growth is seen as a separate problem from overall population growth.

Though the number is not large enough to ease population pressures, some Bangladeshis go abroad to work. The government of Bangladesh promotes such outside employment, allowing funds to be remitted to the families of the workers at favorable exchange rates and goods to be imported under relaxed customs rules. In addition, countries wanting Bangladeshi workers are permitted to actively recruit them in Bangladesh and help ar-range their travel. Thus far, practically all migrant workers go to other Muslim countries, particularly the Gulf states such as Qatar and Oman.

The gains to Bangladesh from foreign employment of its nationals are offset when those leaving are skilled professionals. Although workers, especially construction workers, represent the largest category of migrants, many health professionals and agricultural specialists have also emigrated. The impact of the skills loss to Bangladesh's development as a result of these migrations is not yet measurable, but increasing numbers could slow

Bangladesh's agricultural growth rate and its ability to provide primary health care to its people.

Nation of Farmers

There may be as many farm animals as automobiles on the streets of Dhaka. Bullocks and buffaloes pull heavily laden carts down crowded thoroughfares; goats and sheep graze at curbside; ducks and chickens forage in yards and between apartment buildings. It is as if a city of 5 million people were still a rural market town. Bangladesh has always been —and still is—a nation of farmers.

The dominance of agriculture is apparent in production, employment, and trade. Though industry has grown faster than agriculture in the last decade, farm output still accounts for nearly half the gross domestic product and is about three times greater than industrial output. (Services account for some 35 percent.) The agricultural labor force represents more than three-fourths of the total labor force, estimated in 1976 to be about 27 million. Unemployment in agriculture is thought to be high, although the numbers are difficult to pinpoint in a subsistence economy.

Agricultural products—chiefly jute, jute products, tea, hides, and fish—earn most of the foreign exchange. Like many less-developed countries, however, Bangladesh depends heavily on imports, and its agricultural exports do not cover a substantial gap in the balance of payments. In addition, the export base is fragile and vulnerable to fluctuations in world trade. Even so, it appears that the nation must operate as an agricultural producer for some time to come.

The average farm in Bangladesh is 3.5 acres. Two countervailing practices tend to maintain this size. On the one hand, when a landowner dies, the land is customarily subdivided among family survivors. (Islamic law decrees that this be done when the owner dies without a will.) As a result, individual plots tend to become smaller to the point they become uneconomical and are sold. When this happens, they tend to be bought by persons who already own land. Thus, the balance is re-established.

About half of all rural families own no cultivable land (they may own a homestead) or very little land. However, two-thirds of those with cultivable land own it, and another 25 percent rent land in addition to their own; only 7 percent are pure tenants. Land ownership is skewed toward the larger holdings; 23 percent of the owners have 78 percent of the land. However, the maximum size of land holding is limited by law to 33 acres, so even the large farms are small by the standards of many nations.

Rural Women

On market days in the small towns in Bangladesh, thousands of people converge to sell produce, buy cattle, or simply visit with neighbors. But the large crowd is composed almost entirely of men.

Rural women do not engage in marketing, nor do they usually work in the fields, apart from tending grazing animals. Instead, they tend the homesteads and the products that are grown at the homestead site, such as vegetables and poultry. They also dry the animal fodder, spreading it on the road if necessary, and the rice after it has been parboiled.

The primary responsibility of farm women is to bear children, and it is a rare woman of child-bearing age who does not have one child on her hip and another following close behind. Although women are rarely completely veiled today, the practice of *purdah* still prevails as far as the status of women in Bangladesh is concerned, particularly rural women.

Bangladesh agriculture has diversified in recent years, but production still depends heavily on a few crops. A great many crops are grown in this fertile country: rice, wheat, pulses (mungbeans, chickpeas, lentils), oilseeds (mustard, groundnuts, sesame), maize, potatoes, tobacco, fruits (mangos, guavas, peaches), vegetables (cabbages, tomatoes, carrots), sweet potatoes, sugarcane, cotton, tea, jute, and a variety of forest products such as bamboo and mangrove.

Rice is the major food crop, while jute and tea are the major cash crops. Because of the semi-tropical climate, cropping can occur year-round, and most farmers plant and harvest at least two and often three crops a year. All the crops may be rice, or they may consist of rotations with jute, potatoes, or vegetables.

A typical farmer may also have a pair of bullocks, a herd of goats, and a few chickens, and he (or she) will periodically catch fish from the rivers or the rice paddies to supplement the diet. Landless rural people often collect wood from the forests to sell in the markets.

Rice is the most important crop for most farmers; the grain feeds the family and the straw is used for animal fodder. It is typically grown in three seasons, categorized as: *aman*, planted in June and harvested November through January; *aus*, planted in March and April and harvested July and August; and *boro*, planted December through February and harvested April through June. Rice grown in Bangladesh may also be categorized by: seed variety, method of planting, and method of watering.

Rural Ways and Byways

Officially, there are 3,000 miles of paved road in Bangladesh. Meager though this total may seem, it actually understates the isolation from the outside world that is the lifelong experience of most rural people. Few of them own automobiles, and pavement is narrow and bumpy in any case. Private telephones are rare, and even the postal service is not always reliable. Television programs (government-controlled) are beamed from Dhaka (usually only in the evening), but few people can afford to own receiving sets.

Luckily, there is a rural tradition according to which young married couples are to be given, among other things, a bicycle and a radio. The bicycle will be a major means of transportation, and the radio will be the principal voice heard from the cities.

In addition to their work with their own crops and animals, many farmers supplement their incomes with off-farm work. This may be small-scale industry, such as pottery making; or agriculture-related work, such as parboiling or husking the rice grown by other farmers.

Almost all Bangladeshi agriculture is labor-intensive. The labor involved in growing rice is incorporated into all family members' activities, including those of the women and children. Since the family owns the land, little capital is required. The tools used are simple: wooden plows, spades, sickles, short-handled hoes, and weeding hooks. Many farmers own small boats.

Tractors or other types of sophisticated machinery are rarely seen. Mechanical power is frequently used in irrigation, but the method used to move water for other purposes is often a two-person basket arrangement. Household water may come from a handpump in the yard, or it may be carried in jugs from a stream.

Irrigation water comes primarily from ground water sources, and several programs have been devoted to increasing the number of shallow and deep tubewells. It appears that there has been some tendency for large landholders to benefit more from these programs than smaller farmers, but this does not seem to be a widespread problem.

Animal power is the principal source of energy. Cattle and buffaloes pull the carts, the plows, and the harrows. But only about half the farmers have enough animal power to carry out agricultural operations; the other half have either no animals or only one animal and must share with others.

Other forms of energy, such as fuelwood, are used for cooking and heating. Electricity is used for lighting where available; however, electric

Market day in a rural village. Agriculture is the mainstay of the economy.

power in Bangladesh is not yet adequate to meet the needs of the cities, to say nothing of the rural areas. A rural electrification program is still in the beginning stage. Bangladeshi cattle—usually some breed of Zebu cattle—are small animals with poor diets and are not good meat or milk producers. Calving rates are low, mortality rates are high, and veterinary care is inadequate to deal with the plethora of diseases that affect them.

Animals also serve as an important source of fertilizer, although the use of commercial fertilizer is increasing. In fact, fertilizer is one of the few areas where modern agricultural inputs are beginning to outstrip the traditional methods. Agricultural production depends heavily on fertilizer because alternative ways of restoring fertility to the soil—letting land lie fallow or rotating crops—run counter to traditional cropping practices and the notion that the limited land must be used at all times. The government of Bangladesh has promoted the use of commercial fertilizer and has given priority to the development of a national fertilizer industry.

The typical Bangladeshi farmer operates at the subsistence level, generating barely enough income to feed the family and work the farm. A sample survey of household expenditures in 1974, by the Bangladesh Bureau of Statistics showed that rural residents spent about 75 percent of their income for food, 5 percent for clothing and footwear, and 15 percent for shelter

(including rent, fuel, and furniture), leaving only 5 percent of their income for all other items, including medical care.

Clearly, there is much room for improvement in Bangladesh's agricultural sector. Of course, typical farmers there probably do not think of themselves as a part of the agricultural sector at all but as people trying to scratch out a living on a few acres of land.

To Market, To Market

From miles away they come, bearing produce of every sort on their heads, in rickshaws, in carts, and sometimes in trucks. The road through town is virtually closed as each farmer tries to get his goods to the most favored location. Loudspeakers blare. Buyers and sellers negotiate. It is market day in rural Bangladesh.

This is a primary market. Bangladesh has thousands, each serving a farm radius of 5 to 25 miles. From the local markets, produce goes to hundreds of secondary markets, usually located on rivers or railroads and serving as assembly centers and wholesale outlets. There are also terminal markets, major exchange points between rural and urban areas.

The traders who operate this market system are all fulfilling traditional roles, but all are licensed by the government in one commodity or in several. Particularly important in the marketplace are the *aratdars*. Most represent family businesses of long standing and all regard their jobs as positions of trust. They provide short-term financing, arrange storage, and find buyers for lower-level traders (called *farias* and *beparias*). Other persons provide processing services. For example, landless farmers called *kutials* parboil rice and *kutcha* balers grade and assemble jute. All these services are offered on a competitive basis.

Farming in Bangladesh is primarily a private sector activity, although central management of agriculture was considered as an alternative in the early days of liberation. But farming—growing crops, raising livestock, and harvesting fisheries and forests—is only the largest share of agricultural production. Marketing is another critical share, and it is at this stage that questions of governmental participation are most likely to arise, because the marketing system determines who will get food and other products at what price.

This is commonly considered a matter of public interest in Western nations, and is even more so in developing countries—perhaps particularly in Bangladesh. After independence, the government saw a large and growing population facing starvation. The survival of the government itself

Living with Pests

Although plant diseases, insects, and mammalian pests such as rats do a fair amount of damage to crops in Bangladesh, farm chemicals are not in widespread use. Pesticides are most likely to be used with tea and tobacco, particularly where these crops are offered for export, and with some high-yielding rice varieties.

Otherwise, insecticides, herbicides, and similar preparations have not found favor with either farmers or policy-makers as a means of combatting pests. Of course, cost is a factor. There is some experimentation with biological control, chiefly augmentation of predator species, and with repellant-treated seeds, but most Bangladeshi farmers simply live with the pests.

Though more than a few agricultural scientists are dismayed that chemicals have not been employed to a greater extent, there is a pleasant side-effect to the practice: Waterways are not nearly as polluted as in Western nations and can still be used with relative safety for bathing and washing clothes.

depended on its ability to frame an appropriate public policy to guarantee equitable distribution of food.

Like many less-developed countries, Bangladesh looked in the beginning toward central control of the economy. Banks and major industries were nationalized, and the initial 5-year plan made little provision for private sector participation. Beginning in 1973, however, the restrictions were increasingly loosened. Foreign investment, virtually banned at first, was later permitted and is now strongly encouraged. In addition, many public corporations and enterprises have been denationalized. The current 5-year plan makes development of the private sector a top priority.

Government concern for food security continues, however. Though controls have been relaxed, agricultural marketing has not been released completely from government regulation. Government efforts to ensure low food prices for urban residents has resulted in low prices being paid to farmers, creating a disincentive to increased investment, risk-taking and, consequently, production in the agricultural sector.

The nation still does not produce enough food to feed its population, and donor nations fill the gap. The government of Bangladesh continues to subsidize foodgrains under a complicated rationing system, a practice that works to the disadvantage of rural dwellers. It is a familiar quandary for farmers in developing nations: they receive low prices when they sell and pay high prices when they buy.

In agricultural areas other than foodgrains, government intervention varies widely but generally has been in the direction of deregulation and

In Search of Muslin

One of the oft-told horror stories of the colonial era is the destruction of the Bengali muslin industry by British rulers intent on protecting their own cloth and garment manufacturers. Bengal had been famous for super-fine muslin since at least the Middle Ages.

However, knowledge is very scanty regarding the kind of cotton or lint that was used for muslin, though some records do refer to the production of a muslin variety of cotton near Dhaka. The short-staple *deshi* or Comilla cotton was grown in the area for centuries, but the popular medium-staple American upland cotton was not introduced until after independence.

At present, the local textile mills and handlooms—there are about 350,000 of the latter in the countryside—can meet only half the country's clothing requirements; the rest is imported. But the climate is conducive to the cultivation of upland cotton, and perhaps a new muslin industry can be established.

disinvestment. For example, cotton mills once completely under government control, have now been largely returned to private hands. Cotton production, however, has lagged, and most of the material for the mills must be imported. Tea is produced and sold subject only to market forces and has the distinction of being the only crop sold through public auction.

Tobacco furnishes an interesting example of results without controls. Although the government is part owner in one of the 17 tobacco companies, there is little government intervention in the production or marketing of tobacco—no acreage controls, no fixed prices, no government procurement. Today, the country is self-sufficient in tobacco; whereas before 1971, West Pakistan supplied most of its tobacco.

The trend is toward greater reliance on market forces in the allocation of basic agricultural inputs. In the fertilizer market, for example, the government originally controlled all domestic supplies and imports. In 1978, however, in cooperation with A.I.D., a new marketing scheme was introduced that was designed to stimulate more private activity. It consolidated distribution points and gave price discounts on large purchases. It eliminated dealer registration and permitted them to increase their profit margins. It lifted restrictions on the movement of fertilizer within the country. The changes—which opened up the system and curtailed government involvement—were intended to improve efficiency; and this has, by and large, been the effect. To induce farmers to use more fertilizer, however, the government has continued to subsidize fertilizer sales. The subsidy has kept demand at a level that has strained the marketing system.

Paddy rice ready for market. Most of the rice produced by Bangladesh farmers is sold locally.

To relieve the pressure, fertilizer prices have been increased, but sales have continued to rise.

Until recently, the marketing of irrigation equipment has been under tight government control, but World Bank insistence is bringing a change in this area, also. Government ownership and operation of deep tubewells (through the Bangladesh Agricultural Development Corporation) is moving in the direction of user ownership; and full-cost pricing has been introduced for shallow tubewells.

Although the changes that have been made in agricultural marketing toward a private-sector orientation will benefit agriculture in the long run, the availability of agricultural credit continues to be a problem. The government has not been able to accomplish its goals in all the areas considered appropriate for governmental action—that is, in providing price information, guaranteeing product quality, and developing essential infrastructure for commerce. It has, however, made a significant commitment in one area that is essential to productivity—agricultural research.

The Research Legacy

On a small balcony off the second floor of a laboratory building at the Bangladesh Rice Research Institute in Joydepur, a group of local young men squat around a large basket of mud. Working rapidly, they scoop handfuls of the thick goo and massage it into small round balls, which they then lay to the side in neat rows. The men are carrying out a research project under the direction of Dr. N. I. Bhuiyan, the institute's principal soil chemist.

Bangladesh soil, commonly deficient in nitrogen, needs fertilizer, and a popular source in recent years has been urea. There is reason to believe that the small, white urea pellets can be implanted in the rice fields more efficiently if they are encased in a ball of mud. No one knows if this will be cost-effective because there is no data on the time required to make mud balls. Bhuiyan is trying to provide some data.

The mudball experiment is not typical of Bangladesh agricultural research methodology today, which is actually quite sophisticated, but it indicates the spirit that has long driven this research. The newer methodology has a research legacy on which to build.

Throughout recorded history, agricultural research has been conducted in Bangladesh, as elsewhere, albeit not with the quantitative methods of modern science. In Bangladesh, the farmer has also been the researcher. By observing the more successful practices, or by trial-and-error techniques, the farmer learned how to wrest a living from the land.

The year 1880 is regarded as the beginning of formal agricultural research, loosely defined as institutions engaging in scientific studies. In that year, following the recommendations of the Famine Commission, a Department of Agriculture was established in Bengal under the Department of Land Records. Research on jute and tea, the principal cash crops, began at this time.

In 1905, the Bengal Department of Agriculture received separate status within the Indian Department of Agriculture, and rice research was begun. At about the same time, an experimental station known as Dacca Farms was established to conduct research on other crops.

Between the two world wars, an Imperial Council on Agricultural Research was set up (1929) for all of India, and the Bengal Agricultural Institute was founded (1938) to provide the first higher agricultural education. However, the world depression of the 1930s severely depressed agricultural research, and the onset of World War II, with the Japanese poised to invade India through Bengal, practically brought it to a complete halt.

With British assistance, a foundation for agricultural research in India, including Bengal, was laid. But depression and war damaged this foundation, and partition disrupted it further. Many scientists departed Bengal for

A mudball experiment. Agricultural research has a long history in Bangladesh.

the new nation of India, which inherited the tea, jute, and sugarcane research institutes. It was left to the new Food and Agricultural Council of Pakistan to pick up the pieces.

Advances were definitely made during the 25 years of rule from Karachi and Islamabad. New research institutes for jute, tea, sugarcane, rice, and forestry products came into being. The Bangladesh Agricultural University was founded to strengthen agricultural education, and a completely new

Key Dates in Agricultural Research

1880	Department of Agriculture established under Department of Land Records in Bengal.
1906	Separate status given to Bengal Department of Agriculture in Indian Department of Agriculture.
1929	Imperial Council of Agricultural Research established in India.
1947	Food and Agricultural Council of Pakistan, including East Pakistan, created.
1973	Bangladesh Agricultural Research Council established in independent Bangladesh.

initiative in the peaceful uses of atomic energy—nuclear research—was undertaken under the sponsorship of the International Atomic Energy Agency.

Most importantly, perhaps, the first high-yielding varieties of rice were introduced into East Pakistan in 1965 by the International Rice Research Institute in the Philippines, and other foreign techniques were injected into Bengali agriculture.

In agricultural research as in other areas, however, the Pakistanis perhaps showed a great lack of sensitivity for Bengali concerns. Dacca Farms was taken over by the government to become the site of the second capital; the area is known today as the Shar-e-Bangla Nagar section of Dhaka. By this action, East Pakistan lost its principal agricultural research facility and a rice germplasm collection that had taken 50 years to assemble. Although a replacement for Dacca Farms was eventually provided on 650 acres in nearby Joydepur, this took more than a decade, and the research effort lost the momentum that had begun to build.

The War of Liberation completely disrupted the system. Research institutes were divided and many research scientists fled the country. The fighting destroyed scientific and agricultural equipment, to say nothing of the morale of the research establishment. With independence, there was again a rebuilding job to be done.

Though this task was formidable, it was undertaken with the knowledge that agricultural research would be fully under local control for the first time. As international aid poured into the country, the research institutes were quickly refurbished, new facilities were built, and new crop possibilities

A Prophetic Voice

"Green revolution has already taken place in the world owing to the cultivation of high yielding varieties of maize, wheat and rice along with uses of fertilizers, insecticides and irrigation water. This has brought self-sufficiency in many countries and particularly in areas where wheat is grown. Green revolution is also in sight in rice growing areas of South-East Asia and in this area Bangladesh lies. Experts predict that green revolution will take place to the full extent in the area in the course of a decade from 1971 and this is bound to materialise."

—Dr. A. Alim, writing in *An Introduction to Bangladesh Agriculture* in 1974.

were explored. For example, the scientists from the International Maize and Wheat Improvement Centre (CIMMYT) introduced the first high-yielding varieties of wheat.

In some respects, the most significant action was the 1973 creation of the Bangladesh Agricultural Research Council (BARC) to coordinate agricultural research throughout Bangladesh. This authority was strengthened in 1976, laying the foundation for the agricultural research system that exists today.

The 100-year journey from the Famine Commission to BARC has been a tortuous one for agricultural research. Although frequently dampened by war and political upheaval, the spirit of scientific research has survived to give life to the research institutions. The local base is strong, but international assistance has been a major factor in the perpetuation and strengthening of the agricultural research effort. In fact, agricultural research in Bangladesh is an outstanding example of how cooperation between local authorities and international donors can lead to development gains.

2

Success Stories: The Food Crops

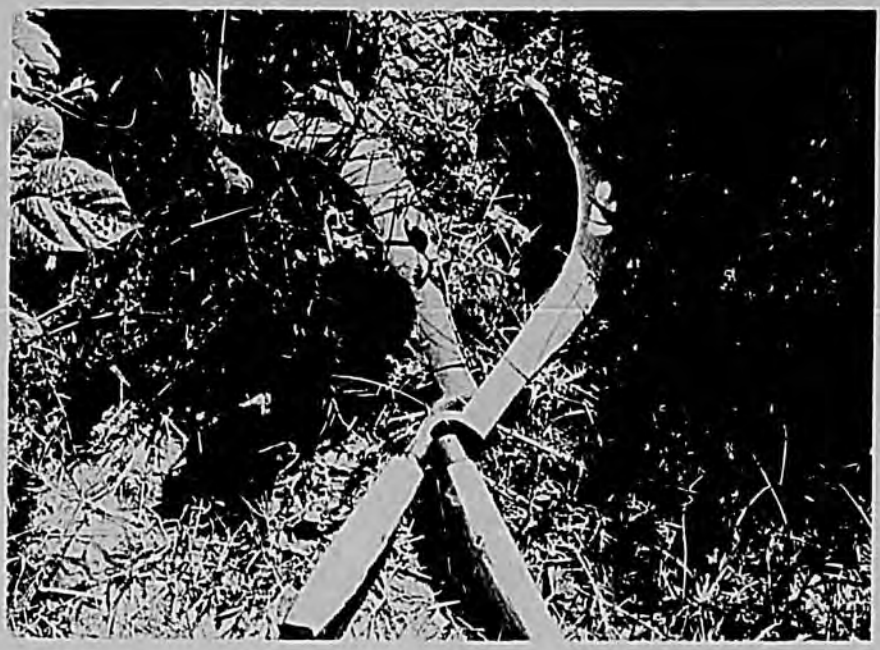
The people of Bangladesh, by and large, believe they eat well enough. Agricultural researchers know better, and they know the job of the institutes is to improve agricultural productivity in order to increase the yield of food and fiber crops that can be sold to buy food. Much of the research in the vast network of institutes and universities is thus crop research. In the end, it is on the success or failure of crops, stocks, and herds that agricultural research is judged.

On the whole, the crop picture has been bright lately. Modern high-yield rice varieties have blossomed, the diet has been diversified with fish and vegetables, and there has been a virtual revolution in wheat and potatoes. On the other hand, jute and sugarcane are merely holding their own, and forestry products are just emerging. On all fronts, at least work is going on.

The Rice Tradition

The Bangladesh Rice Research Institute (BRRI) knows how to entertain visitors: none of the casual handshake-and-handout stuff. Rather, it offers a typed agenda, meetings with all key people, a slide show, a guided tour of facilities, and lunch in the V.I.P. dining room. BRRI has a tradition to uphold—Bangladesh is a "rice" country.

Rice is the people's main food, so it gets more than 80 percent of the total cropped acreage. For many farmers it is the only source of cash income. Keeping this industry prosperous is BRRI's responsibility. With help from IRRI, other international centers, and international donors like A.I.D., BRRI has kept the rice tradition moving forward.



BRRI headquarters are on a 60-acre site in Joydepur just down the road from BARI. The institute has 12 research divisions covering all the basic areas, from agricultural economics and engineering to soil chemistry: BRRI has five substations that adapt rice to the agro-climatic conditions prevailing in their localities; Barisal and Char Chandia test salt water varieties; Habiganj researches deepwater and boro rice; Rajshahi screens for drought tolerance; and Comilla conducts various local testing. More than 200 scientists work at the headquarters and regional locations.

The greatest challenge has been to develop rice varieties with higher yields and greater resistance to disease, drought, cold, and salinity. The first major breakthrough in this respect came in the 1950s, but Bangladesh was not then ready to supply the inputs needed for mass production of the new technology. Fertilizer factories and irrigation facilities had to be extended and intensive cultivation practices had to be demonstrated.

IRRI developed the semi-dwarf IR8 variety in the mid-1960s, and it was readily adopted by Bangladesh farmers, especially in the winter season if irrigation was available. However, as far as BRRI was concerned, the IR8 plant types had limitations: short height; photoperiod insensitivity; susceptibility to cold, drought, and salinity; and slow seedling growth with uncontrolled water in the field. Faster growth to produce taller seedlings within 30 days was needed.

BRRI Searches

In 1983, Bangladesh produced 15.1 million tons of foodgrains, chiefly rice, to feed a population of some 94 million. About 10 percent of this output is not turned into food but into seed, feed, and wastage. Since the present consumption rate for foodgrains is about 0.44 kg per person per day, there is a foodgrain shortfall of some 1.27 million tons annually.

Unless there is some dramatic improvement in population control, there will be, by conservative estimates, some 128 million people in the country by the year 2000. A population this size will require, at present consumption rates, 20.2 million tons of foodgrains annually.

The Bangladesh Rice Research Institute, established by parliamentary act in 1970, is searching for new rice technology to fill this foodgrain gap.

BRRI scientists restructured the IR8 plant type to suit the Bangladesh production environment, developing an intermediate height plant that gives equally high yield and can grow in uncontrolled water. Bangladeshi farmers liked the taller plants because they provided more straw for cattle feed and roof thatching. Also, sensitivity to the photoperiod had to be added to the new germplasm to make the varieties fit double cropping in an unpredictable rainfed system of rice culture.

Bangladesh varieties now compete with IR8 in *boro* production and have tended to replace the IRRI varieties previously used in Bangladesh. Likewise, *aus* and transplanted *aman* varieties are making inroads into traditional varieties. All are disease-resistant and show modest increases in yield.

Some 20 varieties have now been released, and many have been popular with farmers. Biplab (BR3) is the only variety suitable for cultivation in the *aus*, transplant *aman*, and *boro* seasons. It was rated superior to 35 other modern varieties in 1974 nursery trials organized by IRRI at 16 locations on three continents under diverse soil and climatic conditions. Brrisail (BR4), developed for the transplant *aman* season, ranked first in average yield in the same trial in 1976. The following year, BR4 and two advanced lines released in 1891 as Progoti (BR10) and Mukta (BR11) captured the first three positions.

Four other varieties—BR12, 14, 15, and 16—were recommended for release in 1983. They are suitable for the *boro* and *aus* seasons, resist disease, and mature early, allowing farmers to plant *aman* rice on time for high yields. These varieties can also be planted in very diverse soil conditions.

Because of their demonstrated successes, BRRI varieties are increasingly adopted in other rice-growing countries. BR3 is very popular in Vietnam,

Nepal, India, Sri Lanka, and some West African countries; BR4 is popular in Burma, where it is known as Sintheingi.

The new, higher-yield varieties have had a dramatic impact on Bangladesh rice production. In the 12 years between 1970 and 1982, the acreage devoted to modern varieties rose from 2.6 percent to 23 percent of the total. In 1982, modern varieties accounted for 41 percent of the rice harvested. The research strategy is aimed at achieving 60 percent coverage of modern rice varieties by 1990.

In addition to overall achievements as far as rice varieties and yield are concerned, BRRI scientists have also had success in the areas of drought and cold tolerance, pest management, irrigation, cropping patterns, and deepwater rice.

Drought comes to Bangladesh about once every 5 years. It affects the *aus* crop in its early growth stage and the *boro* and *aman* crops at the reproductive stages, depending on the period of drought. Scientists have identified drought-tolerant varieties that are now used to supply genes to develop new varieties for the direct-seeded, rainfed upland rice culture in drought-prone areas. Modern varieties, like BR1, BR3 and BR6, have better cold tolerance and perform well in the *boro* season.

Rice lines resistant to pests (brown planthopper, green leafhopper, and tungro virus) have been identified. Scientists have also found that the nematode disease, *ufra*, can be effectively controlled by transplanting after an application of Furadan.

Drought at the flowering stage of the transplanted *aman* crop, for example, may reduce the yield to zero. Experiments show that just a small amount of irrigation at this stage will save 60 percent of the crop. Also, a small levee can be used for 83 percent effective use of rainfall. This is enough for a satisfactory crop of transplant *aus* or transplant *aman* with no irrigation facility.

For many years most deepwater rice areas had to be single-cropped. With a new cropping pattern, a modern *boro* variety followed by deepwater rice, production has been expanded significantly. It has also been demonstrated that a mixed crop of *aus* and deepwater rice provides no greater benefit than single and separate crops of *aus* and broadcast *aman* rice. When the farmer grows these crops separately, he or she can get the *aus* land free as soon as the flood season is over and then grow another crop early. This practice releases additional acreage for early planting of crops such as mustard, wheat, potatoes, and legumes.

Bangladesh is not yet the success story in rice that Indonesia is, but it seems to be moving in that direction. Too many low-yield traditional varieties are still being planted, but the number should decrease as the

M.A. Mannan, director of BRRI, and Frank Sheppard of IRRI. The CGIAR center has participated actively in Bangladesh research.

modern varieties continue to demonstrate their effectiveness. IR8 started the ball rolling, BR3 gave it a big push, and BRRI has numerous projects underway in all areas of rice production to keep it going.

Diversifying the Diet

M.M.A. Jalil and A.K.M. Naruzzaman are BARC member-directors and agree passionately on one thing: the Bangladesh diet should have more protein. Both men speak eloquently on the subject of nutrition. Rice is a good basic food providing plenty of bulk; vegetables are great for vitamins; but the diet needs to be supplemented by more meat and fish. It is no surprise that Jalil is the member-director for livestock, Naruzzaman the member-director for fisheries. The research they promote may make diversification a reality.

Of course, many scientists elsewhere in the research network also have a great deal to say on the subject of diversification. They work every day with fruits, vegetables, root crops, spices, oilseeds, pulses, and foodgrains other

Fishing for Complements

The effort to develop other food sources to complement the basic rice diet of Bangladesh has led to improvements in the organization of fisheries research.

Before 1984, research into fish culture and capture was carried out in an uncoordinated way under a Directorate of Fisheries, mostly in the context of regional development projects. In that year, the Fisheries Research Institute was established as an autonomous body under the Ministry of Fisheries and Livestock.

The headquarters of the new institute is in Mymnesingh near BAU. Five research stations are planned, and two are now in operation—freshwater aquaculture at Mymensingh and riverine research at Chandpur.

than rice. Each of these items is attempting to make a place for itself on the Bangladesh table through research.

With both an extensive coastline and a vast amount of inland water, Bangladesh is a natural habitat for fish culture and capture, and there is indeed a traditional fishing industry of long standing. As little as 10 years ago, fishing depended mostly on capture; it was rural-based, unmechanized, and labor-intensive, employing several million people.

In the past decade, an urban-based commercial fishing industry, complete with middlemen, has emerged. There is more emphasis on large-scale capture and fish culture. This development has brought a host of social problems—labor displacement, alternative land use, and pricing policies—that are yet to be worked out. But it has also brought fish production into the national consciousness and into the *pro forma* of agricultural research for the first time.

The new Fisheries Research Institute (1984) is mandated to co-ordinate all fisheries research in Bangladesh toward "optimum utilization" of the country's fish resources. The institute itself is being put in place in stages. When it is complete, it will have five research stations: Mymensingh, Chandpur, Khulna, Cox's Bazar, and Chittigong. Each will concentrate on different areas: freshwater aquaculture, riverine fisheries, brackish water aquaculture, mariculture, and marine fisheries, respectively.

Much of the research so far has been taxonomic: an assessment of the fisheries resources of the country; a survey and list of freshwater bony fishes and prawns; an update on hilsa (the most important inland capture fish); a survey of the number of ponds and tanks; and an assessment of the Kaptai Lake fishery. Some work has been done on weed control, fish diseases, and water pollution. There have also been investigations in fish technology: fish feed, use of fish manure, preservation techniques, and use of fish oil.

About 80 percent of the protein now in the Bangladesh diet is contributed by fish, but the present output of the fishery sector does not come close to

Both Safe and Khesari

Many pulses contain toxic substances. The toxicity of some of them is destroyed during cooking and thus is not a problem for human consumption. However, a neurotoxin known as BOAA, found in *khesari*, has caused considerable concern. It has, in fact, caused paralysis in the lower limbs of some Bangladeshi males.

Researchers who work closely with pulses, such as Matiur Rahman at the BARI regional station in Ishurdi, are adamant on the point that the paralysis cases reported are special cases, and that it is perfectly safe to eat *khesari* under normal circumstances. The BOAA neurotoxin is a problem only when unboiled *khesari* is eaten over a long period of time. The incidence of paralysis is also linked to vitamin C deficiency.

All reported cases of *khesari*-related paralysis occurred among very poor people who found themselves in famine conditions and ate virtually nothing else for several months. Even so, BARI is conducting research on low-toxin or toxin-free *khesari* varieties.

meeting national needs. Per capita fish consumption 20 years ago was less than half the estimated minimum requirement. Due to the rise in population, it has now fallen to one-third! The demand for fish is probably five times greater than the amount being produced.

If consumption of fish is to increase, it is clear that production will have to rise significantly. This is more than a research question, of course, but research will have to do its share. So far, it has been a neglected area of agricultural research.

As food sources, livestock and poultry are not important items in Bangladesh. Member-director Jalil's admonition that there should be more meat on the table may some day be followed, but this will be a long time in the future. For now, animals are used primarily as beasts of burden (and, accordingly, are discussed in a later chapter on animal power).

Indigenous breeds of chickens and ducks tend to be small and stringy. Their only food consists of household wastes and scavenging. Accordingly, they are poor layers, and their eggs are small. At least 25 percent of the poultry dies each year due to pests and diseases. Some research has been done on poultry diseases such as salmonellosis and coccidiosis, and further research is among the priorities in the national agricultural plan.

With the chances of diversifying the diet through fish and livestock or poultry very slim, the best option for increasing the protein supply is through an increase in the production of pulses.

The pulses of Bangladesh comprise six major crops: khesari, lentil, blackgram, mungbean, chickpea, and pigeonpea. All have been studied in terms of varietal development, agronomy, nutrition, quality, and diseases.

BARI, BAU, and the Bangladesh Institute for Nuclear Agriculture have all been involved in pulse research.

Only about 8 grams of pulses per person per day were available in 1980; 65 grams are recommended. The second 5-year plan addressed doubling this supply, but unless the pulse equivalent of "miracle rice" is discovered, this goal seems impossible to achieve. Indeed, the success of the high-yielding varieties of rice (and wheat) has actually worked against pulses, reducing the acreage devoted to their cultivation.

Some important new varieties have been released. One very significant contribution is Mubarik, a summer mungbean variety released by BARI that matures in about 60 days. Since all of the pods mature at about the same time, the labor input of repeated harvests, common to pulses, is reduced. Also, since it matures quickly and is insensitive to day length, it can fit into any crop pattern.

In chickpeas, BINA has released a high-protein mutant from the local variety Faridpur 1, which is 25 percent higher in yield than the parent; it also yields 45 percent more protein. In blackgram, significantly higher yields were obtained at a population density of 600,000 plants per hectare with the variety T-9 when no inputs were provided.

Although maize, oilseeds, fruits, and vegetables may not add much protein, they are important to the diet and have been the subject of fairly intensive research in recent years. Increased production of all these crops has been hampered by the familiar tendency of the farmers to grow what they know best, which is usually rice.

Maize production has increased in some parts of the country, and the number of maize farmers went up from about 25 in the early 1970s to some 700 at the end of the decade. BARI has developed five high-yield, medium-duration varieties that can be recommended for expanded maize production in flood-prone areas. If these areas were brought under maize cultivation, 6-10 million tons of grain could be produced, about two to three times as much as the yield to be expected from late transplanted aman rice. Also, if the new Quality Protein Maize (QPM) developed at CIMMYT proves out, maize could help increase the protein content of Bangladeshi diets.

Rape and mustard, groundnuts, and sesame are the major oilcrops in Bangladesh. These crops have a bright production potential, and domestic production could probably be doubled in a short time with the technology currently available. This would require the planting of high-yield varieties that have been developed, as well as better management practices.

Research has already made important contributions to fruit and vegetable production in Bangladesh. For example, a recommendation for a change in the spacing of bananas has increased output many times over. A selection of a mutant lemon, later multiplied as a "seedless lemon," is now

A khesari plant. Researchers are looking for crops that can be used to vary the rice diet.

a leading commercial cultivar. Cashew nuts, an introduced crop, are now common both on homesteads and on commercial plantations in the Chittigong Hill Tracts.

Pears and mangoes, *kalmi sak* and *gikur sak* (leafy vegetables), radishes and carrots, black pepper and bottle gourd, tomatoes and cabbage—all are being tested, all have shown some promise and some problems, all may someday be important food items.

The most important gains in the fruit and vegetable area, however, have been made with potatoes. Since its growing season is relatively free of flood and drought, and since it can be grown easily on fallow land without competing with other crops, the potato has considerable potential in Bangladesh. Potatoes are high in caloric content and provide an ample supply of carbohydrates, as well as various minerals and vitamins. They also contain protein and vitamin C, not found in rice or wheat.

Since 1977, BARI has had a strong research program in its Potato Research Center. The country's production has increased more than 60 percent since the mid-1970s, and potatoes are now the country's third staple food crop.

Critical to the resurgence have been the selection of improved exotic varieties, to replace virus-ridden indigenous varieties, and the improvement in the quality and quantity of locally-produced seeds. Varieties selected and recommended from the many screened in trials include Multa, Patrones, Ukama, Diamant, Cardinal, K. Sindhuri, and Elvira. These varieties have a yield potential ranging from 19 to 25 tons per hectare.

There have also been improvements in disease and pest control, water and fertilizer management, and post-harvest technology. The Bangladeshi achievements in potato production have attracted international attention, and courses in potato seed production are now conducted by the Potato Research Center for other countries throughout Asia. In fact, in the international literature of success stories, potatoes are usually mentioned just after rice. The crop that outshines both of them, however, is wheat.

Revolution in Wheat

Typical mealtime fare in Bangladesh, whether prepared at home, in a restaurant, or in a research station guesthouse, consists of a plate of rice, perhaps a piece of chicken or fish with curry, and a bowl of vegetables (*gourd, dal*). But there is an increasing tendency for *chapatis* to be offered. This is flat bread, hand-made from wheat flour. Bangladeshis have acquired a taste for wheat, and there has been a revolution in wheat production.

With the introduction of high-yielding varieties, wheat production rose from 100,000 tons in 1975 to a million tons in 1982—an astounding agricultural development possibly unique in the world. The wheat revolution was an outstanding example of cooperation between international donors, international research centers (CIMMYT), the Bangladeshi agricultural research system, and, of course, Bangladeshi farmers.

There was interest in wheat production as early as the 1960s when high-yielding semi-dwarf varieties were brought into India and Pakistan. The strains being cultivated in East Pakistan at the time, mostly in the area adjacent to West Bengal in India, were tall, late-maturing, and susceptible to disease. However, consultants hired by CIMMYT's predecessor organization and the Ford Foundation argued that wheat could be an important winter crop if high-yielding varieties were introduced.

Some Bangladeshi scientists agreed, and CIMMYT provided them with financial support for an "accelerated wheat research program" in the early 1970s. A joint survey by Bangladesh and the U.N. Food and Agriculture Organization indicated that 2,300,000 ha of land were physically suitable for wheat production under rainfed conditions. Irrigation would open up an additional 800,000 ha. Assuming that some of this land would be used for

Collaboration with CGIAR

The collaboration between the international agricultural research centers (which work together in a consultative group called CGIAR) and Bangladesh has been very important to the growth of agricultural research in the country.

The work of IRRI in rice, CIMMYT in wheat, and CIP in potatoes are probably the most notable and best-known contributions, but other centers have been involved. The International Food Policy Research Institute (IFPRI) has carried out several studies on agricultural price policy and one study of the food aid program in Bangladesh. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute for Tropical Agriculture (IITA), and the International Center for Agricultural Research in the Dry Areas (ICARDA) have provided germplasm for their mandate crops and training for Bangladeshi scientists. In turn, Bangladesh has received scientists from the West African Rice Development Association (WARDA) for training.

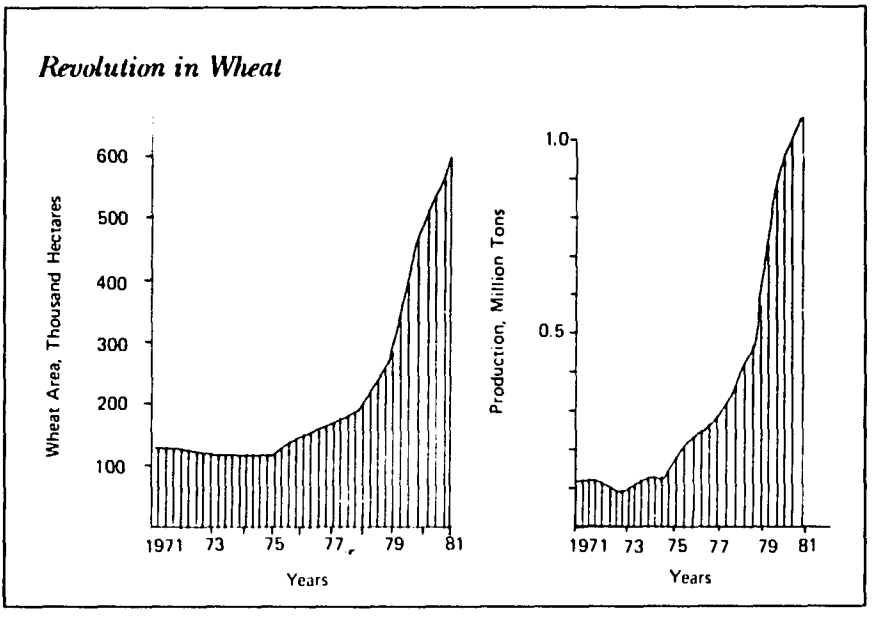
CGIAR contacts are coordinated through BARC and are often financially supported by international donors.

other winter crops, the potential wheat area (rainfed and with irrigation) was thought to be 1,500,000 ha.

By the mid-1970s, local research had confirmed the potential for wheat production, and interest in wheat increased in the Ministry of Agriculture. The "expanded wheat research program" and BARI itself were launched at about the same time in 1975. Armed with soil survey information, proven wheat varieties, and top political backing, BARI scientists threw themselves into a wheat improvement and production research program.

Most of the development research involved making direct selections of suitable cultivars from international yield trials, such as those from CIMMYT. These cultivars were evaluated for disease resistance, environmental adaptation, and agronomic characteristics. Some of the high-yielding commercial varieties supplied from India and Mexico were suitable for Bangladeshi production without further improvement.

When BARI had fully assembled its research team, it began to make "reselections." From the best advanced lines of the international nurseries, BARI researchers selected individual plants better suited than their parental populations for Bangladesh's production environment. They also drew on various germplasm collections and crossing blocks for materials that could be used in the national crossing program. Several early-maturing, high-yielding varieties have now been developed locally and released. Of the BARI varieties, the cultivar Balaka shows considerable promise.

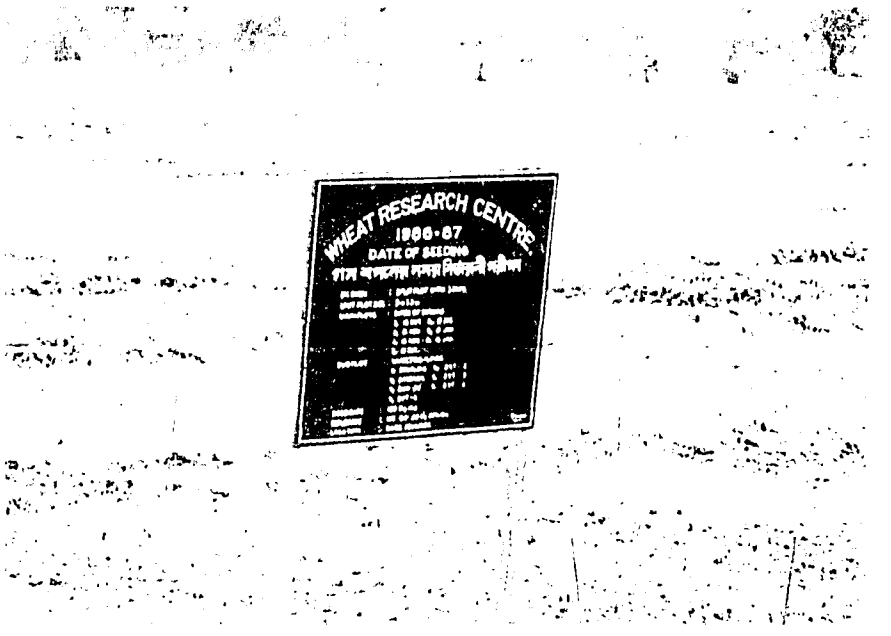


Of the 600,000 ha of wheat planted in 1980–81, about 96 percent was seeded to high-yielding varieties. Sonalika, from India, covered about 68 percent of the HYV area, followed by the Mexican variety, Inia 66, with 10 percent. Other varieties in use were Pavon 76, Jupateco 73, and Tanori 71.

On-farm research trials have been conducted throughout the wheat-growing areas by BARI scientists to work out seeding practices, tillage methods, fertilizer use, and irrigation applications. Socio-economic studies have been carried out to evaluate the profitability of different sets of recommendations in the context of farmers' resources and alternative uses of those resources. The studies show that properly cultivated wheat with one or two supplemental irrigations and adequate fertilizer can produce yields up to and exceeding 3 tons per hectare.

Areas with irrigation show the highest net returns to farmers, but there are incentives for wheat production even in marginal areas. In areas formerly left fallow in the winter, wheat provides an opportunity to use unemployed family labor during the slack months from November to March. Thus, even in rainfed areas where wheat yields with high-yielding varieties are not very high, expansion of areas planted to wheat has continued, often at dramatic rates of growth.

The rapid increase in wheat area and production during 1975-1980 led some to believe that the area planted with wheat would continue to expand



Wheat research in the off-season. The revolution in wheat production was a major success for agricultural research.

greatly. When this did not prove to be the case—production dropped 15 percent in the 1981–82 season—the government of Bangladesh appointed a task force to look into the matter. They found that short-term factors explained the 1981–82 downturn. Due to the poor 1981 *aman* rice harvest, many farmers preferred to grow *boro* paddy rice in the winter instead of wheat. Also, there was competition from other dryland crops (such as pulses). Shortages of wheat seed and fertilizer and difficulties in harvesting and threshing added to production problems and about two-thirds of the 1981–82 area was sown late, due to drought in late 1981 and a late harvest of the *aman* rice crop.

Long-term factors, however, explain why production has remained relatively stable after the phenomenal early rise. Wheat is part of a complex cropping system that is highly dependent on the events in rice production as well as on changing market opportunities for other winter crops that compete directly with wheat. A potentially large wheat-producing area continues to be planted in *boro* rice, despite the fact that rice consumes several times more water than wheat.

Further research is needed. To attain varietal diversification and disease resistance, scientists have released Balaka and Ananda, which resist leaf rust,

and Kanchan, which is adapted to late planting and produces higher yields than Sonalika. Two other semi-dwarf varieties, Akbar and Barkat, also outproduce the Indian variety. Since wheat needs to be planted late to follow *aman* rice, and since much of the production will be on land without irrigation, the main need is for varieties that can withstand drought conditions.

Research on post-harvest technology is needed, too. Threshing equipment is in short supply, as are milling, procurement, and storage facilities. At present, wheat is generally threshed with sticks or trampled by bullocks, but more mechanization may be necessary to complete threshing of increased harvests before the monsoons.

The wheat revolution is unquestionably a success story in applying science and technology to agriculture. New high-yielding varieties and improved agricultural practices came from the laboratories and test plots to the farmers' fields. The result was a short-run production miracle.

But the success of wheat production has created new pressures and challenges for the organizations concerned to equal or top their own records. If the 1.5 million ha potential for wheat production is still seen as a realistic goal, greater efforts will be required in both research and extension.

3

The Donor Organ: Context of a Research Program

The most ubiquitous motor vehicles on the back roads of Bangladesh would be described by most Americans as "jeeps," although they may actually be manufactured in Japan or Great Britain rather than the United States. These are blocky, compact conveyances with sturdy tires, four-wheel drive, and overworked shock absorbers. Most are occupied by either Westerners or Bangladeshi nationals associated in some capacity with donor agencies. The jeeps have become a symbol of not only transportation conditions in the country but an extensive international aid presence as well.

Donors of Dhaka

The universality is apparent at the American Club, the facility operated by the American Recreation Association for the U.S. State Department. Located in the diplomatic enclave of Gulshan, just north of Dhaka, the club's membership list reveals American passport-holders from many agencies—from the World Bank to the World Health Organization. According to director Jeri Glass, the club was one of the few places for aid officials to stay after the great cyclone of 1970, and the tradition of a broad membership continued. Other Western nations operate similar clubs today. Most of their members are involved in one way or another with dispensing aid to Bangladesh.

Since 1971, at least 35 nations have provided grant or loan assistance to the country; more than half the assistance has been in the form of commodity

American Abroad

Frank Sheppard hails from Hutto, Texas, and has spent a good portion of his life as a development worker in Asia. Now past retirement age, he works for the International Rice Research Institute (IRRI) in the Philippines and has been detailed to Dhaka for several years to work with the Bangladesh Rice Research Institute (BRRI).

The arrangement between IRRI and BRRI has been continuous since 1966.

Although he works comfortably with A.I.D. staff and contract personnel, Sheppard is quick to differentiate between the two programs: "There is a consortium of donors that financially supports the IRRI assistance to BRRI. A.I.D. is a member of the consortium and the A.I.D. people consider this a part of their agricultural research program. But their funds go straight to BRRI and we at IRRI are not involved at all."

Sheppard is now contemplating a "second retirement," but is not sure what he will do thereafter. Hutto, Texas, seems far away to an old Asia hand.

and food aid. Western nations have been prominent, but the Eastern bloc and Organization of Petroleum Exporting Countries (OPEC) have also been represented. Among bilateral donors, A.I.D. has been prominent, joined by Japan, West Germany, Canada, and the United Kingdom. In addition, nearly a dozen multilateral aid agencies—notably the World Bank and the Asian Development Bank—have contributed, and a host of private voluntary organizations have pitched in.

The World Bank, specifically the International Development Association (IDA), has been the largest donor. IDA loans of the "soft" variety (long maturity periods, no interest) have gone to Bangladesh in greater profusion than to any country except India.

A brief selection of projects funded indicates the catholic nature of the World Bank's interests: an $11 million forestation project to allow the planting of 100,000 acres of mangrove trees over 5 years; $40 million for the first phase of a national program for universal primary education; $50 million to provide foreign exchange for the import of chemicals, raw materials, and spare parts for selected industries; and $50 million to finance lending by the Bangladesh Shilpa Bank to benefit small and medium-sized enterprises.

In general, according to Walter Kock, the senior agriculturalist in Dhaka, the World Bank funds "hardware" projects and leaves technical assistance efforts to A.I.D. and others, but this distinction is by no means hard and fast. Many World Bank projects finance supporting services to accompany the

hardware, and bilateral donors have had a number of bricks-and-mortar projects.

In the past 15 years, projects related to agriculture and rural development, including agricultural research, have formed the largest part of the World Bank portfolio—nearly 25 percent. The first agricultural research project in 1978 ($6 million) was used to plan and coordinate a national program; to develop several research stations; and to fund contract research on cropping systems, soil and water management, agricultural engineering, and crop protection. This initial effort was followed by a second, expanded project in 1984. Today, the World Bank has become particularly interested in farming systems, as opposed to single-crop research, and has funded seven of the 10 farming systems research sites in Bangladesh.

The Asian Development Bank (ADB) helps more than 20 nations, and Bangladesh is one of the largest recipients of both loans and technical assistance. Projects have included community schools, power systems, fertilizer factories, irrigation systems, and feeder roads. A number of the ADB projects have been co-financed by other agencies such as the United Nations Development Programme (UNDP) and the European Economic Community (EEC).

Japan now ranks first (followed by the United States) in total bilateral assistance to Bangladesh. Aside from the general commitment to food and

Bilateral Donors in Agricultural Research

Agency for Agricultural Research and Development (Indonesia) Australian Development Assistance Bureau
Canadian International Development Agency
Danish International Development Agency
Federal Republic of Germany
Indian Council of Agricultural Research
Japanese International Cooperation Agency
Ministry of Overseas Development (United Kingdom)
Government of the Netherlands
Pakistan Agricultural Research Council
Swedish International Development Agency
Swiss Development Cooperation
United States Agency for International Development (A.I.D.)
United States Department of Agriculture

commodity assistance, Japanese aid has been flexible. There have been some agriculture-related projects, such as fertilizer imports and tubewell equipment, and some support for agricultural research and extension. Fisheries research, for example, has been an important Japanese concern.

Although West Germany has stressed primarily infrastructure projects, it also has been active in agriculture, particularly in livestock breeding. This began in 1972 with attempts to improve herds in Bangladesh through better breeding stock and managerial practices. West Germany has assisted most of the development of artificial insemination in the country. Improving the capacity for seed production through seed processing centers and field multiplication techniques has also been a German priority.

The Canadian International Development Agency (CIDA) has been heavily oriented toward infrastructure and food assistance, the latter category accounting for about half of the Canadian aid. But recent years have seen more emphasis on agriculture—development of new wheat and rice varieties, small-scale water control projects, foodgrain storage, and fertilizer imports.

The United Kingdom has provided aid in this part of the world longer than the other agencies, since its roots go back to undivided India. Today, it joins other donors in supporting agriculture—deepwater rice, tea estates, cereal grains, fish culture, sugar mills, and cotton spinning plants. British designs for country boats and bullock carts are also improving rural transportation.

Jeep, driver, and friend. Vehicles like this one have become a symbol of the international donor community presence in Bangladesh.

Scandinavian countries are also active in Bangladesh. Sweden has been involved in both oilseed research and nuclear agriculture; Denmark has focused on training. OPEC nations, led by Saudi Arabia, have supported both commodity and project needs. Commitments from Eastern bloc nations have mostly been in the form of loans, extended on terms not quite so favorable as the Western loans. Most Eastern bloc assistance has been capital transfers in the form of commodity loans, export credits, and infrastructure development; the Soviet Union is the most important Eastern bloc donor, followed by Yugoslavia and Hungary.

Supplementing the efforts of governmental donor agencies is an army of private voluntary organizations. No one knows the total number of relief, missionary, and development groups that dot the Bangladesh countryside, but it must be in the hundreds. These organizations are involved in family planning, disease control, community development, and many other activities, including agriculture.

With the vast array of donors, programs, and funding schemes found in Bangladesh, coordination is essential. Surprisingly, Bangladesh fares better than many countries in this respect; there is a high degree of coordination

among the donors of Dhaka. A local consultative group composed of the major donors meets once a month to compare notes. At the instigation of the World Bank and A.I.D., a number of important private voluntary organizations have also been invited to join this group. The intent is to keep everyone "on the same page" as far as aid activities are concerned and to avoid duplication as much as possible. These efforts have been successful, partly because the major donors tend to have different interests.

This same diversity of donor interests, however, prevents the total cooperation advised by the aid experts. While donors share information and avoid competing with each other, most continue to fund projects at some level in most sectors; but usually do not share funding of projects, with each handling the discrete elements "they do best."

A.I.D.: The Track Record

A.I.D. mission headquarters in Bangladesh is located on the upper floors of a bank building in downtown Dhaka. It is across the street from the U.S. Embassy, but the street is in fact a broad square, crowded with speeding rickshaws, uncontrolled by traffic light or officer, and full of peril for pedestrians. As a precaution, mission personnel going from one building to the other are transported by buses that circle back and forth throughout the work day. This is not profligacy but prudence. The buses would otherwise sit idle, and a serious injury to a government worker would cost the taxpayer far more than the gasoline burned. In a way, the shuttling buses exemplify the A.I.D. approach in Bangladesh—adjusting to concrete realities, taking the long view, and pursuing attainable development objectives. It is a country of little direct foreign policy importance to the United States, and successes and failures there are not likely to be trumpeted on the evening broadcasts of the U.S. television networks. Thus, there is a degree of stability and continuity to the work of the A.I.D. mission in Dhaka that is lacking in many foreign capitals.

The United States has been providing assistance to Bangladesh for nearly 35 years, and in this period the aid policy has evolved from a series of ad hoc efforts to a well-articulated country strategy. This evolution has reflected partly the changing needs of Bangladesh and partly the differing views of various U.S. administrations—eight, from Eisenhower to Bush—as to the purposes of American aid.

In the Pakistani period, support totaled nearly $650 million spread over a variety of projects in agriculture, health, education, energy, industry, and transportation. There was also a substantial amount of commodity assistance. After Bangladesh obtained independence in the wake of war and

McPherson on A.I.D.

When the Reagan Administration took office in 1981, it inherited a foreign aid program based substantially on a resource transfer process described as meeting "basic human needs." Unfortunately, the burden of meeting these needs grew each year. Countries were not required to take full responsibility for their future, and the program was insufficient to help countries over the long term. . . .We decided to keep the best of the "basic human needs" approach where it involved genuine humanitarian needs. We then recast the remaining development assistance and additional economic support funds to achieve two objectives: to help less developed countries build institutions to promote economic growth over the long run and to help them change their policy and regulatory environment so that people would have the same opportunity Americans enjoyed.

—A.I.D. Administrator Peter McPherson (1981-87), writing in *The New York Times* business section, November 23, 1986, p. 2.

natural disaster, the focus was naturally on rehabilitation, famine relief, and infrastructure. Beginning in the 1970s, the orientation shifted from rehabilitation to development, with a project focused on agriculture, population, energy, and employment.

The Reagan administration increased U.S. emphasis on privatization as an objective of the aid process; that is, reducing the role of government as the engine of national economies and the principal provider of services. Although this philosophy has been implemented in different ways from country to country, it has impacted to some extent the aid posture in all countries receiving U.S. assistance, including Bangladesh.

A.I.D. field missions prepare annual "country development strategies" to guide planning and serve as a backdrop for budget submissions. Though the statements are not official policy documents, they represent the current thinking at the mission as to the program's rationale.

The 1987 development strategy asserted three mutually supporting program goals for the Bangladesh program: reducing human fertility, expanding rural employment, and increasing agricultural productivity. The mission puts forth four reasons for selecting these. First, they are important to Bangladesh development and the government of Bangladesh. Second, taken together, they represent a coherent whole. For example, reducing fertility and generating employment represent opposite sides of the surplus labor coin; most employment is on farms and most off-farm employment is related to agriculture.

Elements of a Country Strategy

Family Planning Service Delivery
Family Planning Demand Generation
Agricultural Technology
Forestry
Agricultural Human Resources
Agricultural Inputs
Agricultural Policies
Rural Finance
Rural Electrification
Rural Roads
Food-for-Work
Rural Institutions
Industrial Policy Reform
Selected Industry Development

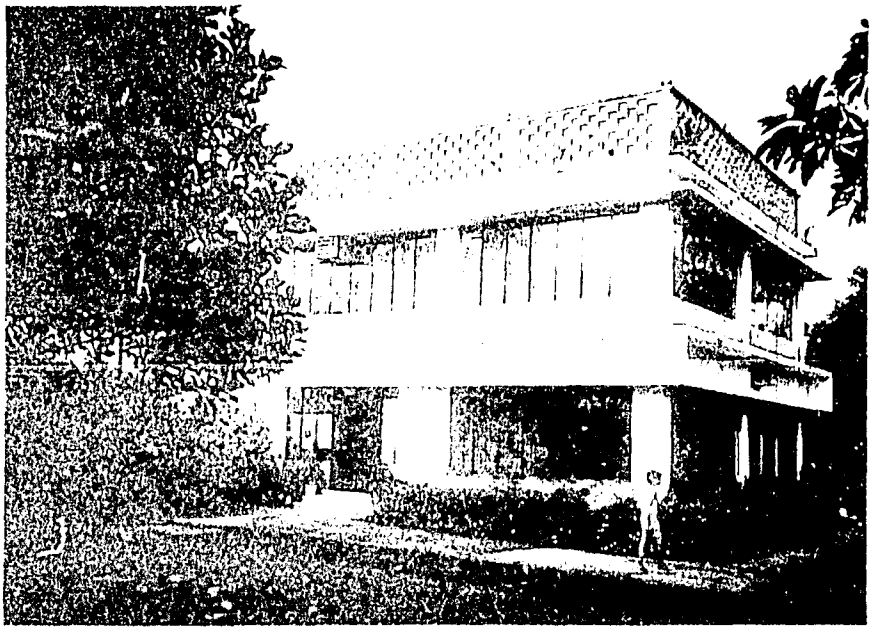
Third, the goals are within A.I.D.'s technical and financial capabilities. Finally, other donors are addressing other development sectors adequately. For example, some 20 donors are already involved in the conventional energy field.

A.I.D. programs in Bangladesh have been fairly evenly split between development assistance funds and Public Law 480 (Food for Peace) commodities. Development assistance funds in recent years have been mainly grants, and the mission supports a continuation of this practice.

As the grace periods on loans made in the immediate post-independence period lapse, debt servicing is emerging as a problem in Bangladesh's public finance picture. In addition, grant funding is thought to give A.I.D. greater leverage with the government of Bangladesh in negotiating policy reform, and such reform has been a key objective of recent U.S. initiatives.

Public Law 480 (PL 480) assistance involves U.S. agricultural products, distributed under three separate programs, usually referred to as Title I, Title II, and Title III. The assistance began in 1971 and has continued to the present, but the program orientation has shifted.

The first phase, a Title I agreement, emphasized the provision of wheat as a relief measure. The second phase, coinciding with the advent of Title II in the mid-1970s, stressed food for work; assistance to the unemployed was used to build public earthworks of various kinds. The present third phase continues food-for-work, but the overall emphasis of PL 480 programming is toward agricultural development and public policy revision.



The American Club in Gulshan, outside Dhaka. A.I.D. has provided assistance both to East Pakistan and to Bangladesh.

The Title II food-for-work program in Bangladesh includes grant assistance to the Cooperative for American Relief Everywhere (CARE), which is the implementing and monitoring agent for the mission. A.I.D. underwrites the cost of the Title II commodities and ocean freight and half the cost for CARE personnel and equipment. The other half of CARE's operating costs are borne by the government of Bangladesh in the form of local currency support.

The projects resulting from food-for-work include the building and upgrading roads, digging canals, and constructing ponds for water storage or fish breeding. Thus, the food aid not only provides relief to needy people, but also employment and useful public works. More than 8,000 such projects have been initiated, and at least 1,000 are underway in any given year. Those who participate in the work program are paid in wheat, the payment being based on the amount of earth moved each day.

The Title III program in Bangladesh, designed to have an impact on national policy formulation, was one of the first such programs attempted by A.I.D. Evaluations of the program have judged it successful in terms of its impact on improving food policy planning, reducing subsidies in

foodgrain distribution, and facilitating more open and efficient marketing of foodgrains. The policy reforms are thought to have been a significant factor in recent increases in agricultural production.

The total amount of U.S. aid, both food aid and development assistance, extended to East Pakistan since 1953 and Bangladesh since 1971 is approaching $3 billion. The A.I.D. record in terms of people fed, facilities built, and policy reforms implemented is impressive.

The major thrust of the overall program is now directed at the agricultural sector—agriculture, rural development, and nutrition. Since the programs in family planning and employment help facilitate development in this sector, it is difficult to evaluate the agricultural program in general and the agricultural research program in particular without considering these programs.

The Population Context

Advertisements for condoms and birth control pills have not yet become common in the American mass media, but they are in Bangladesh. Billboards and television trumpet the virtues of contraceptive devices as if they were a popular soft drink. Family planning is perceived—at least at the policy level—as a necessity for the country, and the government has given the effort its wholehearted endorsement. International donors are also providing support.

Family planning was one of the first activities supported by A.I.D. after independence. The need to reverse or modify existing demographic trends was apparent. At donor urging, the government of Bangladesh developed a comprehensive national population plan and created a national population council headed by the president. The emphasis was placed on reducing population through education and motivation, but family planning assistance in the form of contraceptive devices and procedures was also provided.

At present, A.I.D. considers human fertility reduction its top priority in Bangladesh, recognizing that rapid population growth vitiates all other social and economic gains, given the finite resource base. This ordering of priorities is consistent with the Agency's overall Asian strategy. Of course, decreasing fertility also tends to free women from their traditional social roles and facilitates their participation in the mainstream economy, another important A.I.D. objective.

The mission in Dhaka adopted the specific objective of a contraceptive prevalence rate of 25 percent in 1986, 35 percent in 1990, and 65 percent in 2005, a scenario that would allow the population to stabilize at about 250 million by 2060. This is a larger population than the present U.S. population—in an area the size of Wisconsin.

The Social Marketing Project

Trends on the Indian subcontinent indicate that family planning in the future will be promoted by businesses using many of the advertising and marketing techniques that have been used to sell soap in the West. The biggest recent success story of family planning in Bangladesh is the contraceptive retail sales program, or Social Marketing Project (SMP), partly funded by A.I.D.

In this project, subsidized pills, condoms, and foaming tablets are sold for profit by private retailers. An oral rehydration solution (to combat the often-lethal effects of diarrhea) and an injectable contraceptive are also slated for addition to the SMP product line. With the new marketing approach, condom and pill sales nearly tripled. The SMP now accounts for two-thirds of the national condom distribution and has an even better market share in rural areas.

There are three major population program donors in Bangladesh: A.I.D., the World Bank, and the United Nations Fund for Population Activities (UNFPA), and coordination among them is good. The World Bank has constructed and equipped family welfare centers across the country, and it pays field staff salaries of the government family planning program. UNFPA supports the government's contraceptive commodity logistics program (warehouses, construction, trucks), supplies technical assistance, and provides some commodities, such as medical supplies and injectable contraceptives. In addition to these major donors, the Asian Development Bank, West Germany, and Canada are also contributors, particularly in augmenting the supply of birth control pills.

A.I.D. promotes family planning service delivery both to meet current demand (estimated at 35 percent of eligible couples) and to stimulate further demand for contraceptives. In addition to contraceptive retail sales, family planning services are delivered both through the Bangladesh government program and through the service delivery programs of non-governmental organizations (NGOs). For example, A.I.D.-funded clinical services are provided primarily by the Bangladesh Association for Voluntary Sterilization.

The government program has been hampered by its difficulty in motivating field workers to deliver non-clinical services in rural areas. As a result, the number of pills and condoms the government distributed, between 1981 and 1983 actually fell from 12 percent to 8 percent of the eligible population. Voluntary sterilizations and intra-uterine device (IUD) insertions showed respectable growth during this period.

A.I.D. finances a significant portion of the cost of the government program, primarily in the forms of imported contraceptive commodities,

More Children Wanted

Despite the emphasis given to family planning by the government of Bangladesh and international donors, women in the country still want more children. The final report of a Bangladesh contraceptive prevalence survey, done by Mitra and Associates and released in 1985, noted that: "The government has declared population growth a problem of great importance. High priority has been assigned to the population control program." Still, the report concluded: "High fertility persists in Bangladesh. Bangladeshi women marry young and produce many children. By the time women have completed their families, they have on average given birth to about seven children."

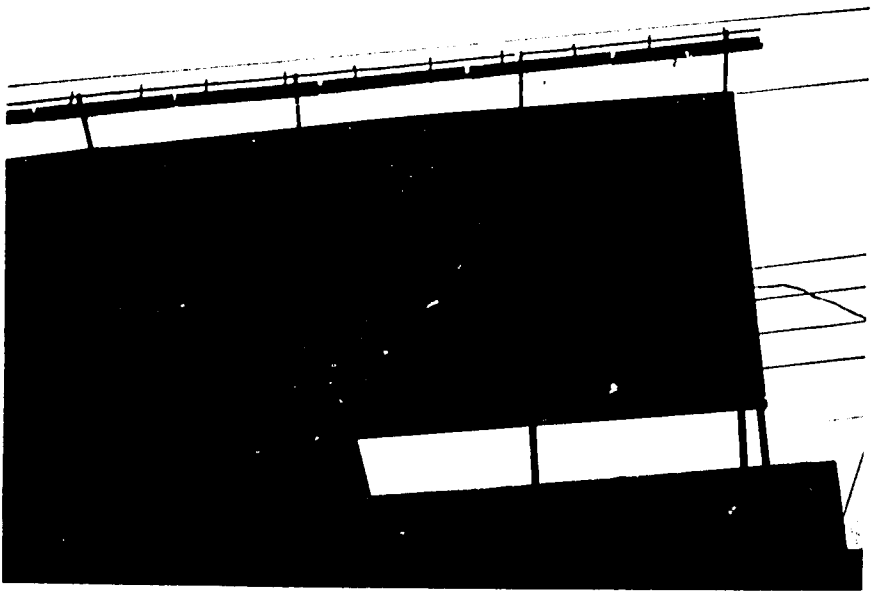
Although knowledge of birth control methods was nearly universal in the country, use of the methods was not general: only one-third of the women used any method at all, traditional or modern. Why was birth control not practiced more often? The reason most commonly given (33 percent) was the most obvious one: The women wanted more children.

reimbursement for the costs of voluntary sterilizations and IUD insertions, and training and institutional support to the government delivery system. A.I.D. insisted that the government of Bangladesh assume an increasing portion of the recurrent costs of the family planning program, starting with voluntary sterilization reimbursements in 1984.

NGO community-based services and voluntary sterilization clinical programs are a second channel for A.I.D. support. More cost-effective than the government program and utilizing better-motivated field workers, NGO programs provide hundreds of thousands of "couple years" of protection. The relative success of these programs, compared to government efforts, is attributable to a more effective chain of command, better staff training, a comprehensive offering of client methods, and systematic client follow-up and resupply.

Given the better performance, A.I.D. expects to continue giving high priority to the NGO programs, particularly since the government recently removed restrictions that prevented the NGOs from operating in rural areas. Since the mission lacks the capacity to monitor large numbers of NGO grants, and since few of the NGOs are administratively suitable for direct funding, U.S.-based or international intermediaries are used to oversee most NGO grants.

While the supply side of the family planning equation is fairly simple, at least conceptually, influencing demand is more problematic. Meeting the estimated existing demand for family planning will only reduce the popula-



A billboard in Dhaka. The marketing of contraceptives is a major feature of family planning programs.

tion growth rate to about 1.8 percent; it must be reduced much further by increasing demand for contraception and then meeting the greater demand.

The new mass media campaign (the Social Marketing Project), which is not product-specific and is directed at reducing resistance to family planning, is a first step in stimulating demand. Another step is the government's decision to introduce incentives for communities with high contraceptive prevalence rates; A.I.D. is financing a portion of this program.

A.I.D. also funded a pilot program providing secondary school scholarships to young women on the assumption that scholarships will keep girls in school longer and ultimately reduce fertility. Since recent demographic studies have shown relationships between education and deferred marriages to female fertility in Asian countries, this may be an area for further funding by A.I.D. or other donors.

Finally, as employment opportunities for women increase outside the homestead, desired family size will probably decrease. A.I.D. attempts to affect this area through its rural industries program. Thus the interlocking nature of agriculture, population, and employment are demonstrated.

Spirit of Enterprise

The courtyard of a mosque in Dhaka is being lowered a foot or so and resurfaced. In a developed nation, the scraping away of the old surface would be done by a bulldozer and would take about an hour. In Bangladesh, the job takes days as the concrete is broken up by workmen with picks, and the rubble is hauled away in baskets they carry on their heads. No one is disturbed by the time consumed; in this labor-intensive country, more hours than jobs are available. And as agriculture becomes more productive, requiring fewer people, and population continues to grow, the pressure of people on jobs will increase.

Given the magnitude of the unemployment and underemployment problem in Bangladesh (usually running at about 30 percent), the A.I.D. country development strategy cannot ignore the need to create jobs. In fact, given the increasing flow of new entrants into the labor force, job creation will probably be the central economic problem the government of Bangladesh will face in the next century. A.I.D. has attacked this problem essentially through enterprise creation.

Practically all the donors in Dhaka are involved in generating employment because practically all aid projects create some jobs, but specific attention to job creation has also become a major donor concern. Development of industries tends to be the single largest sector of donor assistance. The largest donor investment in any one industry is in a capital-intensive industry—fertilizer manufacturing—although the greatest number of projects is in textiles. Other labor-intensive industries, such as jute processing and manufacturing, receive development loans.

Most donors get into the employment act in one way or another. Sweden and UNDP promote small and cottage industries through a parastatal (at least partly controlled or owned by the government) institution; the World Bank funds a major analytical technical assistance effort directed at rationalizing public policies affecting trade and industries. As noted, the Food-for-Work program—supported by the U.K., Canada, and Australia as well as the United States—provides employment for millions of laborers annually.

In addition to expanding job opportunities for women, the A.I.D. employment strategy seeks to increase on-farm employment through improved technologies and more intensive land-use and to promote off-farm employment through expansion of industries and public works. To achieve these objectives, the Agency urges governments to change policies that frustrate the spirit of enterprise and helps build a physical infrastructure in which the private sector can flourish and develop specific enterprises. Enterprise policy reform was initiated as a project in 1985. It was designed to provide both A.I.D. and the government of Bangladesh with a

Rural Enterprise and Rural Women

One of A.I.D.'s smaller projects, Women's Entrepreneurship Development, is, according to some testimony, badly needed. Gloria L. Scott and Marilyn Carr, writing in *The Impact of Technology Choice on Rural Women in Bangladesh* (World Bank, 1985) conclude that the new spirit of enterprise often bypasses rural women.

"In Bangladesh, as in many other countries, the process of modernization has had an adverse impact on the employment opportunities of rural women, especially those from the poorest sections of society. In particular, the spread of mechanization in the crop and food processing subsector is displacing off-farm employment opportunities that provide much needed income to landless women and their families. Although newer crop processing businesses have replaced the old, they employ fewer people, labor productivity and thus wages are higher, but the beneficiaries are inevitably men. Experiments are being made to involve women in alternative productive ventures based on new techniques, but they are a handful of scattered projects. As yet, there are no new women's industries to provide alternative employment opportunities on the scale required."

better understanding of policy and institutional constraints that may hinder the development of labor-intensive, small and medium-size off-farm enterprises. The project is the initial phase of a long-term A.I.D. commitment to removing the constraints to enterprise development in Bangladesh.

In fiscal year 1987, A.I.D. financed an economic census by the Bangladesh Bureau of Statistics in cooperation with the U.S. Bureau of the Census. When completed, the census will generate benchmark data that can be used for further surveys of labor-intensive enterprises. In addition, technical assistance is being provided to the Bangladesh Planning Commission and the Ministry of Labor and Manpower to conduct studies and recommend policies that will encourage the expansion of small, labor-intensive enterprises.

A.I.D. initiatives in rural infrastructure include road construction and maintenance and rural electrification. The development and upkeep of all-weather roads, complete with bridges and culverts, will link formerly isolated areas with vital markets and facilitate the growth of job-creating economic opportunities.

The rural electrification program also promotes new productive enterprises. Evaluations of the first and second phases of the A.I.D. rural electrification project demonstrate a significant increase in economic

activity and productive employment when rural areas get electricity. Fully 70 percent of the power distributed in the second project phase is consumed by rural industries and commercial businesses. The third phase of rural electrification is extending the program to provide greater access to electricity where rural electric cooperatives have already been established. Increasing the number of connections for household, agricultural, and commercial use will strengthen the financial viability and long-term impact of these cooperatives. Technical assistance under the project focuses on improving the financial viability of the rural electric cooperatives by reducing price subsidies, increasing the density of service, and improving management.

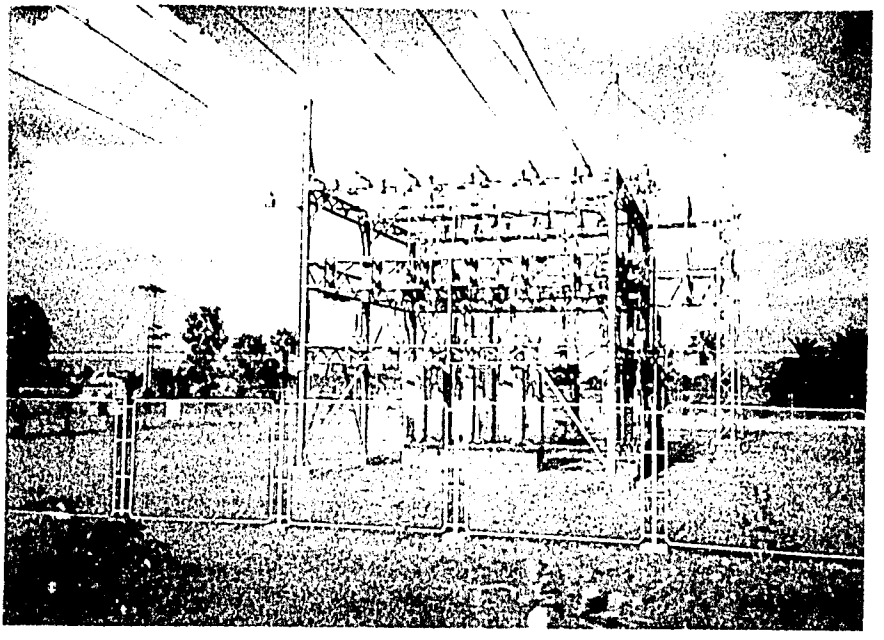
Much of the future industrial growth in Bangladesh will take place in towns that were classified in the 1981 census as urban areas but have direct links to the countryside. The government has targeted 1,400 "growth poles" for industry development, and A.I.D. is providing assistance to specific enterprises.

The present enterprise development initiative significantly expands the pilot activities of Micro-Industries Development Assistance Society (MIDAS), an indigenous non-governmental organization begun under an earlier rural industries project. MIDAS gives technical and managerial assistance and product promotional information to small-scale enterprises.

The A.I.D. mission believes that prospects for small enterprise development have greatly improved as the government of Bangladesh has moved toward private sector production and free markets. MIDAS has played a role in this and has clearly demonstrated its effectiveness as a business consulting and credit institution. An expansion of the project will enable it to assist more enterprises, many with links backward to agriculture or forward to export markets.

One final A.I.D. effort in the area of rural enterprise illustrates the overlap of the agriculture and employment sectors. The fertilizer distribution improvement project began in 1976. Today they continue the process of increasing fertilizer use through improvements in the marketing system, providing adequate fertilizer supplies, and increasing national storage capacity.

A.I.D. has successfully negotiated the removal of government constraints on the operations of private-sector fertilizer retailers, the elimination of officially administered retail prices, and the closing of a large number of government fertilizer sales centers. The current project focuses on encouraging the entry of private sector wholesalers into large-scale fertilizer distribution and marketing, elimination of fertilizer subsidies, the development and training of fertilizer dealers, and sales promotion activities. A.I.D. supports the new distribution system by providing credit for private distribu-



A rural power station. A.I.D. has strongly supported rural electrification efforts.

tors, technical assistance in distribution and marketing, and funding for minor infrastructure improvements to improve access to ports, factories, and warehouses.

Boost for Agriculture

Providing a boost to agriculture is the A.I.D. country development strategy's third objective. Its importance is undeniable, given the fact that agriculture accounts for nearly half the country's gross domestic product and employs fully three-fourths of the labor force. Agriculture is—and will continue for some time to be—the dominant sector of Bangladesh's economy, generating the income and producing many of the raw materials necessary to fuel the growth of new industries.

Almost all the major bilateral and international donors support projects in agriculture. The World Bank, for example, is working to privatize the irrigation equipment business and improve the effectiveness of the agricultural extension service. About a dozen donors have financed fertilizer imports, and at least nine support agricultural research.

ACRE through Palli Bidiut Samity

In 1976, the government of Bangladesh decided to extend the public supply of electricity to rural areas—only 3 percent of the rural population had access to it at the time—to improve the quality of life and stimulate economic growth. Following that decision, a comprehensive rural electrification master plan, funded by A.I.D., was developed by the U.S.-based National Rural Electric Cooperative Association (NRECA). The plan looks toward electrification of all rural areas by the year 2000.

The master plan relies on the concept of "area coverage rural electrification" (ACRE)—the design of a backbone system that can accommodate rapid increases in consumer connections. The ACRE concept involves the development of autonomous member-owned rural electric cooperatives (called PBS—Palli Bidiut Samity), each of which covers 400–500 square miles. On average, the system operated by a PBS will contain 10 MVA substation capacity and 500 miles of distribution lines (backbone and feeder), providing electricity to up to 17,000 customers. The formation of PBSs is progressing smoothly.

The government of Bangladesh fully recognizes the importance of support to agriculture; the top development goal of the government is to ensure self-sufficiency in foodgrain production. A.I.D.'s goal is broader; the mission's program addresses agricultural productivity more generally in the belief that achieving increased national production of cereal grain per capita will by itself improve rural life.

Thus, A.I.D.'s specific objectives are twofold: first, to increase productivity per unit of land by the adoption of technologies spread through market forces; and second, to reduce the reliance on rice and jute through crop diversification. Achieving the latter should make it possible to improve nutrition, increase fuelwood supplies, expand exports, and increase rural incomes, especially for women.

Some of the means being used by A.I.D. to achieve these objectives are the same as those applied to the employment/enterprise area. For example, improving rural infrastructure—district *(zilla)* roads and electricity—benefits agriculture as well as rural industry.

Likewise, in the public policy area, A.I.D. has pressed for greater reliance on market forces in the agricultural system. For example, there has been continuing policy dialogue with the government in regard to managing public foodstocks and influencing prices in the best interests of producers and consumers.

In a high-risk environment, one that includes widely fluctuating farm prices, farmers are reluctant to shift from traditional technology to a higher-

A field of rice. As in much of Asia, the Bangladesh diet depends on cereal grains.

cost, higher-yield technology. A.I.D. has used its PL 480 resources (Title III) to achieve price stability through both an open market sales program (to level off peak prices) and a public procurement program (to support the price floor). The Title III agreement also requires that the government of Bangladesh announce public procurement prices before planting begins so that farmers will know the minimum price they can expect for their grain crops before they buy agricultural inputs.

Improving farmers' access to inputs such as fertilizer and irrigation is another important A.I.D. technique. For example, privatization of the fertilizer marketing system, which is proceeding apace, should lower distribution costs and increase the likelihood that fertilizer supplies will follow demand throughout the country. A.I.D. also promotes the use of micronutrient fertilizers and sponsors research in improving fertilizer efficiency through more effective placement of urea.

Expansion of irrigated acreage is likely to be the factor most responsible for agricultural productivity gains in the near term. Irrigation will permit cropping intensification on lands now left fallow in the winter and will increase yields on lands currently cropped. Progress has been made in recent years in private-sector manufacture, sales, and servicing of low-lift and shallow tubewell pumps. One of the ways A.I.D. has assisted the

government of Bangladesh in promoting the spread of irrigation is through the reprogramming of local currency *(taka)* generated through sales of PL 480 Title III agricultural commodities.

Perhaps the greatest inadequacy is the availability of institutional credit. Farmers have demonstrated a demand for bank credit at interest rates of 24 percent to 36 percent (considerably below those charged by village money lenders). However, the banking system has not yet mobilized sufficient rural savings or developed the capability to meet this demand.

As a result of policy changes effected by A.I.D.'s Rural Finance Project, the banks have taken a major step toward financial viability by boosting agricultural lending rates closer to market levels. However, considerable work remains in refining rate structures, mobilizing savings, and simplifying lending procedures before Bangladesh has a banking system able to respond fully to the needs of small farmers.

A decade after the experiment began in a single sleepy village in the Chittigong district, the rural Grameen Bank has established itself as a specialized financial institution capable of helping the rural landless or poor who are willing to help themselves. Although not formally launched until 1983, the Grameen Bank has flourished by catering precisely to the people most banks avoid: those with no money or land.

By making loans against group guarantee rather than collateral, by making them to people with less than 0.4 of a hectare of land, and by giving preference to women, the Grameen Bank has revolutionized banking in developing countries. Malaysia has recently introduced its own form of "Grameen banking" with technical assistance from Bangladesh, and delegations of development professionals from China, India, Nepal, Indonesia, Tonga, and Kenya have visited Bangladesh to study the bank's operations.

The capstone of A.I.D.'s effort to improve agricultural productivity in Bangladesh is the agricultural research program. A.I.D. takes the position that, despite the constraints imposed by limited land and a growing population, Bangladesh agriculture can supply both the domestic market and some export markets with food and fiber. This can be done, only through a science-based agriculture where the science is brought to the field level through a rational research and extension system.

From A.I.D.'s perspective, there are three keys to achieving a science-based agricultural system. First, there must be solid research institutions. A.I.D. supports the development of a decentralized system featuring research at regional stations and in the farmers' fields. Establishing such a system requires a long-term commitment on the part of A.I.D. and other donors.

Second, improved technologies must be applied in the field to increase yield on acreage already planted and to bring additional acreage under cultivation through irrigation. The "green revolution," with its high-yield

In Praise of Farmers

"The landscape of Bangladesh is an intricate design of small fields. The green and gold of rice dominates. With it are the distinctive colours and shapes of wheat, jute, sugar, maize, and dozens of other crops. Unlike most agricultural areas of the world, the land and farmers of Bangladesh are seldom idle, for our farming is a year-round activity. Our survival as a nation demands this attention.

"It is the small farmers who fill in the details of this design, who decide which crop is to be planted when and where. We depend on these farmers to make the right decisions that will convert our bountiful resources of sun, soil, water, and weather into the food, fibre, livestock, fishes, and forests we need to sustain national life and development."

—Dr. K. M. Badrudozza, former Executive Vice-Chairman. BARC, 1983.

crop varieties, has reached Bangladesh. Although this revolution may not show the dramatic gains experienced in India and Indonesia, it can increase Bangladeshi agricultural productivity.

Third, although attention must be paid to major grain crops—these are the areas where the high-yield varieties have been most prominent—emphasis on crop diversification must be increased. This means the development of new varieties of pulses, fruits, and vegetables, and new farming systems involving livestock, forestry, and fisheries.

Agricultural research, of course, is one area in which the United States would be presumed to have a comparative advantage vis-a-vis other donors. The results produced by the vast American system of land-grant universities and agricultural experiment stations have long been a model for other countries. The challenge for the A.I.D. mission in Dhaka is how best to bring all this to bear on Bangladesh.

Accomplishing Agricultural Research

The A.I.D. mission in Bangladesh is smaller than the missions in Egypt and Pakistan, but it is larger than many others. About 30 Americans work there in a direct-hire capacity; six or seven others are usually there on individual personal services contracts at any given time. In addition, 55-60 Bangladeshi nationals are directly employed by the mission, both as professionals and non-professionals (secretaries, drivers, etc.).

Others, including 55 to 60 Americans, work for A.I.D. indirectly; they are employees of the Agency's major contractors in the country or of non-

Malthus Revisited

"We normally think of the problem here in Bangladesh as involving two Malthusian races. One race is between population and food, and that was the original basis for our programs—trying to get the population growth rate down and trying to get productivity up.

"The other Malthusian race is between workers and jobs. The labor force has been growing at about 3 percent a year. With more and more women entering the work force, this will probably accelerate to 3.5 percent by the end of the decade. Unless productive employment grows at least as rapidly, there will be downward pressure on real wages."

—John R. Westley, former Director of the A.I.D. Mission, Dhaka.

governmental organizations that receive grants to carry out A.I.D. programs. For example, CARE implements the Food-for-Work program and the U.S.-based National Rural Electric Cooperative Association has done rural electrification work. In fact, most A.I.D. field work in Bangladesh, as in other countries, is done by outside organizations, while the mission staff has a supervisory and monitoring role. The staff, says former Director John R. Westley, who had stints in Washington and New Delhi before coming to Dhaka, is large enough to carry out these functions.

The key staff people involved with the agricultural research program in 1987 were Hans Patrick Peterson, director of the office of food and agriculture; Alan Hurdus, deputy director; and Kevin Rushing, agricultural development officer. All are relatively young, career foreign service officers with different styles of dress and address. Peterson is professorial and prefers Bangladeshi-style tropical suits; Hurdus appears studious and wears traditional American ties; Rushing is informal and given to wearing jeans and cowboy boots in the field. All are trained professionals now working mostly in an administrative capacity.

In addition to the three Americans, two Bangladeshi nationals were playing important roles, especially in monitoring the field work, Latiefur Rahman and Habibur Rahman (no relation—Rahman is probably the most common Bangladesh surname), who are products of the local agricultural university system.

Others were doing related work (such as David Shroder, primarily concerned with the fertilizer program), but the five men listed above have primary responsibility for agricultural research. They design the programs, produce the documentation to get programs funded, deal with their counterparts in the government of Bangladesh, monitor work in the field,

Habibur Rahman of A.I.D. (center, facing) with scientists at the Bangladesh Rice Research Institute. Agricultural research has been an important part of the total U.S. aid program.

oversee the work of contractors, provide technical assistance to their host country counterparts in some cases, and generally translate the American taxpayer's money into foreign aid results.

A.I.D. support of agricultural research began in 1976. The $8 million project financed construction of basic physical facilities at the main agricultural research station at Joydepur and a regional station in Isurdi. Adaptive and applied research in wheat, food legumes, oilseeds, and vegetables was conducted at these sites. The project also involved a staff development program using both the host country and expatriate scientists. Loans financed the necessary laboratory equipment, farm development, the farm building complex, residential units, and site development. Grants went for technical assistance, training, and support for in-country research.

In 1980, an evaluation team reviewed A.I.D. and World Bank projects in Bangladesh. The team found that although there had been problems with the original agricultural research project, it was successful overall, and it recommended a second phase for the project (ARP-II). The contract was awarded to International Agricultural Development Service (IADS), later absorbed into Winrock International, the current prime program contractor.

An Ideal Place for Some

"The tranquility and simple life in Dhaka make it an ideal place for young and growing families. The A.I.D. homes are spacious and often have large yards with plenty of space for children to play safely. Since most English-speakers live in the Gulshan and Banani residential areas, children always have playmates nearby.

"There are several good nursery schools. The American International School, which offers kindergarten through eighth grade, has just moved to a new, modern, and well-equipped facility, complete with computer training for children and adults and a top-notch school library with a good adult fiction section. The academic rating of the school is excellent, and extracurricular activities abound.

"Since classes are not offered for high school students, however, children of these grades must be sent to boarding schools in India or elsewhere. This has made it difficult for the Mission in Bangladesh to attract senior officers with high school-age children."

—"Mission of the Month: A.I.D. in Bangladesh," *Front Lines*, Nov. 1982, pp. 9-11.

ARP-II began operations in 1981 and was extended for a second 5-year term to assure that the A.I.D. commitment to institutionalizing Bangladesh's national agricultural capability would receive the sustained support needed. The extension allowed the mission to move agricultural research beyond crop production and irrigation to the broader plateau of farming systems research, linking field trials more closely to the national extension system. In addition, curricula at the agricultural university and training institutes are being updated to incorporate farming systems research as a methodology.

Under ARP-II, A.I.D.'s grant to the Bangladesh Government is administered through a host-country contract between the Bangladesh Agricultural Research Council (BARC) and Winrock. BARC coordinates all agricultural research in Bangladesh, much of which is conducted by the Bangladesh Agricultural Research Institute (BARI). Winrock's staff of up to 23 persons from seven countries includes specialists who each work with a counterpart Bangladeshi administrator or team of scientists at BARC or at BARI, and are considered part of their staffs.

The project is designed not only to strengthen BARC and BARI but also the other institutes in the national research system. This objective is to be achieved through core research programs within the farming systems framework. ARP-II provides support to improve research planning and

management facilities and services, as well as to enhance growth of research programs concerned with crop improvement, soil and water management, pest control, and farming systems. The support includes technical assistance, research equipment and commodities, training, and funds for high-priority research.

There are other related A.I.D.-funded research efforts in Bangladesh; for example, the Agency finances a vertebrate pest project at BARI; it joins with other donors in supporting the work of the Bangladesh Rice Research Institute; and it has recently funded a special agro-forestry project. But ARP-II is unquestionably the core of the agricultural research effort.

Succeeding chapters look closely at the results of the research program in three areas: (1) the institutionalization of research, including the organizations involved and the methodology employed; (2) the results of the research on specific crops and non-crop agricultural products; (3) the progress made through research and field trials using various agricultural inputs.

4

An Established Search: Institutionalizing Science and Technology

Toward Intellectual Leadership

In the period before independence from Pakistan, Texas A&M University, under a contract with A.I.D., provided approximately 70 person-years of professional agricultural advice and graduate-level training in the United States to some 40 Bangladeshis. Those trained abroad returned home to provide a strong core of research expertise to the agricultural establishment. Today, institutions such as Kansas State and Mississippi State also show up on the resumes of research institute personnel—but the American perspective in agricultural research is still very strong.

This perspective is heavily oriented toward science and technology as the engines of agricultural productivity, reflecting the American agricultural experience. In the United States, the land-grant colleges, with their degree programs and experiment stations, provided a vast outpouring of scientific information on everything from crop yields to farm management practices, and a well-trained army of extension agents carried this information to farmers' fields. A.I.D. is helping to bring this approach to Bangladesh—not all the specifics of the American system but the scientific spirit and methodology—and hopes to achieve that by institutionalizing science and technology in the Bangladeshi system.

"Institutionalizing" means creating an agricultural research system that will function over the long term to produce trained researchers, high-quality research products, and research findings that are transmitted to

Rahman on Research

Dr. M. M. Rahman, the executive vice-chairman (and thus chief executive officer) of BARC, is a spare-built but forcefully spoken man. He is quite dapper and appears younger than would be expected, given his position. His office wall is adorned by a quotation in a large frame: "The research embryo which now exists in Bangladesh should be brought to full maturity at the earliest possible time so that a continuing flow of quality information is available for dissemination to Bangladesh farmers."

Rahman is candid about a number of points: (1) Government financial support for agricultural research was minimal until the introduction of the "miracle rice" strains in the 1970s showed what research could do. Since 1974, research funding has increased tenfold, a hundredfold in some areas. (2) Aid from international donors has been a major factor in allowing BARC to perform its function of coordinating research.

farmers and tested in the field. Such a system must be supplied by a strong educational system and motivated by enthusiastic intellectual leadership.

In the Pakistani period, there was a structure of research institutes and much quality research was done, but the system itself was a body without a head. Filling this gap has become the responsibility of BARC.

The headquarters of BARC is in a new (opened 1981) three-story building in Farmgate, Dhaka. It accommodates all the headquarters personnel and has a 250-seat auditorium, a large conference room, and a library. BARC was established in 1973 and serves as the apex in the national agricultural research system. The term is apt because the system is not an integrated bureaucracy but a network of quasi-independent institutions.

BARC is under the supervision of the Ministry of Agriculture, so must compete with other agricultural concerns for government attention. Policies to guide BARC are set by a governing council. This council is chaired by the Minister of Agriculture and includes other agriculture ministry personnel, top officials of other government ministries (Finance, Power), directors of key research institutes, and representatives of the scientific community and the public.

The implementation of directives from the BARC governing council is the responsibility of the executive vice-chairman and the member-directors for specific areas, such as agricultural economics, livestock, fisheries, and so on. In effect, these officials represent the "BARC point of view." The executive vice-chairman is regarded as the head of BARC and, as such, holds the most important position in the research system hierarchy. The member-directors tend to be lobbyists for their particular disciplines within the system. Various committees (executive, technical, finance) facilitate the work.

The functions of BARC are, essentially, to advise the government on agricultural research policy, to interface with international agricultural research groups, and to coordinate the work of the individual research institutes. BARC itself is not a research organization but a planning and management agency. Donor organizations regarded such a body as necessary if the research program were to be put on a sound footing and so pressed the government of Bangladesh to create it.

In practice, BARC has had some difficulty establishing itself as pre-eminent in all its functions. To strengthen its hand, A.I.D. has channeled most of its ag-research funds to BARC and has provided the organization with a well-staffed contractor, Winrock International, to serve as an operating arm.

A.I.D. also worked behind the scenes to ensure that BARC had capable leadership when the able K. M. Badruddoza left to accept a post abroad. The executive vice-chairman spot was vacant for nearly a year before M. M. Rahman was appointed in 1986. He is convinced that the organization had trouble in the past because it became mired in the internal details of the research program. It tended to pore over budgets and staff plans rather than looking broadly at research goals and results. Rahman has vigorously set about the task of restoring BARC to intellectual leadership.

One of the principal ways in which BARC advises the government is through a national agricultural research plan. The plan tends to be something of a research project "wish list," but it does guide the Ministry of

Agriculture on budgeting decisions. The current 5-year plan is keyed to the goals in the overall government 5-year plan—food self-sufficiency, nutritional improvement, export expansion, farming efficiency, improved marketing, conservation, rural development, and employment.

Bangladesh has been something of a laboratory for international research organizations, such as the centers funded through the Consultative Group on International Agricultural Research (CGIAR), led by the World Bank. BARC maintains relations with a number of these organizations and with research councils of neighboring countries, such as India and Pakistan. BARC also advises the government on using foreign aid for agricultural research and on the representation of Bangladesh at international conferences and seminars.

Through its roles as government advisor and international spokesman, BARC has gradually emerged as the center of agricultural research in the country. It maintains the National Agricultural Library and Documentation Centre to collect, process, and disseminate information; and it issues a number of publications, including the *Bangladesh Journal of Agriculture;* it provides services to expatriate specialists and consultants through the International Project Support Unit; its Training Cell oversees degree-level and non-degree training overseas; and it maintains a herbarium and museum. BARC probably still lacks the prestige of the established agricultural research institutes, but it is rapidly making a name for itself.

The Research Institutes

The agricultural research institutions under the BARC umbrella "grew like Topsy" and are still changing. First, there are autonomous institutes that concern themselves with specific crops long important to the Bangladesh economy—rice, jute, and tea. One institute, the Bangladesh Agricultural Research Institute (BARI), covers a number of crops (some of them only recently important locally) and farming practices. These are the most prestigious research bodies.

Other institutes have only recently obtained autonomous status after being under various ministry directorates (nuclear agriculture) or are still in the process of doing so (forestry, fisheries, livestock). These are non-crop institutes whose specialties have only just been recognized as agricultural priorities. Acquiring status generally means that the word "Bangladesh" is added to the name of the institute and it takes its place with most other institutes under the Ministry of Agriculture. Some important institutes, however, are under other ministries (for example, sugarcane, under the

Winrock Interational

Looking for an expert in rangeland management? Perhaps an irrigation specialist? Need help in planning and managing an agricultural program? Chances are that someone among the 2,500 technical professionals listed in Winrock International's computer file can solve your problem. "We know where the qualified people are, and we can deliver quickly," says Steve Breth, a Winrock staffer in the organization's Washington, D.C. office.

The Winrock International Institute for Agricultural Development was created in 1984 from a merger of the Agricultural Development Council, the International Agricultural Development Service, and the Winrock International Livestock Research and Training Center. Headquartered in Morrilton, Arkansas, Winrock is now one of the largest sources of agricultural technical assistance in the world.

Ministry of Commerce and Industries). All institutes, whatever their history or ministry connection, are accorded equal status by BARC. The distinction between the older institutes and the "Johnny-come-latelys," apparent enough to the outside observer, is not officially recognized.

A substantial amount of agricultural research is also conducted at universities (such as Bangladesh Agricultural University) and training centers (such as the Bangladesh Academy of Rural Development). There are a few other independent groups, such as the Bangladesh Institute of Development Studies.

One of BARC's three major functions is to coordinate the research of all these institutions—coordination to include both review and approval of proposed projects and evaluation of on-going projects. The function of prior review is described this way by BARC itself: "BARC scrutinizes and approves research proposals of the research institutions and provides funds to support projects. Project proposals are evaluated against established criteria, while on-going research is assessed annually in terms of technical competence and agricultural relevance."

As for evaluation: "BARC also organizes evaluations of research work done by the research institutions (supplementing evaluations done by those institutions themselves) and arranges periodic reviews of the overall research programs of the institutions. Approved projects and sub-projects are monitored from start to completion to assess achievements and constraints and to develop remedial action as needed."

These are brave words. In practice BARC is only starting to get a handle on the research. In the beginning, BARC could not attract qualified staff, so could not really evaluate institute research proposals. With the

The Member-Director

Omar Ali is one of nine member-directors of BARC, and forestry is his special area. Although he has a grasp of the research needs of agriculture as a whole, he serves as an advocate for forestry interests, feeling that the previous emphasis on crop research has tended to neglect the potential that forestry has for the country.

Ali believes that BARC should not usurp the work of the individual institutes (including forestry) but should review the research programs proposed by the institutes to see if they meet national needs, help the institutes obtain funding for their programs, and coordinate programs to eliminate duplication. He also thinks BARC should be alert to identify any gaps that appear in the research programs proposed.

Although Ali is willing to discuss the overall BARC program, he is at his most enthusiastic when he talks about forestry and the great things that can be achieved in this area. A dedicated environmentalist, he supports the application of appropriate technology in all agricultural areas.

leadership of M. M. Rahman and the A.I.D./Winrock assistance, this situation has changed.

The style of coordination has also changed. When it was trying to establish itself, BARC acted much like a bureaucracy, issuing orders to the research institutes as if they were branch offices. Predictably, given the independent spirit that usually characterizes research scientists, the heavy-handed approach was unsuccessful and counterproductive. Rahman has applied a lighter touch, asking questions rather than issuing instructions, and cooperation in the network has improved.

Still, complete coordination in the sense of well-ordered priorities and no duplication of effort will probably not be achieved. The research institutions each have considerable autonomy of operation and different research mandates.

Also if all the institutes, universities, centers, regional stations, substations, crop stations, and farming systems sites are counted, the total number of places where research is occurring runs into the hundreds. This is a lot of work to coordinate, and BARC should probably not be too troubled if it does not achieve perfection. After all, science is often an untidy business even in the industrialized countries. Some redundancy of effort will likely always occur, and is not a "bad thing" if it results in earlier or more quickly validated research results.

Each of the primary research institutions carries out a wide range of applied and adaptive research activities. The basic research is augmented by

Dave Daugherty of Winrock International. The Bangladesh Agricultural Research Council has a technical assistance contract with Winrock, funded by A.I.D.

Tea Time in Bangladesh

Tea is treated as something of a luxury item in Bangladesh and has not received much government attention. Most of the tea is grown on 150 privately-owned estates in the northern part of Chittigong Division (Sylhet region) near the rain forests. The yield is the lowest in the world.

The Bangladesh Tea Research Institute, established in 1957, is the scientific arm of the Bangladesh Tea Board. The main research establishment is located at Srimangal. The research program is planned and applied largely in accordance with the needs of the tea industry. A major activity of the institute is the advisory service provided to the tea estates, which includes short courses as well as technical assistance visits. There is also a traditional program of agronomic research and an experimental tea factory.

Recently, a collaborative effort with U.K. consultants has been made to improve the quality of teas to an acceptable international level. "Tea-tasting sessions" are organized to highlight manufacturing defects and give guidance to planters.

educational support in the form of workshops and seminars for scientific personnel, in-service training for supporting staff, and field days and related efforts to communicate research recommendations to extension agents, farmers, and others who use the information. Many of these activities are multi-disciplinary and often inter-institutional in nature.

BARI is the largest of the research agencies. The central station at Joydepur—350 acres with an underground irrigation system—opened in 1979; about 250 scientists are at this site. In addition, four regional research stations—Ishurdi, Jamalpur, Jessore, and Hathazari—employ about 60 scientists in total. The stations vary from 75 acres at Jessore to 200 acres at Ishurdi and Jamalpur. Eighteen sub-stations located throughout the country house some 25 researchers directly responsible to their local regional station. The BARI system also includes the Bangladesh Agricultural Institute in Dhaka, which offers undergraduate and graduate instruction to 500 students annually, and the College of Agricultural Sciences at Salna for graduate students.

In addition to being the largest, BARI is also the most diversified of the research institutes. Since the basic food and commercial crops in Bangladesh (rice, tea, jute, and sugarcane) already have institutes, BARI conducts research on all the rest. These crops include oilseeds (mustard and rape), pulses, wheat, tobacco, cotton, citrus, maize, potatoes, vegetables, and other horticultural varieties. Multi-disciplinary studies have been organized for several crops, wheat, potatoes, citrus, and vegetables.

Each BARI regional research station focuses on the crops of its locality. For instance, researchers at Hathazari (near Chittigong) work with spices,

A laborer in a research institute field. Crops produced at the agricultural institutes are sometimes sold to defray operating costs.

condiments, sweet potatoes, potatoes, vegetables, oilseeds, and fruits; Jessore concentrates on wheat, maize, and vegetables. In addition, five special crop stations—for tobacco, cotton, coconut, mango, and citrus—have three to five researchers each.

BARI also carries out research on farming practices. Topics include land use, cropping systems, fertilizer requirements, water management, disease and pest control, crop utilization, food technology, production economics, farm management, and farm implements and machinery.

The other research institutes will be described in later chapters in connection with particular crops or non-crop products. Although these institutes are less comprehensive in scope than BARI, a number of them also have regional staffs and local research sites. Hardly an agricultural item is not being researched at a laboratory somewhere in Bangladesh.

More and more often, however, laboratory research is being supplemented and even overshadowed in some cases by on-farm research. A determined effort is being made to bring research closer to the farmer, not just in the application of research results but at the testing stage as well. On-farm trials and farming systems research have become the key words in agricultural research in Bangladesh.

Down on the Farm

The test plots are a picture of neatness. Whether it is rice, or cotton, or vegetables, the rows run straight and the weeds have disappeared. Each plot is carefully labeled with a prominent sign (usually in English) that spells out what is being tested under what conditions. At the agricultural experiment station, such tidiness might be expected; but many of these test plots are in farmers' fields. When visitors approach, the farmers gather around to answer questions. (The children gather to have their pictures taken.) Agricultural research down on the farm is now a familiar phenomenon in Bangladesh, and the farmers themselves are heavily involved.

"On-farm trials" refers to a general procedure in which researchers work with local farmers to try out new practices under actual farming conditions. The practices may have to do with a single aspect of a single crop; for example, two varieties of rice may be tested side by side for yield. Or they may have to do with cropping patterns, such as interspersing rice crops with different winter crops, in which case the term "cropping systems research" is often used. Or an entire range of practices—from the work habits of women to the use of draft animals—may be studied, in which case "farming systems research" seems to be the preferred term. The important point is that research is done under actual farm conditions. Since research results that do not prove out in farmers' fields have little value, on-farm research helps determine whether new seeds and technology are improvements over those already in use. To bridge the gap between the laboratory and the real world, the national research system in Bangladesh has nearly 20 cropping system sites operated by a number of institutes. BARI's on-farm trial division cooperates with hundreds of farmers annually.

Bangladesh's frequent contact with the international agricultural research community has been an important factor in the spread of on-farm research. A manual published by the International Maize and Wheat Improvement Center in Mexico City (CIMMYT) to lay out the philosophy on which on-farm research is based was issued in part by the BARC contractor as guidance for Bangladesh's agricultural research network.

On-farm research, as formulated in the manual, considers the farmer the primary client in agricultural research and central to organizing an effective research program. The on-farm effort takes place within the broader context of a total research program, including policy analysis.

A major component of on-farm research is the assessment of the natural (physical and biological) and economic circumstances that influence farmers' actions. From this assessment, trained biologists and economists can pinpoint opportunities to increase the productivity of the resources at the farmers' disposal. The opportunities can then be screened for inclusion in

An on-farm test site near Jessore. The agricultural research network stresses on-farm tests.

on-farm experiments. These experiments, conducted in farmer's fields, are the second component of the on-farm research methodology. In the process, information useful for guiding experiment-station research and for policy analysis can also be gained.

If a strong on-farm research program exists, research at experiment stations is primarily aimed at developing new technological components that require more closely controlled conditions, such as new varieties. Also, experiment station research can screen technological components that might have undesirable effects on farmers' fields, such as herbicides that leave residues. Promising technological components arising from experiment station research are further refined and evaluated in on-farm experiments for their appropriateness to farmers.

The flow of information between on-farm research and experiment stations is two-way. Information generated by on-farm research is important for guiding experiment station research. For example, it may indicate the variety that not only performs well in farmers' fields, but also meets farmer preferences for varietal maturity, yield, storage quality, and cooking quality.

Information summarized from on-farm research in several regions can help in setting broad priorities for experiment station work. It can provide

Steps in On-Farm Research

1. *Plan:* Obtain knowledge and understanding of farmer circumstances and problems in order to plan experiments.
2. *Experiment:* Conduct experiments in the farmers' fields to formulate improved technologies under farmers' conditions.
3. *Recommend:* Analyze experimental results in light of farmer circumstances in order to formulate recommendations to farmers.
4. *Assess:* Determine the experience that farmers have with the technologies.
5. *Promote:* Demonstrate the improved technologies to the farmers.
6. *Incorporate:* Develop and screen new technological components to incorporate into on-farm research.

a valuable base for assessing the impact of alternative breeding decisions—for example, the relative emphasis that should be placed on early maturity versus disease resistance. Information from assessments of farmers' circumstances and from on-farm experiments helps establish the production benefit of each technological component, the associated risks, and the types of farmers likely to realize benefits.

The profit environment in which farmers make decisions changes over time. Prices farmers pay and prices they receive may also directly affect farmers' goals and resources. As the market for food staples expands, farmers usually become more willing to depend on the market for food supplies; hence, food preferences decline in their influence on farmers' production decisions. Likewise, new credit programs may increase farmers' ability to buy new seeds and fertilizers, for example, that they decide could increase the production and profitability of their farms.

In the same way that farmers' circumstances have determined their current crop technology, they are also important in a farmer's decision to change technology. When farmers reject new technologies, it is rarely because they are conservative or ignorant. Rather, it is because they have rationally weighed the likely changes in incomes and risks and decided that, for them, the technology does not pay. In farming systems research the researchers' task is to incorporate knowledge of farmers' circumstances into the design of technologies so that the designs are consistent with those circumstances.

This is the philosophy that BARC and BARI, particularly, have begun to apply in the 1980s. At first, most of the work was in single crops and cropping

Major Agricultural Research Institutions

Bangladesh Academy of Rural Development
Bangladesh Agricultural Research Council
Bangladesh Agricultural Research Institute
Bangladesh Agricultural University
Bangladesh Institute of Nuclear Agriculture
Bangladesh Jute Research Institute
Bangladesh Rice Research Institute
Bangladesh Tea Research Institute
Bangladesh University of Engineering and Technology
Chittigong University
Dhaka University
Fisheries Research Institute
Forest Research Institute
National Livestock Research Institute
Rajshahi University
Sugarcane Research and Training Institute

systems. Increasingly, however, with urging and funds from A.I.D. and the World Bank, the principles have been applied more broadly to farming systems.

The Farming Systems Approach

A farming system research site in Bangladesh is hard to identify from the road. It has no walls, no guesthouses, often no signs—simply a mosaic of farm plots around a small village. Somewhere on the site, however, is the office of the research team. It may be a school building or a vacant shed. A few tables and chairs showing the scars of heavy use grace the room, but there are no computers and telephones. There are visual aids, mostly charts attached to the walls, containing numbers—of participants in the program, crop yields, rainfall, etc.—as if it were a laboratory. Indeed, the fields have become a kind of laboratory.

Research was first taken to the farmers' fields in Bangladesh when BARI initiated its fertilizer trial programs in the 1960s. Research on the farming system concept itself began in the 1970s. The Bangladesh Rice Research Institute (BRRI) started cropping system research as a participant in the Asian Cropping Systems Programme established by the International Rice Reseach Institute (IRRI), and the Sugarcane Research and Training Insti-

An International Team

To keep tabs on farming systems research sites and other aspects of the research program, Winrock keeps a team of people in the field, as well as in Dhaka. Attached to BARI regional research stations, these "associate production agronomists" live and work in their various areas of responsibility. Winrock provides housing and transportation, renovating, modernizing, and repairing when necessary.

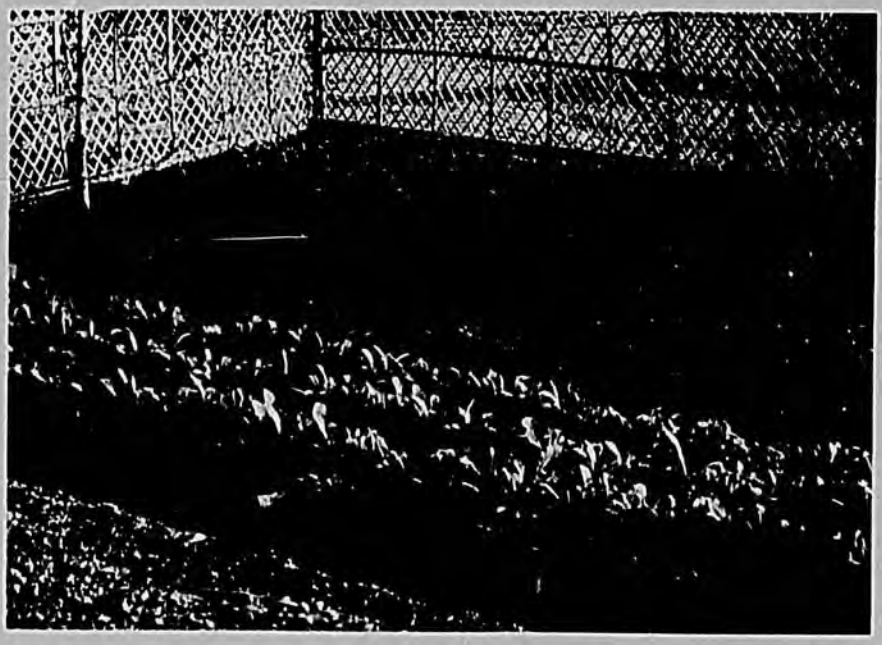
The Winrock field team reflects the international nature of technical assistance in Bangladesh. Dr. R. N. Mallick in Ishurdi is Nepalese (and his book on rice is believed to be the first book in English published in Nepal); Dr. Nadarajah Wignarajah in Jamalpur hails from Sri Lanka; Leopoldo M. (Paul) Villegas in Jessore is from the Philippines by way of California.

tute began similar work in the same year. Other institutes, as well as Bangladesh Agricultural University, soon followed suit. These efforts were brought together in 1980 in the National Cropping Systems Research Programme organized and coordinated by BARC. In late 1986 there were 10 farming system research sites, three supported financially by A.I.D.

Initially these programs tested cropping patterns and component technology and their respective economic profitabilities. Less attention was given to critical analysis of why and under what circumstances farmers adopt certain practices; how they allocate their resources and time to different activities, both on and off the farm, to maximize their incomes; and how external factors influence their decisions. These issues are now being addressed, and the groundwork has been laid for a strong farming system program. BARI took the lead by establishing an on-farm research division with a multi-location network of farming system research test sites. These sites have been linked with experiment stations at central, regional, and sub-regional levels.

To strengthen the system, the research planning process is regional; on-station and on-farm research groups, extension agents, farmers, and other agricultural development workers meet in workshops to identify local crop production problems and determine research priorities. They also meet periodically to review research programs and evaluate the results. Scientists from other research institutes are also involved.

The site at Kalikapur, 6 miles from the BARI regional station at Ishurdi, is an example of farming system research in action. Dr. R. N. Mallick and M. F. Islam lead an interdisciplinary team of scientists that shuttles between the laboratories and the fields, giving the farmers of Kalikapur intensive, hands-on instruction in new farming methods. Kalikapur was selected as a



Vegetables at a farming systems research site in Kalikapur. Farmers have been shown the importance of fencing the plots to keep animals from trampling the crops.

test site because it fell within agro-climatic and socio-economic parameters, indicating potential for both agricultural improvement and extrapolation of test results.

Kalikapur has many small farmers with large families. The total population of the area is just under 3,000, in more than 300 households; the average family size is 8.25 persons. Only a quarter of the adult population is literate (45 percent of the children are). The farmers are classified as landless (36 percent), marginal (13 percent), small (20 percent), medium (16 percent), and large (15 percent). A large farmer is anyone holding over 2 hectares (ha) of land (a hectare is about 2 1/2 acres); the average holding is 0.59 ha, about 1 1/2 acres.

The soil is relatively poor. It is part of the Ganges flood plain and has a sandy loam to clay loam texture. Potash content is low, and nitrogen, sulphur, and zinc content are critically low. The pH range is 6.8 to 7.9. But the land is the farmers' means of survival, and they squeeze every bit they can from it. Cropping intensity is 230 percent; nearly two-thirds of the land produces two crops a year and one-third produces three. Only 5 percent of the acreage is devoted to single-cropping.

Staffing for FSR&D

Farming systems research and development (sometimes abbreviated to FSR&D) emphasizes working with farmers in the field. Since this emphasis is relatively new in agricultural research, the existing staff at research stations and at regional and national headquarters normally requires some reorientation.

This reorientation includes research methodology as applied to field conditions and methods for working with the whole farm family—male and female, young and old. Where appropriate, females may need to be added to the research and extension staff. (In Bangladesh, although women work in the research laboratories, none are on the field staffs, though a number of the cooperating farmers are women.)

However, FSR&D builds on the existing base rather than replacing the existing research and extension staff. Experienced researchers and extension specialists remain in their present organizations, and much of the field staff consists of young professionals trained specifically for FSR&D programs.

The farming methods in use at Kalikapur evolved over centuries. Farmers adopted the practices of their fathers and grandfathers, coaxing enough rice out of the soil and water to fend off starvation, using livestock whenever they could to help with the work. The cropping system component of the farming research project came to Kalikapur in 1981. A survey was first conducted to provide data that would serve as a benchmark for testing purposes. Thereafter, various component technologies and cropping patterns were introduced.

Results? There have been technical breakthroughs. For example, production of mustard, an important oilseed crop in Bangladesh, has increased with the introduction of better strains and improved inputs. The average yield is 627 kilograms per ha. When a modern variety (SS 75) was introduced at the farming system site, the average yield doubled. Some 60 percent of the local farmers now use SS 75, either as a sole crop or a mixed crop. The addition of sulphur to the soil also proved beneficial, improving plant stands significantly. Since sulphur can be obtained locally, the cost-benefit ratio of sulphur use is 10-1 or higher.

There have been other crop improvements. For example, a modern variety of rice (BR 11), tested at Kalikapur and now in widespread use, has produced yields double that of traditional varieties. Sunflowers, grown as an alternate oilseed crop, have proved popular with local farmers because they can be grown after the rice harvest, later than mustard or wheat. Chickpeas, produced using better agronomic practices tested at the Ishurdi research

station, have achieved an excellent stand, even without the use of fertilizer. The controlled-condition results are now being field-tested at Kalikapur.

Vegetable gardening is generating a greater response than field crop research among small, medium-sized, and large farmers. This is good news to nutritionists, because research results indicate that the vitamin A and vitamin C requirements for nine family members can be satisfied with just 40 square meters of land devoted to vegetable gardening.

Five vegetable cropping patterns have been employed with three to five crops a year; spinach and amaranth especially are used for intercropping. To solve the perennial problem of damage by domestic birds and cattle, leguminous trees *(Leucaena leucocephala)* were planted around the home gardens. In addition to serving as a fence, they also provide natural fertilizer, green fodder, and fuelwood. To assure a regular water supply for the vegetable gardens, low-cost pumps have been installed and are being tested for profitability and feasibility.

Of late, attention at the farming system research site has turned to animals. Small farmers in Kalikapur tend to have poultry and goats while large farmers have buffaloes. Ninety percent of the large farmers—but only 40 percent of the small farmers—have bullocks. Cattle serve a dual purpose, as draft animals and as a source of dung. Despite the pleas of researchers, dung tends to be used more for fuel than for fertilizer. There is little veterinary care and an acute shortage of rice straw for fodder from June to August. As a result, the draft animals tend to be in poor health, land preparation times are longer, and yields are poorer.

A detailed look at the work of the farming system research sites (those near Jamalpur and Jessore tell much the same story as Kalikapur) reveals that too much emphasis is still put on crops, not enough on farming practices. The close linkage prescribed between the laboratory and the field is not always apparent, and many researchers pursue their own interests without reference to the farming system approach. Most notably, it is difficult to trace the impact of farming system research on government policy. BARC (especially Rahman, who headed the program when he was at BARI) is enthusiastic about the methodology, but the ministries seem less persuaded.

Still, a good start has been made in institutionalizing science and technology in the research network, and the situation is far better than it was in 1976—or even 1981. BARC is now providing leadership, the research institutes are staffed and organized better, research results are being tested on the farm, and a comprehensive methodology for applying research to actual farm problems is in place—everywhere in principle and some places in practice. What is needed to complete the picture is an educational system to increase the supply of research and an extension service to satisfy the demand for it.

Delivering the Message

Dr. E. Boyd Wennergren and his colleagues looked at Bangladesh's agricultural development in 1983, preparing to write what has become almost the definitive work on the subject. They found much that was promising in agricultural research, but that neither the training of extension workers nor the organization of extension work was adequate.

In a similar vein S. G. Mahboob, professor and head of the Department of Agricultural Extension and Teachers' Training at Bangladesh Agricultural University, delivered a keynote paper on Bangladesh's extension system at a seminar in December 1983, and identified 12 "major constraints" to the communication of agricultural research.

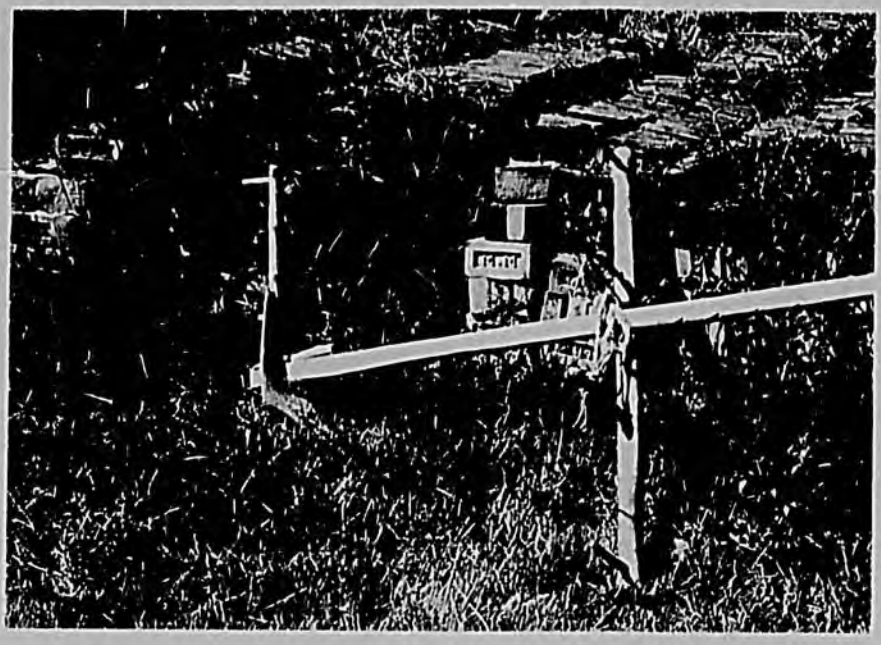
The major criticism of the extension system is that there are too many channels for delivering research messages to farmers. At least 20 separate institutions provide agricultural extension services, including the Department of Agricultural Extension (DAE), the major research institutes, and a host of separate training centers. DAE is the largest extension-oriented institution and is recognized officially as the national extension service.

BARI has introduced an Extension and Research Project in which researchers and extension personnel work together to communicate with farmers. Extension people are always invited to the "farmer days" (described by one person as "snacks and suggestions") that are held regularly by the BARI regional stations. Nonetheless, there is the definite feeling what while research-extension relations are cordial, they are by no means close. The link between research and extension is weak, and contacts between personnel from the two branches are infrequent and informal.

About half of the extension personnel in the country are employed by DAE, which operates in most of Bangladesh's cropped areas and is organized according to political subdivisions. The farmers' contact points with the extension system are the union agricultural assistants and village extension agents who report to agricultural officers at the *thana* (roughly, county) level.

Personnel up to the *thana* level have usually been formally trained at one of the 13 Agricultural Extension Training Institutes (AETIs) operated by the DAE. Although there is variation, the facilities available for training at the institutes are usually inadequate. Above the *thana* level, the focus is less on work with farmers than on program coordination, and most of the higher-level positions are filled by persons with university degrees.

A farmer in Bangladesh cultivates many field crops, maintains cows and other domestic animals, may have a pond for fish, and probably grows plants



A wooden plow. Extension agents try to introduce farmers to newer technologies.

for fuel and timber. The farmer needs information on all these. The fragmented nature of extension work in Bangladesh has been justified on the grounds that only specialists in the particular technology can provide the necessary information to farmers, thus separate extension agents for sugarcane, for rice, for jute, for tea, and for other products are needed.

From the farmer's viewpoint, however, the proliferation of messages is likely to confuse rather than enlighten. A 1982 survey of five districts found that a large majority of farmers had been untouched by official information sources. Most relied most heavily on informal sources—neighbors and fertilizer dealers, for example—for agricultural information. Less than 2 percent could identify the "model" or "contact" farmers set up under several donor-funded extension schemes. Even fewer reported seeking advice from institutional sources, and only half had ever attended local meetings. Not surprisingly, those who most often used official information sources were those who had achieved the highest levels of education and were thus, presumably, least in need of the information.

In 1978, the World Bank sponsored a trial test of the Training and Visitation (T and V) concept in Bangladesh. Special training for local-level

Going Up from a Godown

The Integrated Rural Development Program concentrates on developing cooperatives, and extension training is a big part of this. Much of the training is conducted at the Bangladesh Academy for Rural Development, which began with a successful cooperative-building program at Comilla and now has a center at Bogra as well. A former director of the Bogra center, M. Nurul Haq, recalls the early days of the center:

"Years have gone since a new responsibility came by. I still remember the day [in 1975] when an old Datsun brought us to Bogra. Miss Kristien Westergard was with me. Since then she got her Ph.D. and became an authority on development dynamism; I got stuck struggling for survival at the new rural development academy....On the following day, I went to the "office" and found half the veranda of the Bogra palace being used as a godown for storing cement....No classroom, no hostel, no cafeteria, and no arrangement for training."

The Rural Development Academy at Bogra now operates a full training program. The present director is A. M. Chowdhury, a dynamic and well-spoken young man who is fully committed to rural development.

extension agents was conducted by crop and other specialists at the *thana* and district level; expatriate specialists were also involved. The visitation part of T and V was highly organized; agents visited 160 specific farmers every 2 weeks on a rigorous schedule intended to ensure a systematic routine. Yet in late 1983, Mahboob found "lack of support by subject matter specialists" to be one of the barriers to effective extension work.

Forces external to the extension system have also served as constraints on effective action. These include lack of appropriate technology, national price policies, and agricultural credit. Funding shortages have also restricted the system. Travel money, a critical input for extension, is usually in short supply. In addition, low salaries, minimal opportunities for advancement, and assignment to isolated communities with substandard housing all lower morale in the extension service.

Despite the negative assessments, there are bright spots in the extension system. For some crops, such as tea, tobacco, and sugar, researchers have a close working relationship with both extension personnel and growers. Both BARI and BRRI work very hard to involve DAE in their planning to expose extension people to their research. In the long run, the farming systems research approach will also tend to unite research and extension.

CERDI and Friends

The Central Extension Resources Development Institute, headquartered at Joydepur, was created in 1978 with Japanese assistance. It was intended to provide a liaison between research and other government-supported agricultural information institutions. CERDI staff provide technical training for field personnel, prepare teaching materials for research institutes, and serve as a teacher training center for other agricultural training agencies.

The Bangladesh Agricultural Development Corporation maintains a Staff Training Institute at Madhupur. The institute trains BADC personnel in a variety of technical subjects, such as seeds, fertilizer, irrigation, and pumps.

Over half the *thanas* in Bangladesh have Training Development Centers to train selected area farmers. This includes cooperative leaders, pump operators, and tubewell attendants.

The Educational Embryo

The educational system of a country is the embryo of agricultural research. It must provide a steady stream of trained people to staff the various levels of the research and extension system—the administrators, the top scientists, the mid-level technicians, and the field workers. And the stream must be composed of Bangladeshi nationals; expatriates can help in a transitional phase, but they are not the answer in the long run.

As important as the numbers are the attitudes that come from the educational system. Science-based agricultural research must be objective, technology must be applied in an unbiased manner, and results must be judged by rigorous standards. These are habits of thought best learned in school.

From this perspective, Bangladesh is already in a better position than many developing countries. It has an academic tradition that dates back to the days of the British raj and a strong base of physical facilities and faculty members. Unquestionably, donor assistance has been important in creating this base; many of its university-level faculty were trained abroad at donor expense, and many of the laboratories and other facilities were built with foreign aid. Bangladesh's strong commitment to learning can lead to educational excellence.

That said, there is still sufficient cause for concern. Agricultural research and extension require people with higher secondary certificates and university degrees, and the primary and secondary schools must supply the candidates. Will the Bangladesh educational system be able to do this well enough in the near future?

School Days

The structure of education in Bangladesh is somewhat similar to that found in the United States: three levels of education—primary, secondary, and higher. Religious schools, the *Madrasha*, also provide secular education at all levels. Primary schools and most colleges are public, state-financed institutions, while most of the regular secondary schools and the religious schools are privately financed, although private groups get some public support.

Students enter school at age five and pass through ten grades divided into two five-year segments. Those passing the ten grades and also a written examination are awarded a secondary school certificate. Students may also pursue a two-year "higher secondary" program, after which they are again examined in order to receive a higher secondary certificate. With this certificate, they can pursue higher education.

One-third of the children old enough to attend primary school do not enroll at all. Of those who complete primary school, half drop out between grades five and 10. Three-fourths of the students will not complete grade 10 and be examined for the secondary school certificate. One-tenth of those who finish grade 10 will not make it through grade 12 with a shot at the higher secondary certificate necessary for college admission. This dropout rate cannot be explained away as a bad situation that will inevitably improve; the figures were actually better 10 years ago.

The reasons for the poor showing are all too familiar: teachers (few of whom are women) are poorly paid and ill-trained; facilities are run-down; supplies and textbooks are lacking. Government spending has not reflected a high priority for education, which helps explain why others give it low priority.

One could say education is simply too costly for the poor people in Bangladesh who make up most of the population. Not only are there out-of-pocket costs—books, clothing, etc.—but also opportunity costs. Time spent in school is apt to be income forgone, especially in rural areas where children perform many chores. Since the system does not reward educational attainment, many families are not willing to pay the price.

University enrollment has increased slightly, with about 40,000 students enrolled in the four major liberal arts universities (Dhaka, Chittigong, Rajshahi, Jahangirnagar), the engineering university, and Bangladesh Agricultural University; BAU gets about 10 percent of the total.

The agricultural university was established at Mymensingh within sight of the Brahmaputra River in 1961 to be *the* center for agricultural science and technology. A.I.D. and the World Bank provided the funds for practically

The Graduate

M. Habibur Rahman is from Jamalpur, the product of a middle-class family. Like many Bangladeshis, he fled to India to escape the slaughter of the War of Liberation but returned to help build an independent nation. Having studied English since his third year of school, he is fluent in the language.

Habib is a graduate of the primary and secondary school system and of Bangladesh Agricultural University (master's degree level). He has no quarrels with the program at BAU. He found the instruction very practical and disagrees with charges that the curriculum is inflexible. Most students are absorbed in their studies and there is little time for student life. Habib feels that the university prepared him well for professional life. Now a family man himself, he has no Ph.D. aspirations.

Unlike most graduates, he went from the university into the private sector, working for a tobacco company. For the last year he has worked for A.I.D. in Dhaka, assisting in the agricultural research project.

the entire plant—buildings and laboratories as well as a 1,000-acre experimental farm. They also paid to have many of the faculty trained abroad (the Texas Aggie connection). In addition to the main campus at Mymensingh, BAU also has ties with the Bangladesh Agricultural Institute, the Bangladesh College of Agricultural Science, and the Patuakhali Agricultural College.

Observers differ as to how well BAU is fulfilling its role. Wennergren describes the curriculum as "theoretical and inflexible," the library holdings as "limited," and the research and extension efforts of the faculty as "not a quality learning experience." BAU, he says, has "drifted into semi-isolation" and has little influence on the agricultural sector.

Members of the current faculty as well as some graduates of the university deny these charges. They contend that students do obtain practical field experience. Certainly the farming systems research site that the university operates near Mymensingh seems to provide ample opportunity for this. The faculty members involved in the program are knowledgeable and enthusiastic. They are more concerned with crops than with farming practices, but so are the BARI stations.

Academically, the university still has a long way to go. Only a few doctorates have been awarded and no more than a few are in the pipeline. Graduates with lesser degrees, however, are helping to staff the research institutes and other organizations in the agricultural sector, including A.I.D. About one-third of the BAU faculty members themselves have doctorates, and these were awarded outside the country.

The vast network for agricultural research in Bangladesh is now led by persons trained abroad and is assisted by expatriates. If the network is to be supplied from within, BAU will have to provide more and better training to more people. To do this, the university needs a much larger pool of secondary students from which to draw. The secondary schools, in turn, need to see greater numbers coming out of primary school, and so on. It all starts with basic education, and until Bangladesh can improve its performance in this regard, agricultural research is likely to suffer.

For now, the research network is doing well. The scientists designing the projects in the offices, bending over the microscopes in the labs, and wielding the notebooks in the fields are capable and committed. But international donor agencies are footing a large portion of the bill. If donor agencies lessen their training efforts, it is not clear that the Bangladesh educational embryo could grow to fill the gap.

5

Improving Agricultural Production in Other Crops

Raising Cane

Farmers in Bangladesh, it is reported, like *gur* for breakfast. The thick, syrupy substance is derived from sugarcane and is similar to molasses. The farmers get quick energy by devouring a plate of *gur* with rice before beginning the day's labors.

However, the farmers do not get all the *gur* they want because sugarcane also yields sugar, and the people who control the processing of cane are more interested in having it turned into sugar than *gur*. Even home *gur*-making is restricted by law and has sometimes been banned outright.

Likewise, the people who do research on sugarcane are not encouraged to find ways to improve the making of *gur*, though some of them would like to. The conflict between food crop and cash crop has been resolved in favor of cash, and the farmers must find something else to brighten their morning rice.

Sugarcane ranks third as an agricultural cash crop in Bangladesh, and sugar is the country's second most important (after rice) agro-industry. Still, foreign exchange must be spent to export sugar. Although this is as much a matter of price policy as research, increased productivity would help small farmers improve their financial returns.

Increasing yield is about the only answer, from a production standpoint, since there are no plans to devote more acreage to cultivating cane. Finding ways to raise more cane per ha is the challenge facing the Sugarcane Research and Training Institute (SRTI) at Ishurdi.

The commercial, as opposed to agricultural, orientation of the institute became pronounced after the institute was relocated in the industries

Making of an Institute

The present Sugarcane Research and Training Institute (SRTI) actually traces its lineage back to 1913, when a Sugarcane Seedling Testing Station was located at Dhaka; it was financed by the Imperial Council of Agriculture. The station operated until 1947.

After a brief hiatus, a Sugarcane Research Station was established under the Ministry of Agriculture at Ishurdi in 1951. Suffering from lack of funds and facilities, the new station was first taken over by the Food and Agricultural Council in 1960, then handed to the agriculture ministry in 1965. All activities came to a halt during the War of Liberation.

The present overseer, the Bangladesh Sugar and Food Industries Corporation, Ministry of Industries and Commerce, took over the station in 1973, but its name and assets went through several incarnations before achieving the present status as SRTI in 1980.

ministry in the early 1970s. When the move was made, all scientific personnel but one left the institute, so the staff has had to be rebuilt from scratch. This has been done, and a large and enthusiastic group of scientists now staffs the laboratories.

Research is focused on developing new sugarcane varieties and a clean seed program, experimenting with inputs such as fertilizer, and improving methods and times of planting. Research findings are combined into technology packages and disseminated to the farmers for adoption. Like a number of the institutes, SRTI does a lot of its own extension work.

Small farmers produce nearly half the sugarcane grown in Bangladesh, the typical grower raising the crop on a one-acre plot. Cane yields are low, and so is sugar quality. The average yield is about 15 tons per acre with a sugar recovery rate of 10–15 percent—about 1 ton of sugar a year. Since the growing season is long—12–15 months—farmers have resources invested for a long time, and they often supplement the cash crop by producing aman rice or a winter crop of pulses or vegetables.

New sugarcane varieties are an important research objective, and some higher-yield strains have been developed. Isd-16 is an especially promising variety that is superior to other commercial varieties grown in Bangladesh. It has a higher yield, a high sucrose content, and a low fiber content. This variety produces the most recoverable sugar per acre of any type grown in the country.

Sugar recovery rates are influenced by poor varieties, insects, and plant diseases, but the largest loss is post-harvest. The time lag between harvesting and crushing of the cut cane causes a breakdown in the sugar. Over a 6-day period, the loss can be 34-56 percent of the total sugar content.

Loading sugarcane. Sugar is an important commercial crop in Bangladesh.

SRTI researchers have found that post-harvest deterioration can be reduced by spraying the cut cane with either waste or formalin or by covering it with harvesting trash. Even so, the deterioration will not be eliminated until the collection and transport problems are solved.

Intercropping is a major innovation to improve production of sugarcane. One good practice is planting cane with aman rice so that the cane is growing before the rice is harvested. Another is to plant sugarcane, then plant a short winter crop as the cane begins to grow. In both systems, the yield produced by the intercrops is greater than from sugarcane alone. A winter rice crop can also be planted with sugarcane, thus further increasing the yield from the three relay intercrops.

Intercropping sugarcane and rice is harder to manage than winter crops because of drainage problems. However, several experiments have shown that planting rice and cane together produced significantly higher yields than the monocrop. In poorly-drained areas, scientists recommend the high-bedded method of cane planting and the use of a variety that tolerates waterlogging.

Although researchers believe that the intercropping of rice and sugarcane is generally beneficial, many farmers are reluctant to adopt the

The Aussies Lend a Hand

The sugarcane expertise of Australia was brought to Bangladesh through the Bangladesh-Australia Sugar Industry Project, 1978-83.

The Australians provided funding for construction of several greenhouses, a heated germination chamber, and seedling raising platforms. They also purchased laboratory equipment, furnishings, books and journals, farm implements and machinery, and a small workshop for repairs and maintenance.

A training building was also built at SRTI, and some SRTI scientists received training in Australia.

technology. Their concern is that although the total yield of the two crops will be greater, the yield of the rice will be less. The rice, of course, is what the farmer needs to feed his family. Once again, cash-crop and food-crop needs clash.

There have been no dramatic research breakthroughs in sugarcane as there have been in wheat. The principal results SRTI can point to are percentage increases in yields due to improved farming practices; no "miracle sugarcanes" have been unearthed.

More progress has been made in another crop that ranks along with jute and sugarcane as a cash commodity. This is tobacco. The Tobacco Research Station, under the Bangladesh Tobacco Development Board, has collected and studied a large amount of germplasm at different stages.

Two high-yielding varieties of cigarette tobacco, Orinoco and Sesmaria, have been released and recommended to growers. Two new varieties, BAT-1 and BAT-2, have evolved through hybridization. The varieties are characterized by low nicotine, high-reducing sugar, and high yield. Another good quality cigarette variety, Sesmaria Gold, is under advanced yield trial, and other high-yielding tobacco varieties are expected to be released.

Everybody Grows Jute

A mail order company in the United States offers a man's sports jacket made out of pure jute. Billed as a summer jacket, it is a bit too heavy for tropical wear, but does well in cooler climates. The material is similar in color and texture to sacking.

When the jacket was exhibited in Bangladesh, no one, apparently, had ever seen anything like it. Jute clothing is not an industry in the country. Instead, jute in Bangladesh is used for packaging material or carpet backing. Observers admitted that the jacket suggested a possible export market.

But that would be the future. The reality of the present is that the jute industry is in trouble in Bangladesh. Jute is the nation's number one export, accounting for about two-thirds of its foreign exchange earnings. In addition to perhaps 250,000 people involved in some aspect of jute manufacture, millions of farmers rely on the crop for cash, putting down small plots wherever they can. Said one researcher at the Bangladesh Jute Research Institute (BJRI): "Everybody grows a little jute."

The industry's troubles are primarily in marketing. First, there is a greater supply and thus more competition. India, China, Bangladesh, and Thailand account for more than 90 percent of the world's jute supply, and several of these countries have upped their production. For example, India, with a big stock of processing mills in Calcutta and a reduced growing area because of the loss of East Bengal after partition, has made a determined effort to achieve self-sufficiency in the industry. More and more acres of jute have been planted.

Second, the demand for jute has declined. Synthetic materials have been rapidly replacing jute as a type of packaging material for many years. In any case, due to bulk shipping, not as much packaging material is required as formerly. The jute sacks holding produce that once crowded the docks are no more.

With supply up and demand down, world jute prices have declined and with them a lot of Bangladesh's income. In that country, also, where a growing population must feed itself, jute has had to compete more with rice and other food crops for the available acreage. Everybody may have grown a little jute at one time, but that is not true now with low prices and higher priorities for scarce acreage.

These difficulties indicate that there never has been a better time for breakthroughs in jute research. Some critics say jute research has suffered from a lack of international stimulation. The kind of interaction with foreign research characteristic of rice and wheat has not occurred in the case of jute. The CGIAR centers are concerned with food; little attention is given to fiber.

BJRI researchers are fully aware of this situation. A statement on the first page of a pamphlet on research achievements issued by BJRI in 1986 summarizes the problems of jute research. It reads, in part:

> Bangladesh Jute Research Institute came into existence as a full-fledged, autonomous organization through promulgation of an act in 1974, although agricultural research on jute [was] started much earlier by the Fibre Division of the Directorate of Agriculture. Research on jute was strengthened through the establishment of [the] Jute Research Institute in 1951 under the auspices of the Pakistan Central Jute Committee, and the research organization was to be administered by the Central Ministry of Agriculture from Islamabad.

Utilizing Jute

Consumption of jute in Bangladesh is smaller in relation to the size of the industry than in other major jute-producing countries. Domestic use accounts for only 10 percent of mill output, with sacking being the principal manufactured product delivered for internal consumption.

Competition from synthetic products has had only a limited effect on jute consumption. Locally produced polyethylene film and bags are used primarily for packaging pharmaceuticals, foods, and other industrial products where jute is not normally used. Thus a decline in the use of jute sacks for packaging foodgrains and other agricultural produce means a decline in agricultural production, not an increase in the use of synthetic fibers.

The jute manufacturing industry in Bangladesh will continue to depend on exports for a major part of its demand.

It is needless to mention the importance of jute in the economy of the country, and, therefore, when the Jute Research Institute was initially established in the present campus in the year 1951, it was supposed to have the following three branches: (1) Agricultural Research on Jute; (2) Technological Research on Jute; (3) Marketing and Economic Research on Jute. The agricultural research on jute was started in 1951 [and] technological research on jute in 1963, while the marketing and economic research on jute is yet to be started.

The Jute Research Institute is unique in its kind in the sense that research on jute is not carried out in many places in the world like rice, wheat, potatoes, maize, etc. Research on jute is carried out only in Bangladesh and India, and therefore our knowledge of the subject is very much limited. In [the] case of other crops...we can share and get benefit of the research knowledge being carried out elsewhere. [But] in the case of jute, there is no such scope, and the Jute Research Institute is required to carry out the basic research for which the specialized, trained manpower and additional physical facilities are required. In...agricultural research, particularly to evolve a new variety, the breeder's main tools are the genetic materials or germ-plasm with wide variability. In [the] case of jute, there is no possibility of having improved germ-plasm from other countries or other international research institutes as [is] done in [the] case of rice, wheat, potatoes, maize, etc. The BJRI has to create variability in germ-plasm, [a task] for which it needs more scientists having [a] sound background in breeding.

Jute ready for market. The decline in world jute prices has hurt the Bangladesh economy.

The list of BJRI's research achievements is modest. Some improved varieties have been developed, some agronomic practices have been recommended, some controls of diseases and pests have been advanced. There have been statistical studies and some technological research.

A number of methods have been developed and recommended for improving fiber quality through retting (soaking of bark in water). For example, a ribbon-retting technique was developed by which the green bark of the plants is removed in the form of ribbons prior to retting. Better quality fiber is obtained retting these ribbons. Through ribbon-retting, both the bulk of the plants and retting time are reduced by almost half, thus reducing the total water requirement.

Despite the constraints on jute research, the hardworking scientists at the Sher-e-bangla Nagar complex in Dhaka are not lacking in enthusiasm. Jute production is having difficulty holding its own, but "its own" has represented a good chunk of Bangladesh's agricultural production for a long time. In any case, the fate of jute is in the hands of macro-forces that researchers are powerless to control. Marketing must improve or the research will be meaningless. Perhaps the answer lies in the local manufacture of jute clothing for U.S. export. A market that is rediscovering natural fibers, such as cotton, silk, and linen, may also adopt jute clothing as the new "in" fabric.

Jute Sticks Stocks Rise

Although more than 30 species of jute are known, only two—white jute and tossa jute—are widely grown. The jute plant contains a bast fiber that is separated from the stem and bark after retting (soaking) in water. The quality of jute fiber is strongly influenced by the availability and quality of retting water used to prepare the plant for separation of the fiber from the stem and bark.

Jute sticks (the wood stem from which the fiber is separated) are about twice the weight of the fiber. Historically, jute sticks have been used for such household purposes as firewood, dung sticks, fencing, and roofing. Although important to the household, the sticks were of substantially lower commercial value than the fiber.

More recently, jute sticks have been a source of wood fiber for making paper. This use, combined with the increasing scarcity of firewood in many producing areas, has raised the value of sticks relative to the value of the fiber.

Farming the Forest

Bamboo is a ubiquitous construction material in Bangladesh. The ladder that leans against a building in Dhaka will be bamboo; the scaffolding at a construction site will be bamboo; fish nets are hung on bamboo poles. A tough, durable material that grows locally, bamboo is an important element in the economy.

But the supply is being exhausted. Bamboo is prominent not only in the daily lives of rural Bangladeshis, but in the paper, cellophane, and rayon industries as well. The regeneration of bamboo has, therefore, been given a high priority. The search is on for high-yielding varieties and effective propagation methods, such as branch cutting, culm cutting, air layering, and ground layering.

Given the density of population, there is tremendous pressure to use forest land for agricultural and other purposes, though forest resources are extremely limited. Although less than half of the land is scientifically managed, about 20 percent of the land area of the country can produce forest crops. This includes the unclassified state forests in the Chittigong Hill Tracts, newly formed land in the coastal belts, and village groves. Besides, trees can grow on denuded hills, waste land, and marginal land (road and railway embankments). It will not be possible to meet the increasing demand for forest products from government land alone. Instead, the bulk of the supply will have to come from village resources, waste and marginal land.

Fuel from Weeds

In most places, the water hyacinth, a plant of the lily family with narrow green leaves and fragrant flowers, is regarded as a noxious weed. Resistant to herbicides and even automobile exhaust fumes, it clogs rivers, lakes, canals, and ditches. Millions of dollars are spent in efforts to control it.

So it is—almost—in Bangladesh. The water hyacinth thrives in the flood-prone country, even in the city of Dhaka. But control is not an insurmountable problem. In most areas, hyacinths are actually a *resource* used to meet a variety of needs of poor families. They are used as low-grade cattle feed when fodder is short and are pressed into service as a mulch/fertilizer. When dry, they are used as an inefficient cooking fuel, three to four baskets of dried hyacinths being required for one day's cooking. Fuelwood is in short supply.

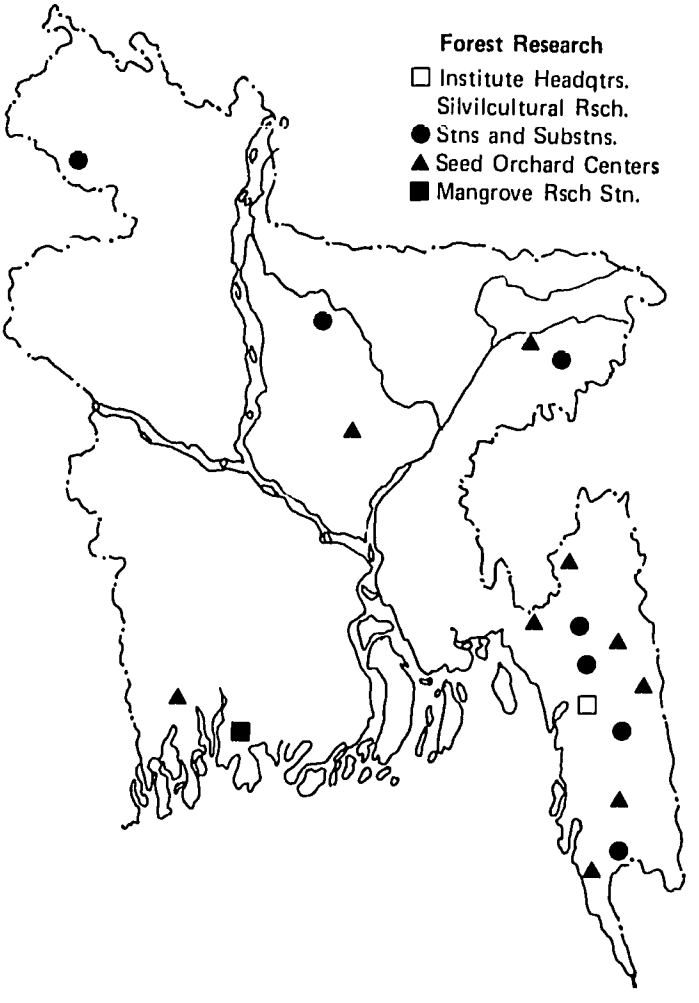
Until recently, relatively little concern was shown for forest resources. The shifting cultivation of the tribal population in the Chittigong Hill Tracts has rapidly depleted the tree cover, causing deterioration of soil fertility, accelerated soil erosion, and heavy siltation of Kaptai Lake. Tidal forests, which offer an important barrier against cyclones, have not been well managed or harvested. In village groves, the rate of removal is higher than the growth, so the resources will soon be depleted.

The projected demand for timber and fuelwood, at the current level of consumption, greatly exceeds the available supply. The demand is not likely to decrease. Most of the people do not have money to buy fuel and must continue to gather wood on the millions of rural homesteads. To close the gap between supply and demand, the productivity of the existing forests must be improved and ways must be found to meet rural energy needs in other ways, including through multi-purpose tree species that can be integrated into farming systems.

This message has now had an impact at the highest policy levels. Afforestation, reforestation, and social forestry programs are being pursued to increase state and homestead forest production. Agroforestry has become a priority with the government, the international donors, and the agricultural research community. One of the challenges is how to manage forest resources, another is to utilize multipurpose tree species in farming systems so as to meet fuelwood and other needs.

The center of research activity is the Forest Research Institute (FRI) in the agricultural ministry, responsible both for forest management and forest products research. The institute is headquartered at Chittigong, and additional experiment stations are in the forested areas of the country. These

Forest Research Institute Facilities



A forest in Dhaka Division. Trees are in short supply since so much land is either under water or under cultivation.

include a number of seed orchard centers and silvicultural research stations, as well as a mangrove research station at Bogi. In addition to bamboo, a number of other areas have been the subject of significant work, including mangrove research, seed growth and propagation techniques, pest control, cost-benefit analysis of forest plantations, and forest product technology.

The tidal mangrove forests of the Sundarbans have an impact both on the economy and the ecology of the country. Phenological studies of major mangrove species have been conducted, and the fruiting, flowering, and seeding habits of the species have been recorded.

To aid natural regeneration and carry out trial plantation programs, studies on artificial regeneration of mangrove species have been done. Since the growth rate and regeneration are related to the salinity of the area, the effect on natural regeneration, due to the withdrawal of Ganges water by the commissioning of the Farakka Barrage, is being investigated. Regeneration data on major mangrove species is collected twice a year, and growth data is recorded every 5 years.

Budding, cutting, grafting, and air-layering have been tried on a number of important indigenous and exotic plantation species, but success in

propagation has been achieved only in teak, gamar, mahogany, garjan, dhakijam, silkori, kadam, semul, and telsur. The techniques are being used to develop clonal seed orchards. More than 1,700 trees of 25 important forest species have been selected for scion grafting in order to raise clonal seed orchards. About 600 acres of orchards of teak, gamar, garjan, dhakijam, and simul have been established since 1978. International trial plots for teak and gamar have been set up at two field stations, and teak and gamar gene banks have also been established.

Trees are susceptible to pest attack from the seedling stage to maturity, so major pests of important tree species have been identified and listed. To lay the groundwork for combatting these pests, a national reference collection of more than 6,000 forest insects has been built up from the different forest areas of Bangladesh, and about 300 species have already been identified. The pathological herbarium houses about 1,800 specimens of wood-destroying fungi, of which 60 species have been identified. A model control measure has been suggested for *Hyblaea puerea*, a serious defoliating teak pest.

In order to assess the comparative profitability of different species on different sites, cost-benefit analyses of forest plantations are essential. An experiment conducted on teak helps to explain forestry's contribution and economic efficiency in relation to agriculture and industry. It also notes management problems and suggests ideas for maximizing sustained net returns from a given area of plantation.

Forest products research determines the technological properties of different woods, develops new products and processes, and finds optimum economic uses for forest products. Properly dried or seasoned wood makes a better product, and treating with preservatives triples the life of wood, bamboo, or grass.

In this connection, kiln-drying schedules of 30 species and air-seasoning schedules of 20 species in plank and sleeper forms have been developed. Treating schedules for a number of timbers and bamboos have been prepared, and the Bangladesh Railway is using locally seasoned and treated species. Also, studies are being conducted on treating freshly felled trees by the sap-displacement method. The process, being simple and inexpensive, can be carried out in rural areas and should have a considerable impact on the use of posts and poles in villages.

A.I.D. has recently joined the agroforestry push in a big way by funding (more than $12 million proposed) the Homestead Agroforestry Research and Extension Project. The government of Bangladesh is to provide several millions in matching resources.

If carried out as planned, the A.I.D. project should have a major impact on agroforestry activities across the board. The funds would be used for a

variety of discrete institution-building and research purposes, specifically: an agroforestry research cell at FRI to carry out laboratory and field station research; homestead agroforestry teams (HATs) to design and carry out homestead trials at farming systems research sites; an agroforestry extension cell within DAE to coordinate training and extension activities; and a new contract research fund at BARC to support new lines of agroforestry research.

In addition to institution-building, the project will also support a host of training activities: international degree and non-degree training for scientists, administrators, and extension workers; short courses and workshops in agroforestry; and development of new curriculum materials.

Progress in forestry research will be a process of patient laboratory research and field testing. Great strides have been made in recent years, and research leadership is good. The new A.I.D. project, together with existing efforts of other donors, should play a major role in sustaining the momentum.

6

Complete Agriculture: The Non-Crop Initiatives

The deep tubewells that have been installed in the drier areas of Bangladesh for irrigation purposes are often used only 4 months of the year; they irrigate one crop for a period of time. The rest of the year they lie idle, subject to deterioration or vandalism because no one looks out for them.

Meanwhile, the drinking water situation in the rural areas of Bangladesh is as bad as in any developing country. Many rural people do not have access to clean water, and water-related diseases abound. (In fact, Dhaka is the headquarters of a major center for research in diarrheal diseases—ICDDR,B.) The United Nations Children's Fund (UNICEF) and other agencies have sponsored a program to install handpumps, but such pumps do not penetrate the earth very deeply. They sometimes fail to deliver quality water and even go dry in certain seasons. Some are installed where crops are served by deep tubewells.

The Rural Development Academy at Bogra is conducting an experiment in one village in which a deep tubewell near the village is used for drinking water when it is not irrigating. An overhead tank was built, and water is piped to several village locations. Five water outlets each serve 20-25 users. In return for the water, the villagers keep tabs on the well.

No one is sure the experiment will work; there are some problems. For example, the well is owned and operated by a cooperative, and many of the users are not members of the cooperative. But if the venture succeeds, it may suggest a way to solve drinking water and irrigation problems at the same time.

This integrated approach has increasingly become a characteristic of Bangladeshi agricultural research. Although the research network focuses on crops (their breeding and cultivation) and lists its research achievements mainly in these terms, it has also found time for research in a number of areas that serve all crops.

Nuclear agriculture, of course, is a research technique employed for a variety of crops. But if crops are to be successful and meet the food and fiber needs of the country, there must be soil in which they can grow, water to nourish them, power to assist in the farm work, and germplasm for breeding. Finally, crops must be processed from harvest to market. This is "complete agriculture."

The Nuclear Approach

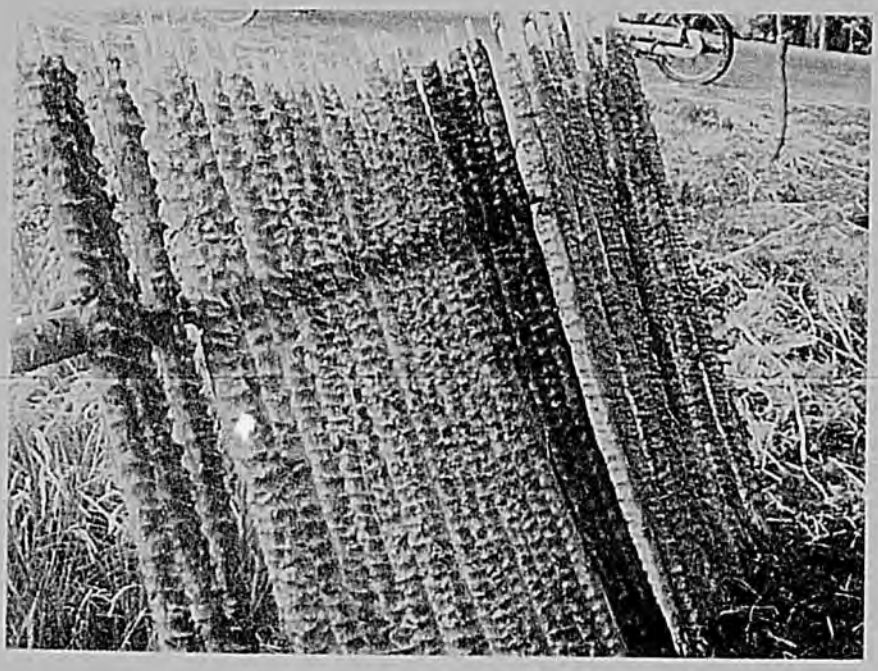
The International Atomic Energy Agency (IAEA), based in Vienna and set up by the United Nations to champion the peaceful uses of atomic energy, sponsors the establishment of research facilities to apply nuclear techniques, including radioisotopes and ionizing radiation, to agricultural problems. One such facility has been established in Bangladesh.

The nuclear approach was applied as early as 1961 in East Pakistan at the Atomic Energy Agricultural Research Center. The center became an institute in 1972 and moved to its present location in Mymensingh in 1975. With facilities provided by a grant from Sweden, the institute now has modern buildings and demonstration plots on the campus of BAU.

For 10 years, however, the nuclear agricultural institute suffered from status problems. Isolated organizationally, it was outside the mainstream of agricultural research and was regarded as something of an impostor by the older research agencies. Salaries and promotion possibilities were not attractive, and the institute could not assemble its full staff complement.

Nuclear researchers argued that they were doing the same work as the other institutes, only with different techniques. The research program was organized around problems rather than disciplines or crops. The emphasis was on mutation breeding of new crop varieties and efficient fertilizer use, all mainstream concerns. These arguments finally prevailed, and in 1986, the Mymensingh group was given full status under the agricultural ministry as the Bangladesh Institute of Nuclear Agriculture (BINA). The new recognition has improved morale noticeably.

Nuclear research now forms an integral part of the national agricultural research system. The programs tries to augment crop production in the country through nuclear techniques by using physical and chemical mutagens and radioisotopes. The principal activities center around removing



production constraints that are difficult to eliminate through conventional methods. Improved varieties of crops, agronomic and soil-plant relations, scientific management of land and water, and pest and disease management practices are all BINA concerns.

For example, the high-yielding rice variety IR-8 takes about 165 days to mature in the boro season. A mutation project was initiated to shorten the long growing period. Out of this project, two high-yielding and early-maturing mutant varieties were released: IRATOM-24 and IRATOM-38. These mutant varieties mature two weeks earlier than IR-8 in both aus and boro seasons. IRATOM-24 has become quite popular with farmers and is being cultivated in various parts of the country.

Seeds of the two most important jute varieties, D-154 in the *deshi* type and Chinsure Green in the *tossa* type, were irradiated; and two improved mutants have been developed in the *deshi* type. One of these, Atompat-38, which has a 15 percent higher fiber yield than D-154, was released in 1980. The other, Atompat-36, is resistant to stem-rot disease. This mutant equals D-154 in yield in normal years, and produces a better yield in years with a high disease incidence.

A mungbean strain having 15 percent higher seed yield than the recommended variety, Kishoreganj, as well as tolerance to cercospora leaf spot disease, has been selected from an unknown cultivar collected in the

The Effect of Gamma Rays

The key word in crop improvement is *variability;* where variability is limited, improvement is not likely. Crops like jute and pulses have a limited number of varieties, and most crop varieties have one or more shortcomings. Nuclear techniques are valuable because they can create the all-important variability.

In varietal improvement through nuclear means, the seeds of target crops are treated with gamma rays or chemical mutagens. These materials bring about changes within the genetic material of the existing cultivars, thereby giving rise to hitherto unknown types. The variability thus created offers opportunities for improving the yield potential and nutritional quality of the crops.

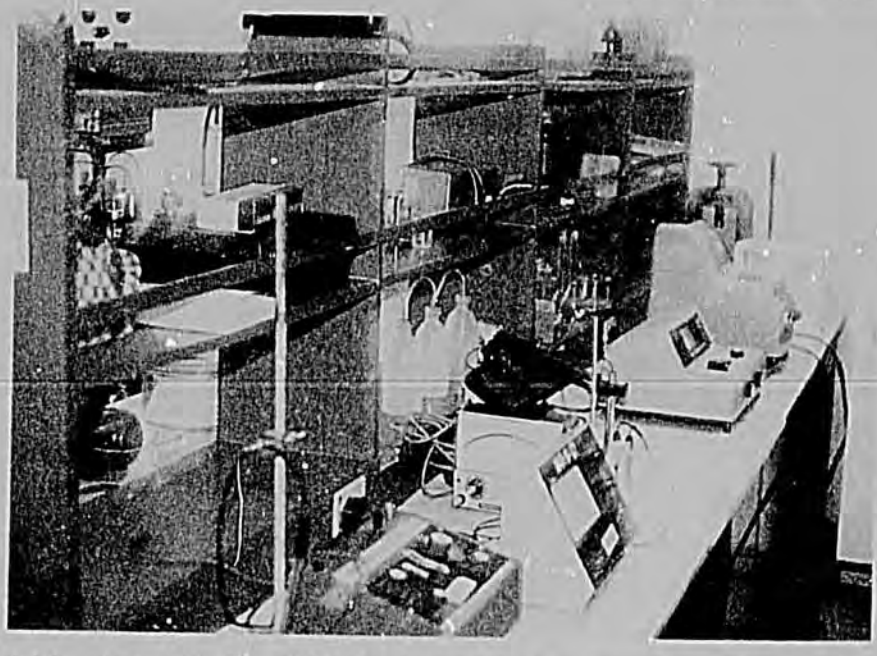
Chittigong area. In addition, a number of mungbean strains have been developed that either resist or tolerate diseases like yellow mosaic virus, powdery mildew, and cercospora leaf spot. Summer-type mungbeans have been developed for cultivation in the Barind tracts through time-of-sowing and adaptability studies on exotic germplasm.

Through the application of gamma rays on three cultivars (two local and one Indian) of blackgram, it has been possible to isolate mutants with various desirable characters such as erectness, upright podding, and tolerance to diseases. Some of these varieties are high-yielding and promising producers.

To cite a final varietal improvement, a chickpea (Bengal gram) mutant has been developed through seed irradiation from the recommended variety, Faridpur-1; the mutant variety was named Hyprosola. It has both 20 percent higher seed yield and 4 percent higher protein content than Faridpur-1. Considering the two factors together, Hyprosola gives 45 percent increased protein per hectare—an astonishing example of varietal improvement. Hyprosola was released in 1981.

Tracer elements are important in nuclear agriculture because they play a critical role in the study of the movement of fertilizer nutrients inside the plant and in the soil. Basically, they trace the fate of the fertilizer applied—how much is being taken up by a particular crop, how much is lost, how much is retained in the soil. Answers to these questions are necessary if the proper fertilizer applications for maximum crop production are to be developed.

BINA has been active in finding the answers. Studies on fertilizer application in rice indicate that phosphate may be surface broadcast and worked into the soil to obtain increased yield. In heavy-textured soils, and under



A laboratory at the Bangladesh Institute of Nuclear Agriculture. BINA tries to develop greater variety in seed types.

controlled irrigation conditions, the application of nitrogen fertilizer in one dose before transplanting is as effective as two half-dose, or split, applications. In light soils, two or three split applications may be required, depending on crop conditions.

A survey on the amount of zinc present in the rice leaf and soil of different districts revealed zinc deficiency in most areas of Bangladesh. Experiments with isotopes of zinc showed poor utilization of fertilizer zinc. Zinc at 5 kg per hectare has been recommended for general application on wetland rice cultivation. Twice that dose may be used in acutely deficient soils.

Another study revealed that zinc sulphate is a suitable source of zinc and that application at transplanting is better than at later stages. A number of rice genotypes of the boro type were tested for tolerance to zinc deficiency, and none was found to be tolerant.

BINA has also made contributions in crop protection and crop quality assessments. The mutants developed and the germplasm collected by the plant breeders have been screened against some major diseases and insects to identify resistant/tolerant genotypes. The mutants released as varieties have also been tested.

BINA Objectives

1. To develop high-yielding and better quality crop varieties, using both mutation and conventional techniques.
2. To assess the efficiency of utilization of applied nutrients by crop plants using radioisotope techniques.
3. To improve water-use efficiency for optimization of crop yields through radioisotope and radiation techniques.
4. To evolve control measures against major pests and diseases of crop plants.
5. To assist national and international research programs through cooperative support.
6. To provide facilities to students of BAU for carrying out research leading to the advanced degrees in agriculture.
7. To sponsor training programs for research scientists in the peaceful uses of atomic energy in agriculture.

Quality assessments of various crops have been conducted. For example, BRRI's entire rice germplasm collection (over 2,500 accessions) was analyzed for various quality characters. Protein content varied from 4.5 percent to 14.2 percent. Tomatoes' vitamin C content was found to increase with the weight of the fruit. In mustard, yellow-seeded forms were found to have a lower percentage of seedcoat and fiber than brown ones.

With results like these, nuclear agriculture has apparently established itself as a valuable research component in Bangladesh. BINA is proud of its test plots, its laboratories, and its library, and is prepared to put its special mark on researching any appropriate crop.

Feeding the Soil

When the sun is bright in the countryside, they can be seen leaning against every farmhouse. Dung sticks, usually jute stems with a big coating of animal manure, are more readily available than wood, and "making fuel while the sun shines" is an old Bangladeshi custom. The soil scientists cringe at the sight. Although they are sympathetic to the fuel problem, they are convinced that dung should be feeding the soil instead of the fire.

In 1962, a soil survey department was created in Bangladesh as a joint project of FAO, UNDP, and the government of Pakistan. Its first function was to survey the country's soil. Since that time, detailed surveys of soil moisture and variability have been carried out to meet the research needs of various clients.

Improving the Pulse Rate

"All pulses have the ability to fix atmospheric nitrogen through activities of *Rhizobium* bacteria living in the root tissue. This nitrogen is subsequently released to the soil for the next crop. Inoculation involves the placement of suitable strains of *Rhizobium* in the soil so that symbiosis results. Annually, 50-100 kg/ha of nitrogen may be fixed by such bacteria, which means that the next crop may not need any additional fertilizer. Even if it does, the amount would be small. Further evidence suggests that while *Rhizobium* fixes atmospheric nitrogen, which benefits the next crop, there is a direct effect of such association on the legume (pulse) crop itself, which is reflected in higher yields."

—Dr. S. H. Khan, Head, Plant Breeding Division, BAU

Soils take hundreds or even thousands of years to develop, and they cannot be easily replaced if they are degraded, misused, or washed away. Soil management is thus a necessity for sustaining crops.

Many soils in Bangladesh are worn out because little thought was given to their role in food production and the preservation of the environment. As a result, crop yields are low in relation to those of other nations. The soils need life breathed into them with fresh organic material. There is hardly enough animal manure to do the job, and manure does not have all the necessary properties at any rate.

Farmers are using more chemical fertilizer than ever before, but it is still not enough. Bangladeshi farmers use about 20 kg of nutrients (mainly NPK—nitrogen, phosphorus, and potassium) per hectare, but crops remove about 150 kg per hectare. More fertilizer would seem to be the answer, except that chemical fertilizers are costly and Bangladeshi farmers are poor. Thus other methods, such as legumes in rotation and crop residue management, must be used.

Bangladeshi soils are deficient mainly in nitrogen, phosphorus, and potassium (the most important elements), and sulphur and zinc. Salinity and acidity are excessive in some places, and there is some soil erosion. Poor drainage and organic matter depletion are also problems. Considerable research documents the soil deficiencies (which many farmers ignore) and suggest corrective measures.

Nitrogen levels are low in Bangladeshi soils because of decomposition of organic matter, rapid removal of mineralized products by leaching, and crop removal. Urea is the main source of nitrogen fertilizer, and its use by farmers has tripled since the early 1970s. Crop recovery of applied nitrogen

Puddling and Ploughpans

"A ploughpan at 5-10 cm below the soil surface is common in most Bangladesh soils. This pan is formed because of puddling for rice cultivation using the traditional country plough. It is good for the cultivation of rice but detrimental for dryland crops. This compact layer impedes internal drainage [and] constrains root penetration downward and the upward flux of nutrients and water from the subsoil. Thus, roots exhaust nutrients and moisture from the shallow topsoil layer above the pan while adequate nutrients and water lie below it. Soil tillage and planting practices need to be studied to overcome this problem."

—Dr. M. S. Islam, Principal Scientific Officer, BARI

is low (10-40 percent for rice, for example) for a variety of reasons, including poor crop and soil management. A balanced supply of major, secondary, and micronutrients is very important to efficient and profitable use of applied nitrogen.

Research throughout the country has shown that two or three split applications of nitrogen give higher yield for most crops than the same amount of nitrogen in a single application at planting. Applications of nitrogen at sowing, tillering, and the beginning of heading are the most efficient for high-yielding varieties of wheat. For rice, the applications should come at transplanting, tillering, and panicle initiation.

The application of preparations containing specialized live bacteria can enhance soil fertility and crop yield. The preparations render unavailable sources of elemental nitrogen, bound phosphates, and cellulose-containing plant residues into available forms so that the root system of the plant can absorb the nutrients. In recent years, the shortage of expensive nitrogen and phosphate fertilizers has created renewed interest in the biological fertilization of the soil.

BAU has made much progress in the field of biological nitrogen fixation, its researchers having isolated rhizobial strains from *mashkalai* and *khesari*, collected from pulse-growing areas. Research on rhizobial strains is also underway at BARI. After isolating and screening a large number of strains, BARI scientists found that ICARDA-5 and a local strain from Dinajpur were most effective on the chickpea. In a field experiment, an inoculation with ICARDA-5, combined with a dose of 20 kg per hectare of nitrogen, increased the chickpea yield by 70 percent; the same nitrogen dose without the inoculum produced only a 20 percent increase.

Cow dung as paddy fertilizer. Manure is widely used to enrich the soil.

Although some Bangladeshi farmers still believe that potassium is not deficient in their soils, this is no longer as true as it was in the past, due to the intensification of agriculture. The addition of potassium has brought numerous improvements in crop response. While some studies have shown the country's soils to be rich in potash-bearing minerals, recent responses to the element indicate either that previous supplies have been exhausted or that their rate of release is too slow to satisfy the demand, given the intensive cropping practices.

Bangladeshi soils are generally well-supplied with magnesium and calcium, but are deficient in sulphur and micronutrients, especially zinc. BRRI was the first institute to discover and identify zinc and sulphur deficiencies in the wet paddy fields, the discovery occurring first in some plots at Joydepur and later in places all over the country.

In trials conducted at the BRRI farm and in nearby farmers' fields, the sulphur deficiency was corrected by the application of either gypsum or ammonium sulphate. In trials at Tebnia and Gournadi, increases in both grain and straw yields were achieved by applying zinc sulphate or by dipping seedling roots in a 2 percent zinc-oxide suspension.

Little adaptive research has been done in Bangladesh on soil erosion, which is moderate to severe in the hill farming areas. Studies elsewhere indicate that crop management and continuous crop cover resulting from good soil fertility are the best erosion controls. Reduced tillage is also a possible solution. Research preference is being given to techniques that increase crop cover, reduce water run-off, and increase infiltration.

About 2.5 million ha of land in coastal areas are affected by soil salinity, derived from tidal flooding with saline water during high spring tides; the dominant salts in the saline soils are sodium chlorides. In some areas, monsoon rainfall is sufficient to control the problem, but crops on the coastal fringe can be affected by saline incursions during exceptionally high tides or by late or low monsoon rainfall. Unfortunately, little data on specific leaching requirements and fertilizer-use recommendations for saline areas are available.

From 1976 to 1981, soil moisture investigations were conducted on the Ganges floodplain, which is the most extensive soil parent material in Bangladesh. The studies used 5 years in order to overcome problems caused by the year-to-year variability in weather and flooding conditions. Seven soil series were examined on 12 sites at four locations. The findings as a whole constitute a wealth of information to guide farmers on drainage, length of growing season, and irrigation requirements.

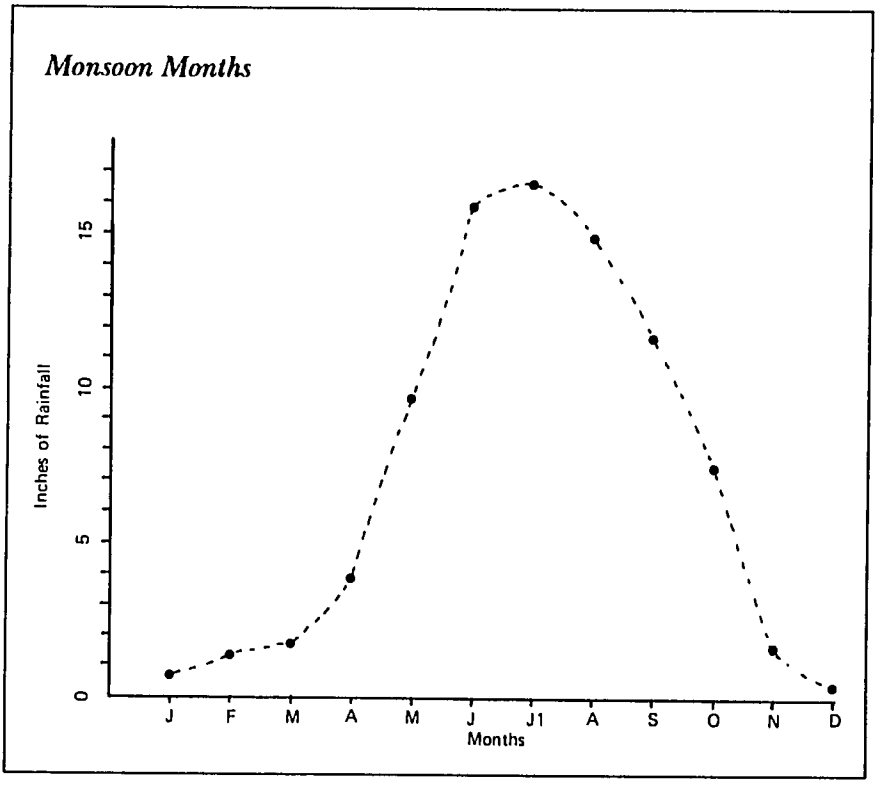
With the available cropland circumscribed by water and overloaded with population, Bangladesh will continue to have problem soils. They may be degraded, saliferous, eroded, waterlogged, acidic, and depleted of organic matter. Soil scientists will have their hands full for generations.

The Ways of Water

The Ganges and Brahmaputra, the monsoon, 80 inches of annual rainfall—these are the images of Bangladesh. Or perhaps it is the deepwater rice harvesting, a flotilla of boats circling on what appears to be an endless lake. Or the world's longest beach, a ribbon of sand stretching 100 miles at Cox's Bazar, or the endless mangrove swamps of the Sundarbans.

Whatever one's image of the country, it is likely to be of water. That being the case, it is hard to imagine parts of even this small country where not enough rain falls to allow crops to flourish, where drought is the number one problem. But this is so, because such are the ways of water. Agricultural research must deal with both soils that have too much water and soils that have too little.

Most of Bangladesh lies less than 20 meters above mean sea level. Rainfall varies widely in the country, from about 140 inches a year in Chittigong to



less than 55 in Rajshahi. Although the overall rainfall is plentiful, 90 percent of it occurs in the six monsoon months from May through October. Thus, the winter in the northwestern part of the country is dry indeed.

About 75 percent of the country's land area is now cropped. During the dry season, the available water (50 percent of the discharge of the Ganges, Brahmaputra, and Meghna; 60 percent of the discharge of minor rivers; and all extractable groundwater) is not sufficient to irrigate the entire cultivated area. About 15 percent of the cultivated area is now irrigated, and this amount could be increased. However, large-scale withdrawal from the minor rivers will greatly increase salinity in the southern part of the country, adversely affecting future agricultural development. The aggregate demand for water for all uses—navigation, fisheries, municipal, and domestic uses, as well as irrigation—must be met by the available groundwater and surface water as fed by rainfall, and the supply is finite. Still, irrigation water is regarded as a priority. Most irrigation water is groundwater, although some surface water is moved to crops.

Predicting the Agro-Weather

"Understanding the relationship between weather and agricultural production is essential to effective research planning. Agro-meteorology deals with the influence on agriculture of various weather variables, namely, temperature (both soil and air), humidity, wind speed, sunshine hours, rainfall, and evaporation. Agro-climatology is the interpretation of the climate over a long period in terms of the most suitable form of crop production. In a broad sense, agro-meteorology is concerned with atmospheric processes whereas agro-climatology deals with the results of these processes. Inputs of meteorological data are essential to determine crop and water requirements on which planning, design, and operation of both rainfed and irrigated agriculture largely depend. The main application of agro-meteorological knowledge is in the planning of farming practices for agricultural development."

—*National Agricultural Research Plan.* 1984, p. 121.

Irrigation is applied to most major crops, but cereals lead the list by a wide margin, especially boro rice. An increasing amount of irrigated acreage is allotted to wheat, and potatoes occupy about 4 percent of the irrigated acreage. The amount of land being irrigated has steadily increased since independence, and modern methods for delivering water are being used more frequently. Swing baskets and dhones are being replaced by low-lift pumps and deep and shallow tubewells.

The adoption of the newer technology has brought some problems, including over-use of subsidies, inequities in the distribution of the technology between large and small farmers, and lack of adequate maintenance and repair parts. In addition, pumps have not always performed up to rated capacity. But on the whole, the spread of irrigation facilities has been a positive development.

Even so, it is now recognized that creation of facilities alone will not solve all the irrigation problems. Expanded facilities are a prerequisite for irrigation, but if maximum benefit is to be derived, improved on-farm water management is needed.

Water management is both art and science. It demands a knowledge of water, soil, climate, crops, and agricultural inputs, and of how these elements interact. It includes everything from the production of water to the disposal of water after its use. It emphasizes not only the delivery of water but also the cultural practices that maximize water-use efficiency, agricultural productivity, human welfare, and net farm income. It sees watershed

management, water impoundment, power generation, water delivery, on-farm management, and drainage as part of an interlocking system.

Some of the most significant research has been done in the area of water requirements for particular crops. Some data are available for rice, wheat, potatoes, mustard, cotton, pulses, and maize. The studies were carried out under field conditions at experimental stations.

For example, several studies found that the performance of high-yielding rice was not significantly affected whether rice is grown in continuously submerged soil or with alternate wetting and drying. A cycle of submergence for 10-15 days, then drying up to the point at which the soil cracks should be maintained throughout the growing period. But standing water must be kept in the field during the ear's emergence.

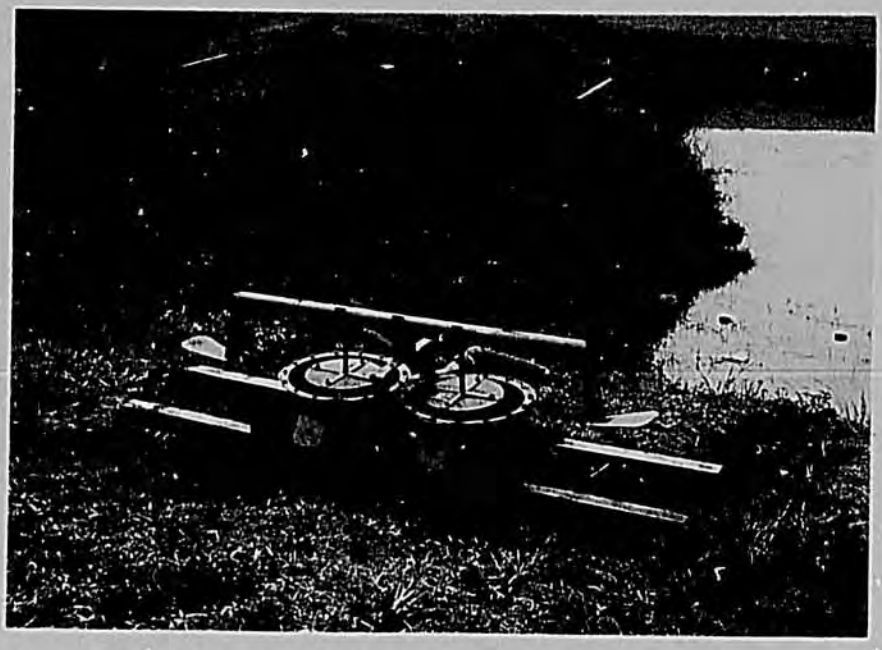
The preferred drying periods are after seedling establishment, after completion of tillering, the post-milk stage, and the late-ripening stage. Consumptive use of water was much higher under a standing water regime than under alternate wetting and drying. A considerable amount of water can be saved to cover additional areas by growing rice with alternate wetting and drying.

There has been some testing of water quality. Some river waters in coastal areas were graded, and poor water for irrigation was found in several places. Salt accumulation was reported to be increasing, leading to the degradation of soil properties (such as permeability and water-holding capacity) and formation of poorly crystalized iron oxides, giving poor tilth and consequent reductions in crop yields.

Although groundwater is mostly saline in coastal tracts, little is known about groundwater quality in non-coastal areas. Farmers from a number of tubewell sites in northern districts reported the deterioration of soil properties due to irrigation water. An examination confirmed that these tubewell sites contained dissolved salts.

Among cultural practices, tilling methods have received a lot of attention from researchers. One finding is that seeding wheat just after the harvest of transplanted aman rice with no land preparation can produce considerably higher yields under rainfed conditions. This no-tillage practice conserves soil moisture and time. Farmers are now using this technique at several on-farm research sites under BARI supervision.

Also, the effect of minimum, conventional, and deep tillage were compared under rainfed conditions. The maximum wheat yield of 2.25 tons per hectare, a 36 percent increase in yield over the conventional tillage, was obtained from deep tillage to break the ploughpan. The improved yield was thought to be accounted for by the ability of the plant to reach residual soil moisture in deep soil layers.



A water pump developed at BRRI. How to move water more efficiently is always a challenge to Bangladesh agriculture.

One area that is in need of further research is the role that farmers can play in water management. Since they are the ultimate users of an irrigation system, their behavior is likely to determine how the system performs. The demands required by the design or by the operation and maintenance plan are the demands that the farmer bears; if plans are made and not implemented, the system fails.

Yet it is not common to involve farmers in the planning. If they participate at all, they do so by contributing labor to the maintenance of field channels or by paying fees for water. Evidence, including cases from Asia, suggests that irrigation projects can be improved if farmers are involved at the outset. Although the Bangladesh Rural Development Academy is involved in work of this kind, it has not yet had much impact on the research network.

Animal Power

Judging by the number of times the picture has appeared in development publications, the Western metaphor for the Third World is a brown-skinned boy on the back of a water buffalo. He may be playing a reed whistle, swinging a small stick, or just lounging about, but he clearly feels comfortable on his perch. Meanwhile, the massive animal either grazes contentedly or plods placidly along the road.

Perhaps the metaphor has been used so much because it is so apt. Boys with buffaloes, or with bullocks, are a regular sight in Bangladesh. Although a tiny pony appears on occasion, mostly bovine animals pull the carts and plows and trample the wheat. In return, they are tethered safely at the homesite, fed paddy straw, and frequently bathed in the ponds.

The country has about 20 million cattle, perhaps 9 million goats, and much smaller numbers of sheep and buffaloes. The cattle are most important because they do the bulk of the agriculture-related work. The cost of plowing, threshing, and transporting represents anywhere from 20 percent to 40 percent of the total cost of producing major crops.

In addition, cattle dung, half of which is either left in the fields or spread as fertilizer, has an annual value about equal to 200,000 tons of chemical fertilizer or 600,000 tons of rice. Cow dung used as fuel is worth about 1.5 million tons of crude oil. All told, livestock contribute nearly 9 percent to the gross domestic product. Hence, cattle represent a significant investment.

The indigenous Bangladesh cattle, referred to collectively as desi, are small creatures that are poor milk producers; they are late-maturing and slow-growing. Mature cows weigh 160-200 kg, produce 500-600 kg of milk per lactation, and calve every 2 years. Calves weigh only 17 kg at birth. (Buffaloes are similarly sub-standard.)

The average weight of the cattle has decreased over the past 20 years because of a decrease in the feed supply. The feed available to livestock, especially cattle and buffaloes, is much below nutritional requirements—45 percent deficit in dry matter; 50 percent deficit in digestible nutrients; and 80 percent deficit in crude protein. Average cattle weights are now 25-30 percent below those in India.

Government plans for livestock include an intensification of the existing artificial insemination program. The present program collects fresh semen from bulls held at district centers and distributes it to insemination centers at thana offices. The bulls used for semen production come from the cattle breeding station at Savar and include the crosses of Friesian and Holstein, Jersey, Sahiwal, and Sindi.

After cattle, goats are the most important domestic animals. They are kept by most rural households and exist mostly by scavenging. Bangladeshi goats

Getting Your Hide Tanned

The export of skin and hides is the third most valuable earner of foreign exchange in Bangladesh. Several hundred tanning industries, many of them small cottage industries, cluster around Dhaka and Chittigong; a few factories make shoes, belts, and purses.

The biggest constraint to the expansion of the tanning industry is the limited amount and low quality of raw materials. Domestic animals are rarely asked to sacrifice their hides until their pulling and ploughing days are done, so the hides that go to market are often cut or otherwise damaged. Tanneries supplement this meager supply with the skins of wild animals and snakes.

An increase in cattle production could give a boost to an industry that employs a fair number of people.

are small but are prolific breeders, with each female producing, on average, 2.8 kids per year. When handled properly, the skins of the Bengal-breed goats produce a very high quality leather, which is a lucrative export.

Probably no sector of the economy has more room for improvement than livestock. If the quality of the national cattle herd could be raised, if animal health could be improved, and if better fodder could be found, the result would be stronger animals, higher milk yields, more protein in the diet, and even better hides for the tanneries.

It must candidly be noted, however, as the BARC member-director for livestock has said, that livestock is neglected from a research point of view. It has not been a priority area in development plans and thus not a favored target for financing.

One reason is probably psychological; land is so scarce in Bangladesh that it is difficult to think of the country as a producer of cattle. Where would they graze? Obviously, cattle improvement cannot mean vast Texas-style grazing herds. It can mean better-bred cattle receiving better fodder and more veterinary care. Research is crucial in these areas.

Unfortunately, livestock research, such as it is, has not been able to "get its act together" in Bangladesh. A number of livestock research institutions are scattered around the country, but they have only a loose association through the agriculture ministry. Several of them mix research and production.

The institutions include Bangladesh Agricultural University; the Veterinary Research Institute and Livestock Research Institute in Dhaka; the Central Cattle Breeding Station and Central Poultry Breeding Station at Savar, near Dhaka; the Animal Husbandry Research Institute in Comilla; the Sheep Development Farm at Noakhali; the buffalo farm at Tejgaon; and disease investigation laboratories at various sites.

Cattle in the fields. Animals are the main source of power for Bangladesh farmers.

These institutions represent much infrastructure but not much useful research. Most of their hundreds of projects have been ad hoc projects without follow-up, and much of the research has been of more interest to the researchers than to the millions of farmers who own livestock. A recent review of the studies undertaken found it hopeful that two-thirds of the livestock studies underway could be considered relevant to farmer problems; only one-third of the completed studies were relevant!

It is difficult to get reliable information on the diseases of cattle in Bangladesh. It appears that some of the major infectious diseases have existed since the introduction of cattle into the region by migrants and invaders from central and west Asia. The earliest report on the prevalence of foot-and-mouth disease, rinderpest, and septicaemic pasteurellosis in the cattle of Bangladesh, for example, was written by a British scientist in 1867.

Use Urea and Urine

With support from the Danish aid agency (DANIDA), BAU conducted several studies aimed at finding ways of increasing the ammonia content of paddy straw fed to cattle.

One study concluded that the urea treatment of straw increases the nitrogen content and the digestibility of its nutrients and promotes better growth responses with calves and increased milk production in dairy cows. It was noted that spraying fibrous materials with urea and storing them is technologically simple, and the practice, with adjustments as necessary, was recommended to farmers in their homesteads.

In a companion study, 12 male calves were used to test the health aspects of using animal urine as a source of ammonia for treatment of straw. The trial lasted 105 days and revealed no negative effects of using animal urine in this way. The performance of animals fed on urine-treated straw was not different from that observed on animals fed straw treated with urea as a source of ammonia. Both performed significantly better than the untreated control group.

Studies since independence have confirmed the presence of dread diseases, but little has been done to deal with them. Bovine tuberculosis is present. Brucellosis was found to be more prevalent in organized dairy farms than in rural areas, although pockets were found in certain herds and villages where the rate of infection was 63 percent. The presence of subclinical mastitis due to brucellosis poses a great threat to human health. Milkers, dairy workers, and agricultural workers were found to be serologically positive to brucellosis.

Rabies, viral diarrhea, papillomatosis, blue tongue, humpsore, gastrointestinal parasitosis, yoke-gall, nasal schistosomiasis—the list goes on and on. A British veterinarian working for the U.K. aid agency, when encountered at BAU and asked about the state of Bangladesh veterinary medicine, shakes his head sadly.

There is an urgent need for coordination of effort, for better utilization of facilities, for the accumulation of trained manpower. None of this is possible when research is scattered through many organizations. In late 1986, the World Bank was working with the government of Bangladesh to pull together the disparate livestock groups into a real Bangladesh Livestock Research Institute, to be located at Savar. If completed, this would be a positive step forward in Bangladesh livestock research.

Banking on Genes

Dhaka's posh Hotel Sonargaon is one of the institutions in Bangladesh in which the Japanese have invested. They have other investments that may be less glamorous but which will probably be of more long-run benefit to the country. One is the gene bank at BRRI. The building and facilities that house some 5,000 pieces of rice germplasm were constructed with aid from Japan. Meanwhile, the Germans have backed a similar facility for BARI. Suddenly, everyone is banking on genes.

A catastrophic loss of genetic diversity in crop plants has been taking place in the last several decades. With the spread of modern agriculture and the replacement of traditional varieties by new high-yielding strains with a narrow genetic base, the variation in major crops is disappearing at an alarming rate.

Plant breeders need genetic diversity if they are to continue to develop varieties with high yields and disease resistance. Recognition of this need has meant an increase in efforts to collect and conserve crop genetic resources in many parts of the world.

Accurate, up-to-date information about the availability of germplasm is as important as its collection and conservation. Exchange of information makes it possible for samples in storage to be used quickly and efficiently as breeding or research materials.

Like most scientific subjects, germplasm is no respecter of national borders, so international cooperation is necessary. Prominent in such activities is the International Board for Plant Genetic Resources (IBPGR). It stimulates cooperation directly through funding and indirectly by mobilizing expertise to establish a number of long-term gene banks for germplasm conservation.

The IBPGR promotes continuing interaction in germplasm matters between the south Asian countries of Bangladesh, Bhutan, Burma, India, Nepal, and Sri Lanka. Liaison officers from these countries first met in 1981 and have continued to promote genetic resource programs.

In 1979, Bangladesh set up a national plant genetic resources unit to coordinate the germplasm collection and evaluation movement. Also, the research institutes that have a monocrop focus maintain their own gene banks, assembling the collections from local and exotic sources.

BRRI has cooperated with IRRI in collecting rice samples. BARI, assisted in some cases by foreign experts, has collected germplasm for pulses, oilseeds, and other crops. Similar efforts have been made by BJRI for jute and SRTI for sugarcane, and BAU and BINA also maintain germplasm. At present, nearly 20,000 pieces of germplasm are held at these six research ins-titutions, and forestry and tea researchers have also moved into the field.

Germplasm Stocks Available

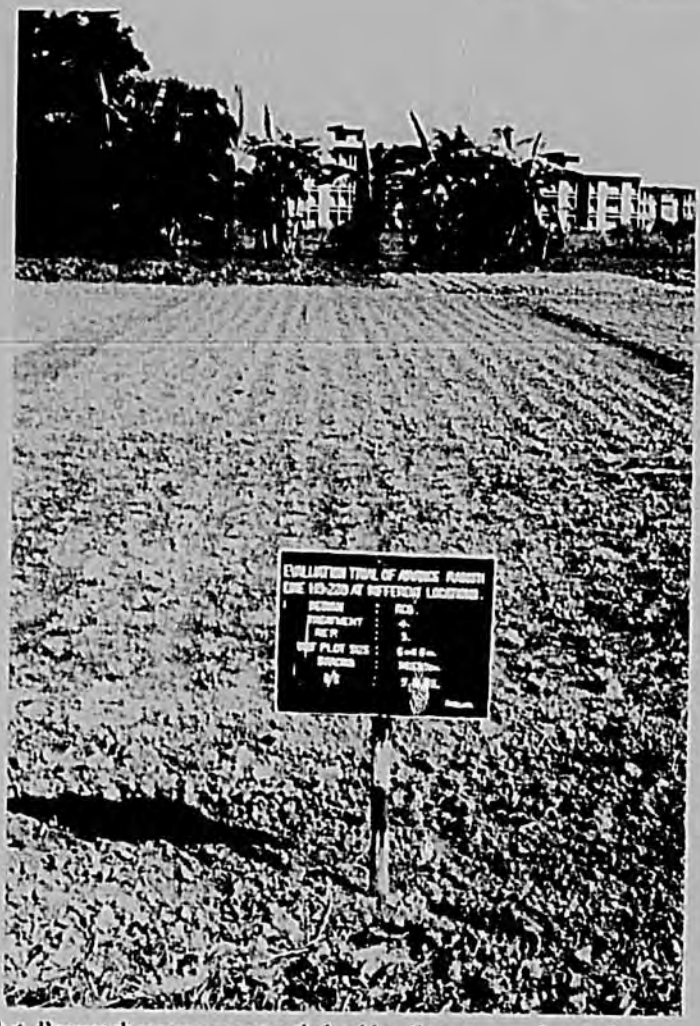
Barley	Grasspea	Sorghum
Blackgram	Groundnut	Soybean
Brinjal	Jute	Sugarcane
Chickpea	Lentil	Sun-hemp
Chili	Linseed	Sweet Potato
Coriander	Maize	Tobacco
Cotton	Mustard	Tomato
Cowpea	Pigeonpea	Tumeric
Dolichos	Potato	Vegetable Brassicas
Flax	Rice	Wheat
Garlic	Sesame	Winged Bean
Ginger		

The materials held at all the research institutes undergo constant evaluation. Selections have been made from available germplasm for sources of resistance to diseases and insect pests in cereals, pulses, oilseeds, vegetables, and other crops. BRRI has started to utilize the germplasm in crossing programs for disease resistance in rice. BARI and BINA have screened hundreds of materials of greengram and blackgram for yellow mosaic resistance. The Mubarik mungbean variety, released by BARI in 1982, was the result of selection from available germplasm.

The experiences of BJRI in collecting germplasm are instructive and suggest the problems encountered. Local types of jute have been collected gradually from all parts of Bangladesh since the beginning of this century. Since the jute was growing in a virtually closed environment, it has not been possible for collectors to avoid duplicates, the morphologic differences between strains being slight.

White jute is produced mainly on Teesta and Brahmaputra alluvial soil, while tossa jute is characteristic of the Ganges flood plains. Peat and gray calcareous soil produces kenaf while flood-free and rough terrains produce mesta. Since the varieties of jute being grown today were mainly cultivars released by BJRI itself, pure forms of new types have not been found. New isolates are either formerly eroded cultivars or natural hybrids that are not commercially attractive.

In 1978–79, however, extensive expeditions were made into the districts of Chittigong, Chittigong Hill Tracts, and Sylhet, areas where jute has not been grown commercially. Newer and varied types were collected from local homesteads where the plants were used mainly as herbs. The varieties collected included all four of the bast fiber species of commercial importance.



A test plot. Researchers are constantly looking for new seed varieties.

"Kitchen garden" collections are particularly prized. The genetic diversity of the crops in such places is often very high, having suffered little from genetic erosion. The diversity of nearby field crops, though, may have disappeared completely. To cover a wide range of variability, samples are collected from several adjacent gardens or even all gardens in one locality.

To add to the local species, FAO assisted BJRI in obtaining white and tossa jute strains from Thailand, Japan, Taiwan, Guyana, Brazil, Indonesia, the Philippines, Egypt, the United States, and the Soviet Union. BJRI itself obtained kenaf varieties from the United States and Iran. Casual collections of tossa jute, kenaf, and mesta have also been made during visits for other

Seeding the Farmers

The Bangladesh Agricultural Development Corporation (BADC) is responsible for the production and distribution of high-yielding varieties (HYVs). Introduction of HYVs has been mostly for rice, wheat, and potatoes. All HYV seeds for rice and some of those for wheat are produced locally; other wheat and all potato seeds are imported.

BADC has an established procedure for distributing local, high-yielding variety seeds. First, cereal seeds are multiplied on 20 BADC farms ranging from 100 to 3,000 acres in size and located throughout the country. Second, the seeds are mass-produced under contract with individual farmers. Third, the mass-produced seeds are cleaned, treated, and certified at nine different BADC processing centers with a storage capacity of 12,000 tons. Finally, the seeds are distributed to farmers.

After the initial planting of HYV seeds, farmers save their own seed and do not seek annual replacements from BADC. Thus, a decrease in BADC seed distribution does not necessarily mean a drop in production.

purposes to Kenya, Uganda, Tanzania, Zaire, Sudan, Ethiopia, Mozambique, Nigeria, and Nepal.

It is apparently BJRI's intent to serve as a repository for a world collection of jute germplasm. Such a repository does not now exist, and Bangladesh, one of the few spots on earth where jute is grown extensively, would seem to be a likely place for it. BJRI has the facilities.

There are nursery plots in six stations (in all the jute-growing regions of the country), as well as at the central research station at Manikganj and near the gene bank in Dhaka. There are also several "glasshouses" (greenhouses) with systems for controlling light intensity, quality periodicity, temperature, humidity, and soil moisture. These are needed for year-round characterization and evaluation of germplasm.

BARI has taken some steps toward becoming the "national gene bank." With funds provided by IBPGR and the German aid agency (GTZ), a major facility has been built at Joydepur. BARI intends, in cooperation with the other research institutes, to store all the available germplasm of seed crops in the country in a central gene bank. Whether the crop institutes will be willing to give up their prized collections remains to be seen.

Beyond Technology

Jahamara Begum has two children and a husband who works in town as a rickshaw-puller to provide the family with cash income. She is the cooperating farmer on a farming systems research site near Jessore. She grows the crops and harvests them, gathers the water and fuelwood, tends the cow—getting what help she can from her husband and children.

But Jahamara's work is just beginning when the crops are harvested. She winnows and dries the rice after it is parboiled, spreading and sweeping it on the roadway; she washes the little jute that the family grows in a nearby pond, not the best quality water for the purpose but the only water she has available; and she performs dozens of other little chores to make sure there is food to eat.

The family eats as well as it can, but it is poor and has no extras. Both Jahamara and her husband burn a lot of energy in work, so both of them are very thin and have difficulty handling heavy loads. Both of the children are undernourished.

Because she has major farming duties, Jahamara may not be a typical rural woman, but her role after harvesting is certainly common for Bangladeshi women. The men take the food and fiber to market, but the women do much of the processing.

Post-harvest technology has a powerful impact on agricultural output, but it extends beyond the traditional bounds of agricultural research into business and engineering. It also raises social and economic questions for researchers in all sectors. The Institute of Food Science and Technology (IFST) has primary responsibility for post-harvest handling and preservation of foods, and a number of the universities are involved as well. Several of the agricultural research institutes also make contributions.

The post-harvest studies done by IFST primarily relate the technology to nutrition. For example, the institute has devised ways to improve parboiling of rice to retain more than 70 percent of the thiamine. The rancidity of rice during village storage has also been studied. Another project on farm-level storage and processing of pulses found that rodents and insects damage 5 to 15 percent of stored pulses, and that the average dehulling loss is 10 percent.

IFST has worked with BARI to develop a simple method for separating maize germ (a source of edible oil) and for extracting starch from maize. Locally available edible oils have been refined and characterized, and a survey is being conducted on the oil-producing seeds of forest plants.

BRRI has designed two types of driers for paddy rice, one electric and the other non-electric. Both can be built with locally available materials. BAU has developed a deep-bed drier that uses a liquid propane gas burner, and

Post-Harvest Women

"The sequence of rice-processing activities done by women is: preparing the courtyard on which the paddy is dried by plastering it with a fresh layer of mud and dung, helping with threshing to separate the grains from the stalk, drying stalks to be used for cattle feed, winnowing and sifting several times, parboiling and soaking, drying (often repeated processes of spreading and sweeping), husking (if it is not sent to the mill), winnowing to separate the bran from the chaff, and storage, including periodic redrying....

Also, women fetch fuel for the fire and the water for parboiling and soaking. The contribution of this effort is, however, seldom considered, since gathering fuel and fetching water are regarded as part of the women's domestic responsibilities....

Women are [also] involved in the post-harvest processing of jute....After cutting, the stalks are allowed to rot in water, then the stripping of the jute fiber from the stalks is done by men and women, as is drying and storing of the fiber. Jute stalks are used for fencing, which is also done by men and women. The making of jute rope and other articles from jute fiber is done by women."

—Scott and Carr, *The Impact of Technology Choice on Rural Women in Bangladesh: Problems and Opportunities*. Washington: The World Bank, 1985, pp. 16-17.

BARI has worked on solar driers. A number of agencies have developed technologies for the post-harvest handling and preservation of fish. These include a process for producing fish protein concentrate known as "solar tent drier," and a method for better handling of fresh fish in rural areas—simply covering the catch with moist weeds when ice is not available.

The list of technological triumphs for post-harvest application is not particularly long. This is not due to lack of astuteness among the researchers, but rather to the particular circumstances of Bangladeshi agriculture. Post-harvest technology, like high-yielding seed varieties, must be assessed not just for its utility in increasing production, but for its impact on the economy as a whole.

The processing of most crops in Bangladesh is undertaken with low-cost traditional technologies characterized by high levels of labor input. This imposes severe constraints on increases in agricultural production. The total output that can be processed expeditiously is limited, and heavy losses often occur in the processing. However, the shift to modern capital-intensive technology can hardly be undertaken lightly under Bangladesh conditions.

Jahamara Begum. Women do most of the post-harvest work.

Family Energy

"A study was conducted in a central-west Bangladesh village in 1981 to assess the pattern of within-family allocations of available energy in different seasons of the year. This was done by weighing individual food intakes for three consecutive days at four different seasons and covering periods of normal and relatively short and abundant food availability. Detailed information on socio-economic parameters was also collected to categorize the households into poor and better off groups.

"The findings revealed highly significant seasonal differences in energy intake of the adult working population but a lack of socio-economic differential. A widely-held notion that the intra-household allocation of food discriminates against women and children, particularly at times of food shortages, was not demonstrated. On the contrary, the findings suggest that seasonal food shortages affect every member of the family, and the impact of the shortage is largely absorbed by adults, particularly the adult males, rather than being transferred to children."

—M. Abdullah, Institute of Nutrition and Food Science, University of Dhaka.

In the first place, large-scale technologies may not be appropriate for processing crops grown on scattered small holdings; they may even be counterproductive. Some of the technologies introduced to speed up rice processing, for example, have foundered on this rock. In any case, new technologies are likely to be expensive and well beyond the means of the average Bangladesh farmer.

Second, any technology that displaces labor must be regarded with concern, since Bangladesh has a rising population growth rate and unemployment. Of particular concern in this regard is the fact that women do so much post-harvest processing. Large-scale technologies tend not only to displace workers but to displace women workers in disproportionate numbers.

The jute industry provides an illustration of these problems. Jute is second only to rice as a provider of employment in processing activities. About 105 person-days per acre are involved in jute production, and some 30 to 40 percent of this is processing (retting, stripping, washing, drying, and bundling). Women do most of this.

Since 40 percent of the annual jute crop is of low quality due to inadequate retting and washing facilities and practices, BJRI began to search for new technologies. A commercial decorticating or ribboning machine was imported and tested for technical feasibility and economic

viability. The machine was largely a failure on both counts. It was too costly for the average jute farmer, and it tended to break the jute sticks. (The sale of whole sticks for fencing and building represents important income to farmers.)

BJRI then introduced a more appropriate "intermediate" technology that reduces retting time from 12 to 8 days, doubles the quantity of fiber that can be retted in the same amount of water, and improves the quality of the fiber extracted from the plant. The technique is being tested in 550 different locations, and if it proves feasible, it can increase employment and incomes. One problem remains: the technology is being demonstrated by men, but women do the retting and washing. This may make it harder for the new technology to gain popularity.

Wheat provides another example of the difficulty of introducing new technologies. Wheat is harder to thresh than paddy, and there are often post-harvest bottlenecks on small farms. When new technology was sought, it was found that the smallest available imported thresher was too expensive and too big for the farmers who needed assistance. A locally produced paddy thresher was no more efficient for wheat than the traditional techniques of beating and trampling. The search for an applicable technology goes on.

Research will go forward on new machines for drying, stripping, threshing; new methods for stacking, storing, and hauling; and new processes for cleaning and preserving. The challenge will be to design the research so that the outputs can be adjusted to scale.

7

The Greening Threshold: Impact of Agricultural Research

The specter of famine in Bangladesh has receded somewhat into the background, and agricultural production, while still short of meeting national needs, looks promising. Bangladesh has not yet had the "green revolution" of some Asian countries, but it has stirrings of this revolution and may be on the threshold of greening. Agricultural research has helped Bangladesh get to this point.

An agricultural research program can be evaluated from many standpoints: its efficiency as an activity, its effectiveness in cost-benefit terms, and its impact on key indicators of progress. Of course, those who put money into the program have a slightly different standard—are they getting their money's worth? All these measures must be addressed.

Research Revisited

In December 1983 BARC sponsored a symposium in Dhaka to mark its tenth anniversary, "ten years of agricultural research in Bangladesh." The volume of proceedings, published in 1985, has a handsome cover, a facsimile of the *nakshi kantha* (embroidered quilt) that is an indigenous Bangladeshi handicraft. The volume includes congratulatory reports of achievements and negative assessments. Some reports cover discrete research projects; some are descriptions of areas that need to be researched. Others are, in effect, critiques of whole areas of agricultural research.

The symposium reflected the range of conclusions that different observers might reach when evaluating the efficiency of the Bangladesh agricul-

Truth Test

"Today we face economic insecurity and difficult planning choices with inadequate resources. We fly from crisis to crisis, flood to drought, with the spectre of famine at the back of our heads. Crisis management is a crucial adjunct to the practice of normal science in research programs in our region. We have learned that technology approaches to crisis are not enough. Famine is often caused by lack of entitlement among the poor, not simply by physical shortage of food supply....

More often than not, the research evaluation process has been ritualistic rather than analytical. I urge you to see it as a kind of truth test against the inertial momentum of all hierarchic systems that protects us from new sources of knowledge."

—A. M. Anisuzzaman, Secretary, Agriculture and Forests Division, Ministry of Agriculture, at a workshop in October 1984.

tural research system. On the whole, the system is performing well, but it has many weak spots. Even some of its aspects that can be cited as strengths are only potential strengths because they are evolving.

Overall, the system could be given an "A" for effort—there is no end of trying; perhaps a "B" for relevance—the research is relatively farmer-oriented; a "C+" for coordination—things have improved but there is a long way to go; and a "D" for comprehensiveness—some whole sectors, such as livestock, the extension system, and education must be brought up to speed.

The measures commonly used to judge agricultural research systems are essentially procedural: Are priorities for research clearly established? Is the research effort coordinated to ensure that priorities are adhered to? Are facilities and personnel adequate for high-quality research? Are research findings useful in terms of the priorities? Are the findings communicated to those who need them?

Looking at the Bangladesh system in these terms, there is, as they say, some good news and some bad news. Priorities are theoretically set by a national agricultural research plan based on the national development plan. Although this plan outlines some parameters and objectives, it does not set priorities and is not much in evidence where the research work is going on. The plan lists, as an objective, just about everything that can be researched, and most of the items are given "high" or at least "medium" priority.

BARC has responsibility for assuring that work is coordinated and research priorities are set and followed. BARC has good leadership, solid

staff capability, and the desire to pull the work together. This will not be easy, however, as long as research institutes are scattered in different ministries and individual institutes establish outside international alliances. Still, BARC is beginning to emerge as a force in research.

The mix of the research subjects needs to be assessed to determine whether the heavy emphasis on genetic research and the search for "miracle crops" (to repeat the rice and wheat revolutions) should continue to eclipse research in cultural practices. The monocrop focus should be reviewed in terms of its effect on some other areas—fishing, forestry, livestock—that have been neglected.

Improvements have been made recently in all these areas. New initiatives are underway in neglected sectors. The farming systems approach is forcing research out of its customary academic pigeonholes and into areas of interest to farmers. The farming systems approach, in principle, forces farmers and researchers alike to concentrate on the total end-product and not on specialty areas. So far, farmers have learned a great deal about intercropping but not enough about the use of livestock, the employment of family energy, or the management of water resources.

Facilities and staffs can always be improved, but these are not really major problems for the research network. The laboratories and test plots are, on

Small Advances on Many Fronts

"[High-yielding crop varieties and gene-splicing technology] are spectacular developments, and have taken place at times in other areas of science as well, but the fruits of these developments take a long time to reach the backward areas of the world where they are...needed most urgently. We must keep in mind that progress in agriculture is accomplished also by numerous small advances on many fronts. There is an interdependent association between advances in such matters as fertilizing practices, control of pests and diseases, use of more productive strains of crops and livestock, and other aspects of farm management, all of which together make agriculture more productive. These smaller and less spectacular research accomplishments are much less appreciated and more difficult to evaluate. Nevertheless, their impact is cumulative and very important."

—M. O. Ghani, President, Bangladesh Academy of Sciences, in a speech in 1984.

the whole, well maintained. The Bangladesh system does not need more buildings and test tubes; it needs more direction and support.

Two of the weakest areas are not in the research network itself but on either side of it. The system of agricultural education is not producing enough "home-grown" scientists to supply the network. Unless this is improved, Bangladesh will be forced to rely on expatriates and foreign training, which a self-sustaining agricultural research system cannot do.

The extension system, by common consent, also needs reorganization. A great proliferation of organizations reaches out to farmers and evidence is that farmers are simply being missed by all these messengers. A study of one village (107 households) found that the overwhelming majority of farmers who knew about high-yielding rice varieties had heard about them from other villagers or on the radio; only six got the news from extension agents. The Bangladesh government may need to consider using modern technologies—radio and television—as well as traditional extension systems and links with a private agrobusiness sector to communicate new technologies.

Although the government of Bangladesh avows its commitment in policy terms, the investment being made in agricultural research is too low, based on the size of operating budgets. It is a poor country, and many demands are made on government funds. But when research institutes are forced to generate income from their test plots to cover operating expenses, as some have done in the past, then research resources are not being well used. So far, international donors have always come to the rescue, but this is not a good basis for a permanent national system.

Checking the yield. On the whole, the Bangladesh agricultural research network is performing well.

The key to the research program is BARC. If it can obtain more resources from the councils of government, if it can maintain its momentum as a coordinating force, if it can enforce real priorities on research projects—then the efficiency of the research network will be immeasurably improved. If BARC fails to do these things, then a promising network will not mature and Bangladeshi farmers will suffer the consequences.

Rates of Return

The parliament of Bangladesh meets in an imposing new structure built in the area that was once Dacca Farms. Paved walkways, outdoor lighting, flowering plants, and water features grace the site, which covers a vast area in Dhaka. Yet parliamentary government in the Western sense is hardly an established fact in the 15-year old country.

But Bangladesh is striving for democracy. If the country survives its troubled early years and meets it economic challenges, it may become a functioning democracy, and the parliament building may get more use. The parliament will be judged by its results.

What Can Bangladesh Afford?

"The agricultural research system of Bangladesh today stands at a crucial point in its history. On the one hand, it has passed through much of its initial gestation period and is beginning to show solid and worthwhile results. Some of these results are being 'borrowed' by neighboring countries....[M]any more innovations are in the pipeline....Such innovations could transform agriculture in this country, yet on the other hand, the system is constrained by shortage of funds and budget cutbacks, which do untold damage to ongoing research programmes. [T]he question is not whether Bangladesh can afford to invest in agricultural research, but whether it can afford not to."

—G. J. Gill, Agricultural Development Council, 1983.

Just so the agricultural research system. However efficient the research network may be by administrative standards, it must ultimately be judged by its output, both in terms of cost and impact. It is known that Bangladesh's spending on agricultural research is low by Asian standards; Japan spends 800 times as much per person on agriculture. The comparison may be unfair, Japan is much wealthier, and its farming practices are modern and scientific. Its agricultural productivity is also high, an acre of rice yielding about three times as much as an acre in Bangladesh. But this was not always so; agricultural research helped make it happen.

Even if it is assumed that Bangladesh inevitably would have less money to spend on agricultural research than many of its neighbors, the program can still be judged by an internal comparison: the rate of return on the money invested. G. S. Gill, in studies for BARC, seems to have done the most work on this subject, and his analysis is worth reviewing.

One way to estimate return on investment in agricultural research is to: (1) analyze the rate of growth of output for the agricultural sector as a whole over a period of time; (2) separate this into its various components; and (3) assign credit proportionately among them. Thus, some of the credit might go to better irrigation, some to use of fertilizer, and some to agricultural research. Such analysis does not yield exact amounts, of course, but it does produce a range of estimates depending on whether the underlying assumptions are optimistic or pessimistic.

Gill looks at the 1970s, a period when crop outputs showed some important gains. During that period, he estimates the benefits of agricultural research to be twice as great as its cost, including long-term investment costs, even with very pessimistic assumptions. If more optimism is tossed into the equation, and if only current operating costs are included, the benefits

Elastic Choices

"The impact of technological change on the distribution of income between producers and consumers is probably the most powerful and pervasive of the distributional consequences of the [high-yielding varieties] and of other cost-reducing technologies in agriculture....

In general, if the main goal of technology is to benefit consumers in the form of lower prices, research emphasis should be on agricultural commodities with relatively low elasticities of demand, such as foodgrains, beans, and root crops. On the other hand, if technology is to benefit primarily a country's producers, research should then be directed toward products with higher elasticities of demand, such as cash crops, export crops, and crops with attractive fixed prices."

—*Agricultural Research.* World Bank, 1981, pp. 22-23.

exceeded costs 20 times over. The rate of return on investment in agricultural research in the 1970s was judged to be at least 30 percent a year and probably (the optimism again) closer to 50 percent.

These gross figures are based largely on costs and production figures from particular crops during a time when advances were being made in a number of areas—rice, wheat, oilseeds, and pulses. Many of the advances were due to new high-yielding varieties, an obvious product of agricultural research.

One example, summer pulses, illustrates what can be achieved. In 1979, BARI launched its intensified pulse improvement project to produce viable strains of summer pulses. By 1981 two strains, 7706 mungbean (greengram) and T9 *mashkalai* (blackgram), were released to farmers on a trial basis. After the new strains had been demonstrated for a year, farmers in the districts of Pabna, Kushtia, and Jessore adopted them enthusiastically, partly due to the failure of the *aus* paddy crop in these districts.

Summer pulses proved to be a good investment in 1982. The cost of seed, fertilizer, land preparation, and labor for weeding, harvesting, and processing is estimated to have been 670 *taka* per acre. (In 1986, one U.S. dollar was worth 30 *taka*.) The crop was worth about 2,800 *taka* per acre, plus by-products such as cattle feed and fixed nitrogen worth 200 *taka*. Since the land would otherwise have lain fallow, the opportunity cost of the land was zero, and the net value of the farmers' investment per acre (discounted at 10 percent per month, the village money-lending rate) was 1,848 *taka*. The benefit-cost ratio was 3.9 and the internal rate of return was 154 percent. After the first harvest in 1982, many farmers immediately replanted a second and sometimes a third crop of summer pulses.

Keeping records. Agricultural research shows a high rate of return.

The investment also paid off for the nation as whole. Total investment in the pulse improvement program, from both foreign sources and the Bangladesh government (including the cost of research, extension, seed production, storage, distribution, and subsidies) totaled 4.5 million *taka* until the summer of 1982. Estimating yields conservatively, 30,000 acres would produce around 9,000 tons of pulses worth 84 million *taka*. Discounting the national investment at 15 percent per year and the farmers' investment at 10 percent per month, the investment by government, donors, and farmers produced a net value of 33 million *taka*. The benefit-cost ratio was 10.4 and the internal rate of return was 317 percent, a good investment even if pulses were never grown again.

Besides, there were side benefits to pulse improvement: about 600,000 additional person-days of employment were attributable to the new crop, the supply of protein-rich foods increased, and farmers obtained greater flexibility in cropping systems. It is difficult to assign dollars and cents—or *takas*—to these benefits, but no one doubts they are substantial.

The moral is that in an agricultural system, particularly one characterized by low productivity and traditional farming practices, some research findings can be translated immediately into economic benefits that far exceed the cost of the research. This has proved to be true in Bangladesh for a number of crops. At other times, research takes longer to show results, and

Bangladesh also has examples of this, such as livestock and forestry. On the whole, however, the agricultural research network, paid for by public funds, has proved its worth.

The private sector cannot be relied upon for agricultural research because the pay-offs are not primarily in profit. They are mostly general pay-offs—cheaper food, more jobs, higher incomes. Likewise, research does not produce immediate tax revenues, a source of concern to policy-makers. The benefits of research accrue to the community at large.

From Fields to Meals

Beggars are not nearly so common in Bangladesh as many people have been led to believe and as might be assumed, given the poverty of the country. They cluster mostly around the airport, the American Embassy, and other places where people might be expected to have money. In fact, begging does not seem to be so much the spontaneous entreaties of a distressed population as the regular income-producing activity of some people.

One thing that beggars have in common is malnourishment. These people (they are mostly women and children) who ask strangers for money do not get enough to eat. But neither does the people as a whole. The rickshaw-pullers who propel heavy loads through the streets of Dhaka are as thin as rails. Standing on the street, separated from their occupational context, the rickshaw-pullers would be hard to distinguish from the beggars.

One result that everyone hopes to achieve from agricultural research is better nutrition, but the effort has so far fallen short. Of course, this failure cannot all be laid at the door of the researchers. It is a long way from fields to meals, and the road leads through markets that the researcher does not control. But it is an area of concern that research hopes to impact.

Studies done by the Institute of Nutrition and Food Science (INFS) at the University of Dhaka confirm the nutritional problem. The daily caloric intake per person is less than 2,000. There are serious deficiencies in many micronutrients, especially vitamin A. The Bangladeshi diet is high in carbohydrate content but has little fat and animal food; protein deficiency is common.

As disturbing as the general picture are the trends. Similar surveys were conducted in 1962–64, 1975–76, and 1981–82. They show a steady decline in caloric intake and a deteriorating nutritional status. Consumption of animal protein declined 23 percent from the 1960s to the 1970s, for example, and vitamin A intake dropped more than 50 percent.

A rise in food prices coupled with a decline in purchasing power are perceived as the primary reasons for the worsening nutritional situation. Rural people, especially, have been hard hit by inflation and economic

Women and children. These two groups are the hardest hit by nutritional deficiencies.

instability because they lack the purchasing flexibility and other hedges available to urban groups. This is compounded by the fact that people are generally not well-informed on nutritional requirements or ways of using food for maximum efficiency.

Children are the most severely affected. An estimated 9 percent of newborns die in their first month, and 12 percent die by the twelfth month. Of those under age five, about 15 percent suffer from acute and chronic malnutrition, and more than 80 percent are anemic. Only one child in five below the age of 11 has a normal weight and height for the age group.

Partly, the children reflect the poor condition of their mothers. Pregnant and lactating women are seriously deficient in protein, calories, vitamins A and C, and iron. In addition to normal requirements, a full-term pregnancy and lactation require 300 and 800 *additional* calories, respectively.

Following the comprehensive surveys in the 1960s and 1970s, BARC moved some research resources into the nutrition area. With BARC financing, INFS sponsored the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN). In addition, with supplementary funding from UNICEF, INFS established a nutritional surveillance program. An Applied Nutrition Cell was also established in BARC.

Rice and Nutrition

Rice is a cereal grain, the principal component of which is starch. The starch content of milled rice varies from 84-93 percent on a dry weight basis. The second most prominent component of rice is protein, which varies from 4-14 percent. Rice has the lowest protein content of any of the cereal grains, but nutritionally it is the most balanced.

Nutrients in rice are not evenly distributed. The non-starch constituents decrease from the surface to the center of the grain. The outer bran layer is rich in protein, vitamins, and minerals.

The nutrient content of rice is decreased during milling. Much of the fat, ash, and B vitamins are removed with the bran. Calories in the form of starch and protein are retained to a greater extent. Parboiling during milling reduces the loss of vitamins and protein.

The BIRTAN project was built around "solution of nutrition problems with self-help." Nutrition education is conducted through mothers' clubs, farmers' clubs, youth clubs, and home visits. Families are trained in kitchen gardening, poultry raising, fish culture, basic sanitation, and obtaining drinking water. Through a demonstration center—manned by a medical officer, a medical attendant, and a home economist—they learn how to prevent communicable diseases by immunization, how to practice family planning and child care, and how to treat general diseases locally. There is also special vocational training for women and disabled persons.

The mothers' clubs include mothers and expectant mothers organized by home economists. They meet in one of the households and discuss menu preparation, diets for all ages, the importance of breast feeding, cooking methods to prevent nutrient losses, care of vulnerable groups (such as very young children), gardening and poultry raising, and preservation of foods. Nearly 50 such clubs (about a dozen members each) have been organized.

Farmers' clubs discuss the use of agricultural inputs such as fertilizer, crop rotation, soil conditioning, cattle raising, and vaccination against poultry diseases. As in the other activities, the emphasis in the farmers' groups is on believing through seeing; demonstrations are used as much as possible.

The results of the self-help project have been encouraging. Nutritional awareness has greatly increased, and people have become motivated to change dietary habits (such as from rice to wheat), to distribute food in the fam-ily according to need, and to improve sanitation and hygiene. The training has been reflected in better food intake generally, the absence of nutritional deficiencies in the project area, and improvement in infant mortality.

. . . And Eat It, Too

Although jute is grown primarily as a fiber crop rather than a food crop, the young leaves are also used as vegetables. They are picked several times during the growing phase as well as during the thinning of the plants but are unused at the jute harvesting phase.

Jute leaves contain 18 to 22 percent protein. Since 1.4 to 1.6 million acres are used for jute cultivation in Bangladesh, there are a lot of jute leaves produced, possibly enough to meet 5 to 10 percent of the protein needs of the country. But a large portion of the jute leaves go to waste while the nation suffers from protein deficiency.

The nutritional surveillance project worked in 10 distressed areas of Bangladesh to develop indicators of nutritional deficiencies. None of the project findings were particularly surprising: the percentage of income spent on food is an indicator of nutritional status; the incidence of malnutrition is highest among children under age three; and the percentage of school-age children attending school correlates positively with nutritional status. The indicators developed will be useful as a basis for policy decisions and for designing intervention programs.

The Applied Nutrition Cell in BARC coordinates the applied nutrition research and issues reports on various aspects of nutrition policy. For example, a report on the status of zinc in nutrition summarizes the information available on that important issue. The materials issued generally help generate support for nutrition programming.

The work on nutrition in Bangladesh is based on sound premises. It recognizes that good nutrition is more than improving agricultural production so that there is more to eat; it is also affected by a host of external forces, from floods to employment policy, and by personal habits. In other words it is essentially a development problem.

Toward Rural Development

One of the professionals actively involved in development work has some interesting ideas about rural development. Although he supports family planning programs now underway, he doubts that the retailing of contraceptives by itself will ever solve birth control problems. He thinks more money might be spent on television sets so that people would have something to do besides have children. Although battery-operated sets would suffice, more rural electrification would be better.

The CIRDAP Project

In 1982, the Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) sponsored a survey of national action on behalf of rural children in Bangladesh, Sri Lanka, and Nepal. The survey was followed by a workshop in Nepal that recommended that each country develop, with CIRDAP funding, an action program. The Rural Development Academy at Bogra, which was involved in conducting the survey, was chosen to implement the project in Bangladesh.

The CIRDAP project is a broad-gauged effort to impact rural development. The objectives of the project, a demonstration effort in one village, which began in mid-1984, are to provide basic education for out-of-school children aged 5-10; to improve child health status; to improve environmental sanitation in the village; to motivate families to grow vegetables and fruit trees; to encourage parents to limit family size; to organize parent groups for capital formation; and to provide credit to group members.

The reservations about contraceptives could be extended to agricultural research. If high-yielding crop varieties may eventually displace farmers, doesn't money also have to be spent on basic education so that people will have alternatives to farming? Does agricultural research really contribute much to national development? These questions can be approached in two ways. First, to what extent has the agricultural research network itself researched the broader development issues? Second, has agricultural research affected development?

The agricultural research network is not really organized for socio-economic research. BRRI, BARI, and SRTI established units for agricultural economics research in the mid-1970s. Before that, the only work done was by a small unit in the Ministry of Agriculture. Some of the institutes do not even have agricultural economists.

The main focus of research undertakings by the institutes is production economics. BARI has done some work in cost-benefit analysis, budgeting for cultivation, and economic advantages of various crops. BRRI did a research project to determine the socio-economic constraints affecting the adoption of high-yielding varieties. There have been studies of a market-research and policy-analysis nature. Research is underway on irrigation and water management and cropping systems. BARC also implements some economic research studies directly, such as the work done on agricultural research as an investment.

It is not likely that the agricultural institutes will devote major attention to broad development issues in the near future. It has been difficult enough to break into the single-crop research pattern with the farming systems

Rural Development Academy at Bogra. Agricultural productivity is only one part of the rural need.

approach. Most of the researchers are trained in fields like agronomy and entomology, not sociology and economics, and their expertise cannot easily extend beyond the more technical subjects.

Probably the most likely groups to engage in development research are the Rural Development Academy, the Bangladesh Institute for Development Studies (BIDS), and the Bureau for Socio-Economic Research at BAU. The Rural Development Academy at Bogra is doing field research in rural institutions, local planning, the role of women, etc., but it is primarily a training institution. BIDS was set up in Dhaka to conduct policy-oriented development research, but it has not assumed leadership. BAU does not have the trained manpower to carry the development research load, although it is probably the natural center for it.

One reason socio-economic research has been neglected is simply the "first-things-first" principle. If there is not enough food, why worry about other development issues? Another reason is that many of the socio-economic issues are politically sensitive. Research on plant diseases won't create much controversy; inquiries into the status of women or the land tenure system will.

Serious Sericulture

The Rural Development Academy felt that rural Bangladeshi women, given the opportunity, would use their leisure time for an income-generating activity. Accordingly, a sericulture (raising silkworms for the purpose of making silk) project was initiated in 1980.

The project became the focal point for a host of other development activities: establishing a credit union, processing rice, making fish nets, raising milk cows, family planning. In fact, the project began with a literacy program, teaching members of the group to sign their names.

Although there have been problems, the project has succeeded on the whole. The women are sincere in attending the weekly meetings and in depositing their savings regularly.

As the economy moves beyond subsistence, however, the government must devote more research attention to the other areas. The politically sensitive issues can be addressed with research projects that limit the scope of the investigation. For example, inquiries into employment opportunities for women can be undertaken without shaking the foundations of the society.

The impact of agricultural research on development, the second of the major questions posed, is hard to assess because so many factors are involved, and they impact each other. The theory is that agricultural research (among other things) leads to increased agricultural productivity which, in turn, leads to more general development, particularly improved nutrition and economic development in the rural areas.

Agricultural research in Bangladesh has unquestionably helped raise agricultural productivity, and there are glimmers of improvement in nutrition. The question is whether this progress is being translated into rural development. Is the rural economy being raised above the subsistence level? If not, why not?

Wennergren's study of agricultural development in Bangladesh uses a "good news, bad news" approach to the question. He observes some factors that contribute to agricultural development and others that constrain it. He recommends some policy guidelines for the Bangladeshi government.

The positive factors are that the government supports agricultural development, education, and, increasingly, market allocation of resources; there is a good natural resource base (land and water); farmers are willing to respond to economic incentives; a base of technology has been developed (high-yielding varieties, irrigation methods); there are a cadre of scientists and technicians, an emerging industrial sector, and solid donor support.

Kevin Rushing of the A.I.D. Mission in Bangladesh (wearing glasses) and scientists at BARI station in Jessore. U.S. aid funds have been well-spent in Bangladesh.

The list of constraints is formidable, however. The research base is still weak, it is inadequately supplied with human capital, and it has ineffective extension support. The lack of physical infrastructure and continued population growth pose threats. Inefficient public services, inadequate farm power, and a deficient export base are limiting elements. The status of women is still very restricted, and land tenure problems are not yet solved.

Despite the constraints, there are visible reminders in Asia that development is possible. Korea and Taiwan are countries that were at one time undeveloped with rice-based economies and population pressures. They have made successful transitions to at least a "newly industrialized" status. Obviously, there are many differences—historical, cultural, political, economic—between these countries and Bangladesh; there is no "approved" list of development policies that Bangladesh must pursue at pain of failure. What the "model" countries do is provide hope. Bangladeshis should not despair just because the challenges are severe.

What Americans Think About Foreign Aid

In 1986, the Overseas Development Council and InterAction, two U.S.-based private voluntary organizations, did a systematic survey of the views of Americans on development and U.S.-Third World relations. Here are some of the findings with regard to American foreign aid:

1. A majority of Americans favor U.S. efforts to assist Third World countries with development. Nearly 90 percent agreed with the statement that "wherever people are hungry and poor, we ought to do what we can to help them." More than three-quarters agreed that as a world leader, the United States should set an example by helping poor nations. A similar number believed that helping the Third World would also benefit the United States in the long run.
2. Americans express a strong preference for those types of U.S. economic aid programs that most recognizably aim to deliver help directly to poor people. Disaster-related aid was rated "high priority" by the largest percentage of the public. Also rated "high priority" by a majority were assistance programs essential to *long-term* development efforts—health care, education on family planning, providing birth control, and help for farmers.

This is good advice for the agricultural research system as well. It has not revolutionized the society, but it has produced concrete results that have affected events. The researchers must now build on this record.

Aid and Comfort

Hans Patrick Peterson says, somewhat ruefully, that he is "just a bureaucrat now." Trained as an agricultural economist, he has had little opportunity to ply his trade in Dhaka. Like other missions, the A.I.D. mission in Bangladesh plans and monitors programs; it does not implement them directly. Implementation is primarily in the hands of contractors, such as Winrock, CARE, and NRECA.

The missions plan and design programs, pick the implementing organizations, and supervise the work. The programs probably cost the taxpayer a little more this way, but most U.S. aid money returns to the United States or goes to U.S.-based organizations, thus helping to build support for the program. This is no small matter for an agency that gets little comfort from the public responses to its efforts.

The Faith and the Vision

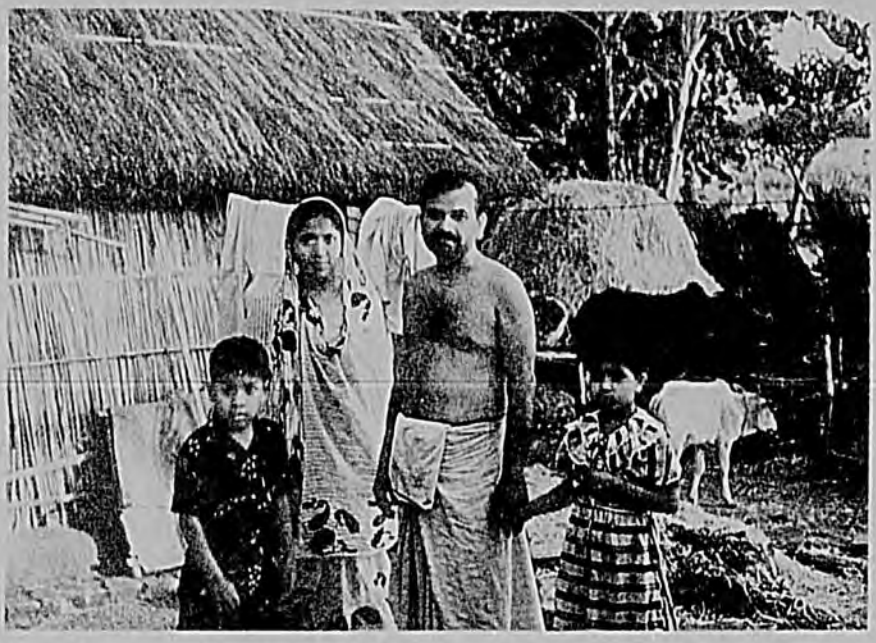
"I believe that our money has been well-spent; I think we have a sound program. What we have done here may not be relevant in other countries that have a different level of development. We have stressed institutional development here, the need for the nation to establish a strong agricultural research system to develop some of its own technology. The results of our efforts have not shown up fully yet. You have to have the faith and the vision to give things time to work."

—Alan Hurdus, A.I.D. Mission, Dhaka.

An A.I.D. mission has an enormous responsibility. It must articulate a long-run strategy showing how U.S. assistance can be used to develop a country, making sure that the strategy accords with the policy orientation of the administration in Washington and the capacities of the host country. It must then come up with programs that fit the strategy, tailoring the programs to meet budgetary guidelines. To carry out the programs, it must gain the support of dozens of autonomous agencies—other donors, the host country government, and contractors. If the programs fail, the mission may lose funding on grounds that the effort is wasteful; if they succeed, the mission may lose funding on the grounds it is unnecessary.

The A.I.D. program in support of the agricultural research program in Bangladesh is an outstanding example of what an aid program should be. In the first place, the aid is desperately needed. The government of Bangladesh is committed to improving agricultural research; it chooses workable policies and eschews cant and rhetoric. But it lacks the resources to fully sustain the required effort. Without donor assistance, the research program will decline, and a country friendly to the United States that badly wants to improve itself will lose ground.

Second, the A.I.D. program is based on all the right principles. It does not go for the "quick fix" that ultimately fails, for gaudy projects that look good in reports but bad in the field, for relief measures that put people on the dole rather than the road to self-support. The mission is institutionalizing science and technology. Its support of BARC, and its emphasis on farming systems research, its push for private sector initiatives, its drive for modern technology all support this goal. In the long run, the Bangladesh agricultural research network will be able to do the job itself.



Anwar Hossain and family. The small farmer is the ultimate beneficiary of agricultural research.

Third, there are already concrete achievements. Great production strides have been made in rice, wheat, potatoes, and pulses; greater reliance on fertilizer and irrigation has been achieved; BARC has finally gained control of the research effort; farmers are becoming aware of the importance of vegetables, livestock, and fish in their diets; and neglected areas of research, such as forestry, are being addressed. These are noteworthy achievements in a country that started as recently as Bangladesh did. It took the United States at least 50 years to build a credible agricultural research and extension program; Bangladesh was born in 1971.

Fourth, the gains have been made with the full participation of the Bangladesh government. Nothing has been forced on unwilling officials, and little has been wasted; corruption in high places is minimal in this country. The United States has worked through local institutions like BARC and has had good relations with the ministries. Coordination of effort with other donors is exceptionally good.

The Testing Fields

Beyond the diplomatic enclave of Gulshan, beyond the sprawling city of Dhaka, the life of rural Bangladesh goes on with grit and determination. Rice farmers plow with bullocks and take paddy to market; women farmers fetch water and dry straw in the roadways; landless farmers gather wood for sale and water hyacinths for fuel; part-time farmers rig nets for fish and pull rickshaws for cash. Life is hard but not without hope.

At research stations and on-farm sites, agricultural scientists check their experiments, observe their plots, record their findings, frame their questions, and plan their tests. How can farmers be prevailed upon to grow more wheat and vegetables? Test it in the field. How can marginal land be forced to yield three crops instead of two? Test it in the field. How can families stretch a meager food ration for better nutrition? Test it in the field. How can fertilizer, irrigation, and high-yielding variety seeds be made to add up to a bountiful harvest? Test it, test it, test it. Bangladesh has become a vast mosaic of testing fields.

Of course the people are poor, the resources are limited, and the road to prosperity is long. But the government cares, the farmers are enthusiastic, and the donors are generous. Above all, the fields are always there—sometimes lush, sometimes brown, but always promising. Research and agriculture have met in the testing fields, and the strength of the relationship holds the key to the future of Bangladesh.

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