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LOW RICE PRODUCTIVITY IN BANGLADESH

by

MOHDUDUL HUQ

A thesis submitted to the Faculty of
Graduate Studies and Research in par-
tial fulfillment of the requirements
for the degree of Master of Arts

Department of Geography

Carleton University

Ottawa, Ontario

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1977

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1977

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ABSTRACT

In this thesis some of the relationships between rice productivity and certain physical parameters involved have been investigated and land productivity in environmentally different parts of Bangladesh has been assessed. Land resources in Bangladesh are scarce; as rice is the staple crop an attempt has been made to demarcate the major limitations existing in different agro-ecological zones for its production.

It is found that Aman, Aus and Boro rice are not suitable for cultivation in different agro-ecological zones in Bangladesh. At the same time the cropped areas are not utilized to their optimum for rice cultivation. In this study, it is found that less than 50 per cent of the cropped land was utilized for rice cultivation during the periods 1965-1974.

No well-defined methods to assess land productivity in rice growing areas are available. In this paper, by adapting techniques employed elsewhere, five methods (coefficient) are employed to describe rice productive patterns in the country during the period 1965-1974. The methodology developed in this thesis is believed to be important in measuring land productivity. These coefficient and techniques can be employed in any country.

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GLOSSARY

- Aman Rice varieties growing in the monsoon season and harvested in November-December. They include broadcast aman varieties, sown before the monsoon season and capable of extending their stalks up to 10-15 feet in length with the rising floodwater; (also known as deepwater aman or 'floating' rice). Transplanted aman is sown in nursery beds and the seedlings transplanted in shallowly flooded fields in June-August.
- Aus Rice varieties growing in the premonsoon season, usually sown in March-April and harvested in June-July. Aus varieties do not need to grow in flooded fields, although they will withstand flooding. Most of the crop is sown broadcast, but transplanted aus is grown in some southern areas.
- Basin The lowest part of a floodplain landscape, usually saucer shaped.
- Boro Rice varieties growing in the dry season, usually with the help of irrigation. Boro varieties are sown in nursery beds and transplanted to shallowly flooded fields in December-January, to be harvested in April-May.
- Broadcast aman See Aman.
- Clay Mineral particles less than 0.002 millimetres (about 1/10,000th of an inch) in diameter. A soil in which the clay content is higher than 40 percent. A heavy clay (or fine clay) has more than 60 percent clay.
- District Is the largest administrative unit.
- Drainage The removal of water from the soil or land, either naturally or by artificial means (e.g. by ditches or pumps). The terms used to describe natural soil drainage are defined below.
- Well drained. Water moves from or through the soil sufficiently quickly that water does not remain on the soil surface for more than a few hours at a time and the soil does not remain saturated in the surface 2-3 feet for more than 2-3 days after heavy rainfall).
- Moderately well drained. Water may remain on the soil surface for a few days following heavy rainfall and the

soil may remain wet in the surface 2-3 feet for 1-2 weeks at a time during the monsoon season.

Imperfectly drained. The soil remains wet for several weeks during the monsoon season and water may stand on the surface for 1-2 weeks at a time following periods of heavy monsoon rainfall.

Poorly drained. The soil remains wet for several weeks during the monsoon season and is normally flooded for more than 2 weeks but not for the whole year.

Very poorly drained. The soil remains wet throughout the year.

Seasonally flooded. Flooded by rainwater or river water for a period of a few weeks every monsoon season.

Droughty(-iness)

A condition in which there is insufficient moisture in the soil for proper plant growth.

Haor

A permanently wet basin area (term used in Sylhet and the east of Mymensingh Districts).

IRRI

Abbreviation for International Rice Research Institute (located in the Philippines) from which improved rice varieties have been derived.

Loam

A soil texture (which see) in which sand, silt and clay particles occur in roughly equal proportions.

Lowland

Land seasonally flooded more than about 6 feet deep.

Medium highland

Land seasonally shallowly flooded (usually less than 3 feet deep).

Medium lowland

Land normally flooded up to 3-6 feet deep in the monsoon season.

Peat

An accumulation of partially decomposed plant remains with little or no mineral matter.

Saline

Containing salt (usually implying the presence of sufficient salt to be harmful to plants).

Silt

Mineral particles intermediate in size between clay and sand (i.e. 0.002-0.05 millimetres). Silty soils generally contain more than 50 percent of silt. Silt as a soil textural class contains more than 80 percent silt.

Thana

It is the smallest administrative unit, with a police station, that could be mapped; average size is about 34410 hectares.

Transplanted aman

See Aman.

Waterlogged

Saturated with water.

Source: "The Time Atlas of The World, Times, News Papers Limited Printing House Square, London, 1974.

CHAPTER 1

INTRODUCTION

The impoverished millions of under-developed countries are struggling hard with the twin problems of an unprecedented demographic explosion and highly inadequate food supplies. In the Third World the expansion of food production has been negligible in comparison to population growth, certainly during the late 1960's and early 1970's.

Bangladesh is one of the most critical areas among the Third World countries in terms of its ability to feed people adequately. There is a pressing need for honesty, ruthlessness and thorough analysis of the basic economic problems that hinder and stunt the development of the country and, above all, those relating to food production. Only when present difficulties have been identified is it then possible to begin to overcome them. Basically the all prevailing problem is one of low productivity, both in terms of domestic food supplies and crops for export. Due to low food productivity, not only per capita income is low but the greater part of the population, both in urban and rural areas, suffers from malnutrition. Many authorities are agreed that the most glaring problems of the country stem principally from low levels of productivity.¹

Bangladesh, with its predominantly peasant type of subsistence agricultural economy, is one of the most densely populated areas of the world,

with about 495 persons per km²², comparable, for example, to Java's 565 persons per km²³. Of a population which is approaching 80 million, over 90 per cent live in rural areas and 75 per cent are directly engaged in farming. Growth of population has been more rapid in the past 15 years than in any previous period, and population has increased from 50 million in 1961 to 75 million in 1974, to an estimated 80 million in 1977. This tremendous surge has been due mainly to a progressive decline in the death rate in this period (2.9 per cent per annum).⁴ Population is increasing at the very alarming rate of about 3 per cent per annum. In comparison to population growth food production is rising very slowly.

Agricultural output in recent years has accounted for about 55 to 58 per cent of the country's Gross Domestic Product (GDP). Approximately 40 per cent of the GDP comes directly from a few major crops, i.e., tea, jute, sugar cane; 28 per cent is from rice alone.⁵ On the other hand, increases in food production, especially rice, from 1960-61 to 1967-68 amounted to only 0.7 per cent per annum.⁶

The estimated total annual requirement for food grains in Bangladesh is approximately 12.5 to 13 million tons. However, the three major types of rice only yield 11 million tons annually. Including a normal loss of 10 per cent due to seed wastage and 5-10 per cent resulting from natural calamities, the net total quantity of available rice for domestic consumption is generally about 10 million tons. There is, therefore, an annual deficit of nearly 2.5 to 3 million tons of basic food grain.

Present difficulties in food supplies are principally a result of the cumulative effects of negligence in the agricultural sectors of the economy over a long period of time. Unfortunately the agricultural history of the area which is now Bangladesh is not well documented. Some improvements were made by Emperors Akbar, Shershah and several others in the fields of irrigation and in the land tenure system in the sixteen century. The East India Company, which came to India in the middle of the eighteenth century, was interested mainly in the cultivation of indigo, jute, tea and sugar cane all of which commanded good prices on foreign markets.⁷ During the British period, from 1850-1947, three important developments characterized the agricultural sector:

1. a spread of commercial agriculture;
2. the beginning of plantation agriculture; and
3. important developments in jute and other industrial crop production.

No significant advances took place in rice production, which then, as today, was the staple food crop of Bengal. From the Jute Commission's report it appears that jute lands were competing with the Aus variety of rice which is grown in the same season. Between 1911 and the early 1950's there was a considerable increase in the rice area of 2.23 million hectares. The resultant increase in production has, however, been offset by a population increase of 10 million.

"The extent of the imbalance between population and rice lands is reflected in a statistical survey in 1944, that in Bengal about 36.2 per cent, or more than a third of all rural families, did not own any rice land, while 40.5 per cent or two-fifths had less than two acres [>1 hectares] of rice land per family on an average. This extremely small size of rice holdings may of itself be considered as one of the basic causes of many of the agricultural problems in East Pakistan [Bangladesh] even today."⁸

In 1947 the Indian sub-continent was divided to form Pakistan and India. Bangladesh did not emerge until 1971. The basic agricultural structure which the new country inherited from Pakistan was little changed from that of the pre-World War II period. Bangladesh was the victim of misdirected agricultural policies by Pakistan rulers because they were interested in jute cultivation which earned foreign capital. In addition, there was a lack of proper planning in the agricultural sector, especially in relation to rice production. During this period there was very little investment in the countryside. The agricultural sector was subjected to concealed taxation, in addition to moderate direct taxation of land and some less than successful attempts to tax those with higher incomes. As a result, this sector of the economy lagged seriously behind.⁹

In the lower basin of the Ganges and Brahmaputra, what is known as Permanent Settlement was introduced by Lord Cornwallis in 1773, creating a class of Zamindar who were declared to be the proprietors of the soil. Permanent land revenue was set at ten-elevenths of the rental of the land at the time that settlement was established. The Zamindars were allowed to retain the remainder, i.e., one-tenth of the state's share, plus a future increment that might result from extensions of cultivation or other causes.¹⁰

The main features associated with Permanent Settlement are: a) fragmentation of the land; and b) lack of development programs--a result of a feeling of insecurity on the part of the tenants. In some cases more than 50 intermediaries were created between Zamindars and tenants. It has been asserted, also, that the effect of fragmentation led to a lack of interest in agricultural development.¹¹ The anachronistic nature

of the Permanent Settlement, and the deterrent effects on the productivity and efficiency of agriculture were clearly revealed in 1940 by the report of the Bengal Land Revenue Commission, presided over by Sir Francis Floud.¹²

In 1950 the Zamindari system was abolished through legislation, but subsequent measures fundamentally failed to change modes of production. Legislation had as its two main objectives the abolition of the Zamindari system and, at the same time, the establishment of direct contacts between the government and the peasantry through payment of land taxes directly to the government and to the Zamindar. Government action failed to achieve these objectives for two particular reasons. First, each Zamindar was allowed to retain as much as 13.3 hectares of land as his personal holding. Second, the right of land subdivision continued to be recognized. This directly contributed to the formation of a class of absentee landlords who, in the name of legal ownership, combined to thrive as a non-cultivating, parasitic and rent-receiving group, which had no interest whatsoever in the farming process or in changing the system of marketing.¹³ Today, as in the past, absentee owners of share-cropped land do not take any risk or responsibility for production. They make no investments and are not interested in any improvements in seed quality or farming techniques, nor do they share the cost of production. The most common sharing arrangement is one of a 50-50 division of produce.¹⁴

Most recently, Dutt (1976) has made an interesting study regarding the characteristics of the Green Revolution in Bangladesh, compared with those in the Punjab. The introduction of modern agriculture has been more successful in the Punjab than in Bangladesh. In the latter agriculture lags behind that of much of India. Dutt writes:

"Density of population is much higher in Bangladesh than in the Punjab, resulting in more fragmented plots and smaller family land holdings. Furthermore, recent consolidation initiatives in the Punjab have encouraged farmers to further consolidate their scattered farm land, which makes farming operations both inefficient and time consuming. In Bangladesh, on the other hand, no such consolidation efforts have been made. Because farm size is larger in the Punjab the expandable surplus for the medium and larger size farm owner is higher, making it possible for him to pay for his own inputs (HYD seeds, fertilizers, water pumps, and labour costs) which are necessary in the Green Revolution agricultural system. ... However, both medium and large size farms are smaller in Bangladesh, farm owners have less expendable capital to invest, cannot pay for inputs, and thus lag behind farm owners in the Punjab in employment of Green Revolution techniques. Finally, British army recruitment among Punjabi Sikh villagers provided a source of income which could be channeled in local agricultural improvements.. In contrast, the villagers of Bangladesh lacked any such additional sources of income. Some of the more educated villagers were able to obtain employment in cities such as Dacca and Calcutta, but never cared to return to their former homes for farming. As a result, agricultural improvements in Bangladesh lagged tremendously."¹⁵

Today in Bangladesh the main problems in the agricultural sectors are due to weak administration in the Ministry of Agriculture and a lack of coordination within the government machinery. According to Tepper: "Governments from Akbar through Ayub have centered their rural government at the district level and the district collectorate. The result for nation building agencies such as the Agricultural Department was tension, insecurity, and limitation of effectiveness."¹⁶ Aktar Hamid Khan has emphasized that the other major limitations to agricultural development are bureaucratic red tape, the resistance of money lenders, the lack of local leadership, and of administrative capability.¹⁷

Morrison¹⁸ made an intensive study regarding the relationship between the different socio-economic factors affecting productivity. According to him, the role of landless labour may be taken as an index of the care in cultivating land. He viewed share-cropping as an indicator of exploitation and inequality of the ownership of land and

7

found a high positive correlation between these two indicators. "As the proportion of landless labourers rises so does the proportion of share-croppers. The sub-division where share cropping and landless labour are highest may be most backward agriculturally and most socially conservative parts of the countryside." Morrison mentioned 11 thanas of high agricultural productivity, i.e., within the 37 thanas marked by a low percentage of agricultural labour and share-cropping. This study clearly illustrates the relationship between agricultural productivity and the land tenure system.

Badruddin Umar, an eminent Bengali scholar and sociologist, referred to share-cropping as "the worst remnant of feudalism." To him it represents the survival of the forces which will not only restrain economic growth but also subvert all attempts to improve methods of agriculture.¹⁹

In a recent article Elkinton identified several constraints in the achievement of food grain self sufficiency that are linked with population growth and the difficulties associated with Bangladesh's physical geography. At the same time, there are other constraints such as: frequent recurrence of floods and natural calamities which regularly cause a 5 to 10 per cent loss of food grain; an under-developed and inadequate agricultural credit system, inadequate extension and research servicing, completely inadequate marketing institutions and facilities; lack of hydrological information about the country's surface and ground water; and, finally, inadequate or weak management and operation on the part of most development agencies.²⁰

Today there is a most urgent need in Bangladesh to focus on the agricultural sector in order to lessen and hopefully close the gap between

food production and population growth. There appears to be no alternative but to adopt intensive types of agricultural land utilization, in addition to modernizing techniques of production.

Special attention should be devoted to rice production, the country's staple food crop. Increases in rice production are possible, not only through improvement in seed quality, irrigation and drainage control, application of fertilizers and pesticides, but also by utilizing the land throughout the whole year. It is often little appreciated that intensity of land use varies considerably from one region to another. Rashid found low cropping intensity densities in no less than nine agricultural regions, are found. Little attention has been paid to improving rice production in particular in those regions. From agricultural surveys, it has been found that there are some thanas where the gross cultivated areas reaches as high as 180 per cent, while else where it lags at 101 per cent. Why does this variation occur? Is it simply the differential in the fertility of the land? Is it availability of water at critical times in the agricultural cycle? 21

1.1 Objectives

The broad question underlying this study is: "Is there a shortage of food in Bangladesh?" (Figure II). If so, is it due to high population growth, to low productivity, or is agricultural land under-utilized? It is helpful to identify regions which are unsuitable for rice cultivation in terms of their agro-ecological conditions and, secondly, to discover the positive or negative regions, or areas, in terms of rice cropping intensity, and the extent to which land is utilized.

Fig.II

DIAGRAMATIC REPRESENTATION OF RICE PRODUCTIVITY AND FOOD SHORTAGE IN BANGLADESH.

Three problems^{21A} are investigated in this paper, 1) whether Aman, Aus and Boro rice are suitable for cultivation in all areas of the country; ii) whether the cropped areas are utilized to their optimum for rice cultivation; and iii) to what extent the land is productive for rice cultivation.

1.2 Methodology

Many methodological approaches have been used by agricultural economists and a few geographers to measure agricultural productivity in different areas.

Productive equivalence, in terms of crop yields, has been used as a basis of land classification in Germany by C.O. Sauer. But his system did not account for the human and economic factors that can change the basic value of land.²²

Kendall devised a highly mathematical model for measuring regional productivity, based on per acre yield of crops. According to him, productivity is a synonym for fertility. He uses the word to express particular capability to produce crops without regard to whether that power is due to the bounty of nature or the efforts of man. Productivity, in fact, depends not only on the quality of soil and climate but also on such factors as farming efficiency, availability of labour, the supply of capital, and the degree of government encouragement.²³

Regional crop distribution patterns cannot be assessed simply on the basis of crop yields and thus problems arise of measuring potential productivity on a local or regional basis. Kendall proceeded to describe four different coefficients, i.e.: i) productivity coefficient; ii) ranking coefficient; iii) money value, and iv) energy content.²⁴

A different kind of relative index, i.e., a co-efficient of localization was used by Florence in 1944 and Chisholm in 1962, to measure relative regional concentration.²⁵ The difference for each district or state is calculated by

$$\frac{EC}{EN} - \frac{TC}{TN}$$

where EC is the area of agricultural activity at district level

EN is the country's agricultural activity

TC is the total area of the specific agricultural activity at district level; and

TN is the country's area of specific agricultural activity.

The positive differences are added together and divided by 100, giving a co-efficient ranging between 0 (specific agricultural activity distributed evenly) and 1 (specific agricultural activity highly concentrated). Negative differences can also be added together, and divided by 100 to give an index of relative absence of agricultural activity. This technique is deficient in that relative concentration, or relative absence, is assessed.²⁵ Florence (1948) further developed a quantifying general distribution pattern by using the location quotient.²⁶ Location quotient techniques were originally used, for example, by economic geographers as a means of comparing a region's percentage share of a particular activity with its percentage share of some aggregate.²⁷ (See Appendix XXII.)

The advantages of the location quotient techniques are many fold.

Values can be easily calculated and understood. It is usually used as a percentage; and changes in the size of census districts do not affect

values,²⁸ thus allowing comparisons through time periods. Areal activities can be visualized in the map when it is studied through different time periods.

In the present study different methods, have been used to identify the regional productivity patterns of rice.

1. Location quotient²⁹
2. Z- scores of location quotient³⁰
3. Productivity coefficient³¹
4. Rice cropping intensity, and
5. Ranking coefficient.³²

Location quotients have been used to determine the concentration of the major varieties of rice, such as Aman, Aus and Boro, in Bangladesh, from 1965-1974. Data have been analyzed on the basis of agricultural district. The location quotient may be expressed mathematically as:

$$\frac{R_1/R}{N_1/N}$$

where R_1 is the total area of rice land in an agricultural district

N_1 is the total cropped area in an agricultural district

R is the total area of rice land in the country, and

N is the total cropped area of the country.

The location quotients for Aman, Aus and Boro have been calculated separately by computer. If the location quotient value gives 1, then it can be taken as a normal percentage of phenomena on rice acreage, while values over and under 1.00 reveal clustering and dispersion.³³ The location quotient values identify concentrations of rice productivity but do not indicate

the significance of concentration. In order to determine the significance of location, quotient values can be expressed as Z-score tests³⁴ as follows:

$$Z = \frac{X - \bar{X}}{Q}$$

where X denotes the yield of crops in a particular area or region
 $\bar{X}$ is the mean yield of crops, and
 Q is the standard deviation.

But Kendall used Z-scores of yield per hectare as a productivity coefficient.³⁵ Here they are used as a productivity coefficient and as a measure of regional productivity of different varieties of rice from 1965-1974.

The fourth method used in this study is rice cropping intensity which is measured in terms of district levels from 1965-1974, as follows:

$$\frac{X}{Y} \times 100$$

where X is the total rice acreage in each district, and
 Y is the total cropped area in each district.

When X is divided by Y and its value is multiplied by 100, it gives the rice-cropping intensity. In this way different varieties of Aman, Aus and Boro rice are measured in terms of district level. On this basis difference maps have been prepared to show their relative intensity in terms of district levels (Appendices XXVI - XXVIII).

The fifth method is by ranking coefficients which are calculated by dividing the total value of ranks by the number of criteria, e.g.:

1. Location quotient, and
2. Productive co-efficient and rice-cropping intensities for individual varieties of rice.

These values have been grouped in quintiles. If they are arranged by productivity in a ranking order, the r_1 will be the lowest ranking value which can be expressed $r_1/r_2/r_3 \dots /r_{20}$. A distributional map has been prepared of four orders (see Figure III). The lowest ranks reveal the highest rice productive areas and thus the highest ranking coefficient gives the lowest rice-productive area of the country.

For purposes of analysis of physical factors, Land Development Units³⁶ by FAO/ UNDP, have been used. Each Land Development Unit was selected as an area with distinctive physiographic, hydrological and soil conditions. In addition, agricultural data have been collected on the basis of Bangladesh agricultural districts. Initially data were compiled employing traditional mapping methods. Major limitations of rice productions and rice cropping patterns have been correlated with the physiographic, hydrologic and soil conditions of the country. Rice productive patterns have been assessed on the basis of agricultural districts (Appendix VIII).

1.3 Sources of Data and Materials

Agricultural data have been collected primarily from the Agricultural Census of East Pakistan 1947-65; Basic Statistics of Bangladesh Agriculture 1975; The First Five Year Plan and Bangladesh Rice Research Institute reports.

Fig. 111

BANGLADESH

RICE PRODUCTIVE AREAS
 BASED ON RANKING COEFFICIENT
 (ie, i) Location quotient, i
 Z-scores of Location Quot
 ent iii) Z-scores of yield
 and iv) Rice cropping inte
 sities, (1965-74)

Regions of Highest Rice Productive Areas

"	"	Medium	"	"	"
"	"	Low	"	"	"
"	"	Lowest	"	"	"

0 20 40 80 120 160 200 KM

(Data Source: Ministry of Agriculture Government of Bangladesh.)

Rainfall, soil and hydrological data were obtained from the Meteorological Department of Bangladesh and the Master Plan of the East Pakistan Water and Power Development Authority. Food and population data have been collected from the Bangladesh Population Census 1974 and the Center for Population Studies of Harvard University. In addition, other relevant information and materials have been gathered from the Bangladesh Institute of Development Studies; Queen's University Library; the International Development Research Centre (IDRC) Library, Ottawa; and the Bangladesh High Commission Library, in addition to the Carleton University Library.

1.4 Thesis Format

The study has been divided into six parts. Following this chapter, the Introduction, the five remaining chapters deal with various aspects of the study as outlined below:

- Chapter 2 - is concerned with the current food situation in Bangladesh. Since rice is the staple food crop, its production determines the food situation in the country.
- Chapter 3 - deals with land utilization and rice cropping patterns.
- Chapter 4 - contains an analytical description of suitability of land for rice production in different agro-ecological conditions in Bangladesh.
- Chapter 5 - endeavours to identify the regional productive patterns of different varieties of rice.
- Chapter 6 - Conclusions and Recommendations for further study.

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- 21A. In this thesis only physical limitations to rice cultivation are discussed. In addition to these, there are social, political and economic constraints which need to be considered for better planning in the agricultural sector. These, however, are not discussed in this thesis.

CHAPTER 2

FOOD SITUATION AND POPULATION GROWTH IN BANGLADESH 1965-1974

Food grain production in Bangladesh experienced a small growth of 0.7 per annum between 1965 and 1974, which is less than the rate of growth of population. Growth of rice production remained mostly stationary until 1958,¹ fluctuating periodically during this period mainly due to weather, failures of the monsoon, floods, cyclones and to some extent salinity problems.² The annual production of rice during the last few years is shown in Table I. Areas and production of rice showed substantial increases during 1964-65; however, production declined in the years 1965-66 and 1966-67 due to unfavourable weather conditions. During the early part of the 1970's food grain production fell substantially as a result of civil disturbances, the war of independence, and the large-scale migration of farmers from the border districts. Shortages of seed and heavy losses of bullocks, which provided the bulk of the draft power available, caused a 7 per cent drop in paddy acreage, from 10.04 million hectares in 1970-71 to 9.27 million hectares in 1971-72. At the same time rice production in 1971-72 was 13 per cent below the previous year's crop and 20 per cent below the record crop of 1969-70.⁴

In the current Five-Year Plan, emphasis is being given to the agricultural sector. The main objective is to attain self-sufficiency in food grains by 1978, to expand employment opportunities and to increase

Table.I

AREA, PRODUCTION AND PER HECTARE YIELD OF AUS, AMAN AND BORO RICE IN BANGLADESH.

Year	Total Area(Aus, Aman, Boro)	Production	Per Acre Yield
	Area '000 Hectares	'000 Tons	In Tons
1964-65	9232.79	10337	.45
1965-66	9364.37	10335	.45
1966-67	9074.49	9424	.42
1967-68	9893.52	10995	.45
1968-69	9746.15	11165	.46
1969-70	10318.21	11816	.46
1970-71	9916.59	10967	.45
1971-72	9301.61	9774	.43
1972-73	9633.60	9930	.42

(Source: Bangladesh Agriculture in Statistics, Statistical Series No 1, Nov 1973.
 Ministry of Agriculture, Agro-Economic Research Section, Dacca, Bangladesh,
 page 6.)

the production of export crops. Agricultural output is planned to grow at an annual rate of 4.6 per cent; this sector of the economy has received 24 per cent of the funds spent on development. In order to increase crop production, great emphasis is placed on a package of modern inputs, namely: irrigation, high-yielding varieties of crops, fertilizers, and plant protection measures, together with the necessary incentives and institutional measures. Unfortunately, growth rates in agricultural production, especially food, did not increase substantially by 1973-74, the last period for which data are available. According to the Food and Agricultural Organisation of the United Nations, during that period the agricultural growth rate was 8 per cent less than the previous year.

2.1 Shortage of Food in Bangladesh

The problems of food supply have remained critical during different time periods. In the last few years harvests have been very poor due to four successive disasters. Other factors, such as population growth, crop failures, low crop yields, and under-utilization of land during the cropping season have also contributed to the food shortages in Bangladesh.

Food imports are usually calculated on the basis of the total food production minus the total amount of food requirements in terms of population growth. If the food consumption is much higher than the total food production then imports are necessary. This is the case in many areas of the country.

Food consumption patterns are directly related to population growth, and the age and sex ratios of the population. It has been calculated

that an individual requires approximately 482 grams of cereal per day.⁶ In Bangladesh daily per capita cereal consumption patterns have been calculated by Abbas, Huq and Khan,⁷ based on the Survey Report of Household Expenditures shown in Table II. The results of the survey showed that the population is living below the basic requirement.

On the basis of a 75-million population, Bangladesh required 11.5 million tons of food grain in 1972-73, and during that period production was only 9.9 million tons. In those years the food deficit of 1.6 million tons was met by importing wheat and rice from the United States, Canada, Japan and Burma. From the import figures for the last ten years (Table III) it is easy to visualize the country's food situation. It would seem that in the future this situation can only deteriorate. An increasing food grain deficit will impose an unbearable burden on the national economy.

Table. II

DAILY PER CAPITA CEREAL CONSUMPTION IN BANGLADESH, 1963-64, 1966-67, and 1968-69.

Year	Sample Population	Ounces Per Person Per Day	
		Expenditure Consumption	Availability Estimate
1963-64	23868	15.5 (425 Grams)	15.9 (450 Grams)
1966-67	31556	14.8 (419 Grams)	13.8 (390 Grams)
1968-69	30159	13.8 (319 Grams)	14.2 (402 Grams)
Weighted Average		14.6 (413 Grams)	14.2 (400 Grams)

(Source: Chen, C, Lincoln, " Household Income and Expenditure, 1963-64, 1966-67 and 1968-69 ", Report of the Quarterly Survey of Current Economics in Pakistan, Central Statistical Office,

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Table.III

Food Grain Imports, 1960-61 to 1970-71

Year	Thousand Tons		
	Rice	Wheat	Total
1960-61	464	234	698
1961-62	206	202	408
1962-63	542	894	1436
1963-64	346	656	1002
1964-65	95	250	345
1965-66	360	529	889
1966-67	432	649	1079
1967-68	908	712	1020
1968-69	236	884	1120
1969-70	502	1045	1547
1970-71	381	898	1279

(Source: Ambassador Erna Sailer, Report on the Mission of High-Level United Nations Consultants to Bangladesh. March-April 1972, United Nations, vol 2, P.14.)

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CHAPTER 3

LAND UTILIZATION PATTERNS

"The utilization of land according to broad classes, e.g. cropland, grassland, and wood, and forest land is determined to a large extent by climatological and topographical factors".¹

Detailed studies of land utilization are absolutely necessary in Bangladesh in planning future agricultural development. There is much controversy regarding the opening up of agricultural land for rice cultivation. Major areas remaining for cultivation are in the Haor Basin area, the Moribund Delta region, and isolated pockets in the northern region of the country (Figure IV). These waste lands are fertile and covered with vegetation, but due to low population density they are left idle.²

The total area of Bangladesh is estimated to be 144,000 km², according to the 1960 census, of which 8.8 million hectares are cultivated (about 62 per cent of the total area). It is estimated that 38 per cent is not suitable for agriculture. About 0.12 million hectares of waste land is found in the Moribund Delta region, the Haor Basin area and high sandy areas in Jessore, Kushtia, Rajshahi, Rangpur and Dinajpur districts suitable for cultivation.³ (See Figure IV. All these areas would need substantial improvement before cultivation could be achieved. In 1971-72 the net cultivated area (NCA) had decreased by 0.64 million hectares to

Fig. IV

BANGLADESH

UNCULTIVATED AREAS WHICH CAN BE
BROUGHT INTO CULTIVATION.

1. Haor Basin

2. Moribund Region

3. Dinajpur and Rajshai Districts.

0 20 40 80 120 160 200 KM

(Source: Pashid H. 1965, East Pakistan A Systematic Regional Geography And Its Development, Sh Ghulam Ali And Sons, Karachi, Pakistan, P.125.)

8.8 million hectares. The total cropped area and rice areas also dropped sharply in 1971-72 in comparison to 1965-66.

3.1 Future Land Utilization in Bangladesh

Day-by-day the area of agricultural land is decreasing at a very accelerated rate, due to expansion of industry, urban growth and other non-agricultural uses. It appears clear that the only presently practical way to significantly increase agricultural production in Bangladesh is to increase cropping intensity and improve crop yields on presently cultivated lands.⁵ In spite of great scarcity of land within the major agricultural regions, cropping intensities are not high, only about 35 per cent of the total agricultural area is cropped more than the average each year.⁶

Other methods of increasing production include the reclamation of land by filling up derelict ponds with earth obtained from dredging, which also performs the dual tasks of assisting with irrigation and increasing land availability. It is little known that 40 per cent of the country's ponds are derelict.⁷ On the other hand, there is a possibility that some of the tidal swamp areas, locally known as "Sunderbans", can be reclaimed for rice cultivation, but the possibilities can be assessed only after detailed surveys of the more favourable areas. Some new land is constantly being formed in the Meghna estuary and, where provided with protection from the tides, is very suitable for cultivation.⁸

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CHAPTER 4

INVESTIGATION OF RICE CROP SUITABILITY FOR PRODUCTIVITY IN TERMS OF DIFFERENT AGRO-ECOLOGICAL ZONES

4.1 Agro-Climatic Conditions for the Production of Rice

On the basis of 1962-1973 statistics, about 9.6 million hectares of paddy are sown annually, of which, on average, 0.4 million hectares are unharvestable due to annual flooding. An even greater area of land, intended for paddy cultivation, is left idle owing to inadequate water supplies.

Of the many factors that determine agricultural production in Bangladesh, the most important environmental criteria include climate, relief, drainage, hydrology, and soil conditions. Crops and cultivation practises are mainly determined by climate and hydrology and to a lesser extent by soil make-up and cultural traditions.² Differences in soil and physiography are becoming important with the introduction of more intense farming methods requiring adoption of water control techniques, high-yielding varieties of rice and other crops, increased use of fertilizer and some motorized tillage. The various physical elements of the environment, together with social and economic factors, need to be taken into account in planning for agricultural development. On the basis of ecological factors, and rice cropping patterns, Bangladesh can be divided into six macro-agro-ecological zones.³ Each agro-ecological zone possesses its own distinctive rice cropping pattern, based on climate, soil-geomorphic conditions and annual inundation.

For better land-use planning, it is necessary to appreciate the different rice cropping patterns and the major limitations of each agro-ecological zone.

4.2 Rice Cropping Patterns

Today, cropping patterns are one of the most important concerns of agricultural planners. The Food and Agricultural Organisation (FAO) of the United Nations emphasizes the introduction of multiple cropping systems in developing countries. It is currently a great challenge to scientists and planners to effect changes in existing cropping patterns.⁴

4.2.1 Existing Rice Cropping Patterns in Bangladesh⁵

<u>TYPE OF LAND</u>	<u>RICE TYPE</u>
Very High	Aus
High	Aus - Transplant Aman
Medium High	Aus and Aman
Low	Deep-water Aman
Very Low	Boro

In order to increase rice production in Bangladesh, it is necessary to intensify the uses of existing cultivated lands by adopting methods such as growing high-yielding varieties and improving irrigation facilities. Rice cropping patterns can be changed if well-planned irrigation is adopted in the existing system.⁶

Land type is determined by depth of flooding.

1. Very high land and high land lying above normal flood level.
2. Medium high land seasonally shallowly flooded less than one meter.
3. Low land seasonally flooded one to two meters.
4. Very low land seasonally flooded more than two meters.

4.2.2 Proposed Cropping Patterns with the Aid of Irrigation⁷

<u>Type of Land</u>	<u>Rice Type</u>
Very High	Aus
High	Aus and Aman mixed.
Medium	Aus and Aman mixed
Low	Deep-water Aman and Boro
Very Low	Boro, deep-water paddy

4.3 Rice Cropping Seasons

In order to plan the rice-cropping pattern throughout the year, it is necessary to understand the role of the different rice-cropping seasons. In Bangladesh, the rice-cropping season is divided into three parts:

1. The rabi or dry season
2. The bhadoi or rainy season
3. The hemantic season.

The rabi season lasts from October to April. During this period the rainfall is unreliable for rice. Sometimes 'norwesters' bring short, heavy, but localized downpours of rain. Boro rice is grown where irrigation is practised, as the only rice crop in winter on land that is too deeply flooded during the monsoon season to permit growing any other crop. The seed beds for boro are prepared in October and November. Within five weeks of sowing, the seedlings are transplanted. Boro is able to withstand low temperatures. The average minimum temperature in the Haor Basin, which is the heart of the major boro region, in early January, is only 10°C. The crop is harvested in April.

The bhadoi season lasts from April to August.⁸ Aus rice is the principal crop at this period of the year. Aus rice is adapted to relatively dry conditions and saline soils. Excessive rainfall or flooding reduces yields. Aus depends on monsoon rains. The seeds are broadcast in March, April and May, and the crop is harvested from May to August.

The hemantic season begins in June and ends in November.⁹ It overlaps the bhadoi season. The country's third major rice type, Aman, is then grown. There are two main varieties of Aman, one is transplanted paddy, the other is broadcast Aman which is normally called deep-water paddy. Transplanted Aman rice is grown where flood depths range from about 30 to 90 centimeters during the monsoon season.¹⁰ Aman seedlings are cultivated in nursery seed beds in June and July when heavy monsoon rain begins and are transplanted in July to September when water depths are very high. The Aman crop is harvested between mid-November and mid-February, after the water has receded from the fields.

Broadcast Aman, or deep-water rice, is grown where flood depths range between about one and three meters. The seeds of broadcast Aman are sown in March or April.

4.4 Variability of Rainfall, Impact on Rice Crops¹¹

Floods and drought account for a considerable percentage of the damage to all varieties of rice in Bangladesh. An understanding of moisture requirements for rice, patterns of rainfall distribution, and fluctuation of rainfall during the cropping season, are vitally necessary. The moisture requirements of rice plants vary with the type of paddy grown; on the average a crop which matures and is harvested within

a six-month period requires approximately 1,875 millimeters of water and 90 per cent of this is needed during the early growing period.¹² Rainfall patterns greatly affect rice-cropping patterns and yields, especially where irrigation of any sort is not practised. Aus crops mainly depend on showers in March and April for land preparation and seed germination. If showers fail, or come too late, a crop may be damaged by drought or planting so delayed that it is damaged by monsoon floods. Late planting also reduces the possibility of double rice cropping, for example, Aus and transplanted Aman. The second most critical period, so far as moisture is concerned, occurs about six weeks before the Aman rice harvest when plants are in the flowering stage, usually the later part of October or the first week in November. A drought at this stage causes considerable damage.

Average annual rainfall totals are misleading in estimating rice cultivation requirements, because the rainfall variation from the average can vary to a great extent. Over most of Bangladesh rainfall variability is small but in certain regions it is greater than is usually appreciated. The variability of rainfall for the country is less than 15 per cent annually. However, the mean variability for the northern part is about 17 per cent, and for the remaining parts of the country, with the exception of the extreme west, it is 5 per cent.¹³ In the northeast, including Rajshahi, Bogra, Dinajpur and Rangpur, there is an extraordinarily high variability. In these regions rainfall is 1,600 millimeters below the requirements for rice cultivation.

Mean rainfall values and co-efficients of variability of precipitation during the November to April dry season, for the years 1961-1972 are shown in Table VI. In this period Aus and broadcast Aman are usually grown. Between November and April rainfall is negligible for rice cultivation, i.e., below 250 millimeters. During those months the co-efficients of variability of rainfall range from 18 per cent to 89 per cent from one region to another. During the dry season the rainfall variability in the northwest is more than 80 per cent, (Figure VI) which causes considerable rice failure. In the wet season rainfall is considerable (Figure V) for every rice district. The mean rainfall in the wet season is 1,940 millimeters. Except for a few places the co-efficient of rainfall variability (V) is 30 to 40 per cent (Table VI) where the rainfall totals are high and variability for V low. In the northeastern and southeastern parts of the country floods are a major hazard; while in the northwest and southwest rainfall is relatively low, and variability relatively high, the risk of drought is high.

Table VII shows the frequency of drought periods at several representative stations where rainfall is deficient for crop growth or for transplanting operations. Where the rainfall is low, and the variability for V high, as in the northwest and southwest of the country, drought is a great hazard. Where both values are relatively high, they endanger the paddy crop.

Since rainfall is most reliable in Bangladesh during the months of May to October, the drought hazards and resultant damage to the standing

Table. IV

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VARIABILITY OF RAINFALL IN BANGLADESH

STATION	DRY SEASON (NOV-APRIL)	WET SEASON (MAY-OCT)
	$\frac{Q}{\bar{X}} \times 100 \%$	$\frac{Q}{\bar{X}} \times 100 \%$
Dacca	38.71	32.39
Chittagong	44.08	22.61
Maijdicourt	39.59	21.59
Sylhet	17.64	15.85
Rangpur	62.82	33.62
Mymensingh	53.21	29.74
Dinajpur	61.86	35.27
Faridpur	38.50	36.89
Comilla	38.58	26.02
Pabna	50.00	40.37
Khulna	55.81	34.83
Barisal	53.52	31.27
Bogra	89.46	38.89
Rajshahi	78.33	39.11
Jessore	55.14	39.35
Rangamati	53.05	24.87

(Source: Computed on the basis of ten years rainfall data, 1961-74, collected by the Metrological Department of Bangladesh, unpublished.)

Fig.V

(Data Source ; Meteorological Department of Bangladesh, 1964-74)

Fig.VI

BANGLADESH

DRY SEASON RAINFALL
(IN MILLIMETERS, NOV-APRIL)

(Data source; Meteorological Department of Bangladesh, 1964-74)

Table. V

PERCENTAGE OF YEARS WITH LESS THAN INDICATED
PRECIPITATION IN MILLIMETERS, (1900-1959) :-

Station	March		April		July	Aug.	Sept.		Oct.		Nov.	
	50	127	50	127	254	254	50	127	50	127	50	127
Rangpur	81	100	33	76	28	24	2	11	26	54	93	100
Dinajpur	72	100	48	93	17	33	0	9	30	58	94	100
Dacca	54	91	9	46	33	26	2	16	27	52	80	100
Pabna	67	91	45	85	46	35	2	16	24	57	85	94
Sylhet	31	61	4	11	0	2	0	0	4	18	74	87
Chittagong	65	85	27	56	4	4	0	2	9	27	27	83
Rangamati	67	85	21	56	2	13	0	4	9	39	54	95

Note: During those months with less than fifty mm of precipitation, a substantial part of the crops moisture requirements must come from supplemental irrigation.

In July and August, there will be insufficient water for aman transplantation on the higher land when rainfall is less than 254 millimeters.

(Source: East Pakistan Water and Power Development Authority, "Master Plan", Supplement B, Agriculture, International Engineering Company Inc, San Francisco, California, 1964, p.BIV-6: with metric conversion.)

crop are more frequently experienced in the period from November to April in the north and northwestern part of the country. In this area yields of paddy per hectare are low in comparison to other regions. FAO estimated that the water requirements of transplanted Aman and Boro rice in the northwest, on medium (silty loam) soil, is between 1,020 and 1,270 millimeters.

Precipitation records show that the months of November, December, January, February and March usually have little precipitation for rice cultivation on the basis of consumptive use factors. This method is used for monthly and seasonal water requirements for Aus, Aman and Boro. On this basis it is easily known which areas, and which month, is critical for rice cultivation.

The average Consumptive use co-efficients of different varieties of rice are as follows: transplanted rice 1.4, Aus 1.0, and Boro 1.4. According to the Blancy Criddle procedure, the country may be divided into seven climatic zones (Figures VII).¹⁵

Consumptive use factors have been correlated with the three major rice varieties in the different climatic zones, which are shown in Table VI. It can therefore be concluded that the moisture amounts in the western parts of the country are more critical than in the east and this region, on the whole, has a lower potential productivity. There is, however, much variation in yield from one climatic region to another (see Figure VII and Table IX).

4.5 Soil-Geomorphic Conditions for Rice Production

The Geological Survey of India classified the soils¹⁶ of Bangladesh into two broad classes:

Fig.VII

BANGLADESH

CLIMATIC ZONES

(According to Blancy Criddle,
Based on Consumptive Use Water
Requirements of Different
Varieties of Crops.)

(Source: East Pakistan Water And Power Development Authority,
Master Plan, Supplement B, Agriculture, International Engineering Company Inc,
San Francisco, California, 1964, P vii- 34.)

Table VI

WATER DEFICIT MONTHS FOR AUS, AMAN AND BORO RICE IN DIFFERENT AGRO-CLIMATIC ZONES

Climatic zones	District	AUS		AMAN		BORO	
		Total Months		Total Months		Total Months	
Northwest zone I	Dinajpur	3		3		5	
Northwest " 2	Rangpur	2		3		5	
Westcentral " 1	Pabna	3		5		5	
Central "	Dacca	2		4		5	
Northeast "	Sylhet	1		2		4	
Southern "	Chittagong	2		3		5	
Southeastern "	Rangamati	2		3		5	

Note: Computed on the basis of Climatic Data and Consumptive Use Factors.

(Source: East Pakistan Water And Power Development Authority, Master Plan, Supplement B, International Engineering Company, Inc., San Francisco, California, 1964.)

Table.VII

YIELD VARIATIONS IN DIFFERENT CLIMATIC REGIONS, RICE CROP, 1972-73.

District	Eastern, North, North-eastern, Southeastern.	District	Western, North, Northwestern, Southwestern
	Yield Per Hectare in Tons		Yield Per Hectare in Tons
CHITTAGONG	1.28	RAJSHAHI	0.90
COMILLA	1.07	PABNA	0.31
MYMENSINGH	1.10	KHULNA	0.73
CHITTAGONG H.T.	1.02	JESSORE	0.89
NOAKHALI	0.97	FARIDPUR	0.66

(Source: Bangladesh Agriculture Statistics, Ministry Of Agriculture, Government of Bangladesh, 1973, P.9.)

1. The newer and older alluvium areas , including North Bengal, the eastern plain and Noakhali and Chittagong coast; and
2. The Deltaic area (bounded by the Ganges, Pabna and Meghna rivers).

The latter group can be further subdivided into

- a) fine silty clays to the north
- b) peat deposits in the south; and
- c) Deltaic swamps near the coastal areas and sandy, gravelly and limy soils south of Sylhet and the Chittagong Hill Tract.

In 1947 a soil map of Bangladesh was attempted on the basis of physio-chemical analyses,¹⁷ but no systematic soil survey was undertaken until 1952. In the early part of 1960, a reconnaissance soil survey project was carried out by the FAO and the UNDP to provide more detailed information about soil tracts in Bangladesh. In terms of physiography and parent material, the soils of Bangladesh can be divided into seven tracts. However, according to the FAO and UNDP, there are at least one hundred different kinds of soils which are similar in appearance and mode of formation, but differ in certain properties, texture, drainage and depth, which affect their agricultural use and potential. The FAO and UNDP classified the soils of Bangladesh into 20 broad units which are shown in Figure VIII. These soil units are correlated and demarcated according to their non-suitability for rice production.

(Source: Food And Agriculture Organization Of United Nation, 1971, " Soil Resource " Technical Report 3, Rome, p.133.

4.6 General Soil Characteristics for Paddy Cultivation in Bangladesh

Areas suitable for paddy cultivation depend on the conditions under which the plant is grown and upon the nature of the soils. Water is the most important factor in rice growing, with the soil-water relationship largely determining the ability of a soil to develop its full potential for rice production. Most of the paddy areas in Asia are situated in the deltas of the great rivers. Paddy rice grows better in heavy soil than in light soil containing a higher proportion of sand. Most good paddy-yielding areas are found on a low impermeable soil with finer particles of clay. These soil types contain 70 per cent clay and silt.¹⁹

The degree of acidity also determines the quality of a soil. Good paddy soils are acid in reaction. When the soil is dry the pH value varies from 5.5 to 6.5 and when flooded the pH rises to 7.0. Most of the highly productive rice soils of China are either slightly or strongly acid. Kanoshita found that alkaline soil reactions are harmful to paddy during the first period of growth. Tomlinson found that below pH 4.0 growth of paddy is greatly reduced and below pH 3.0 most varieties cannot survive.²¹ In Bangladesh pH values vary from 4.5 to 8.0 from one soil group to another.

4.7 Soil Conditions for Aman, Aus and Boro Rice

The soils of Bangladesh are divided into 20 soil units. According to the FAO/UNDP classification these units differ considerably from one to another in terms of major physical and chemical components. Each soil unit is by no means suitable for all varieties of rice. This is

reflected in rice cropping patterns which differ considerably from one place to another. According to agronomists, sandy loams and clay are the best soils for paddy.²² Triple cropping usually occurs in these soil areas (Figure IX).

Coastal alluvium soils are best for Aman paddy. These soils are tidal in origin and are found in the Khulna, Barisal, Patuakhali, Noakhali and Chittagong coastal areas where pH values range from 5.5 to 7.0.²³ Aman paddy is also grown in the laterite soils which occur in low-lying areas of hilly regions. These soils contain low organic matter, nitrogen, phosphate and calcium. They have an acidic reaction and pH ranges from 5.5 to 6.4.²⁴

Aus paddy is usually grown on sand or sandy loams. Coarse-textured soils are suitable for Aus.²⁵ Sandy and clay loams are the most extensive soils in Bangladesh and cover larger areas in the north, south and east. They are generally referred to as "doas" or "doash". These soils are suitable for Aus both in the wet and dry seasons.²⁶

Boro paddy is grown usually in a clayey and marshy environment. Clayey soils are characteristic of the great depression areas of North Bengal, Mymensingh, and the Sylhet marshes.²⁷

4.8 Areas Not Suitable for Aus Rice Production Without Irrigation

On the basis of soil conditions, Aus rice cannot be grown without irrigation in the acid, sulphate soils on the Madhupur Tract, and on the red-brown soils which comprise soil units 12, 15 and 20 (Figure X).

Soil Unit 15 can be subdivided into three subunits:

SOIL GROUPS

(Source: Ahmad, N. , An Economic Geography Of East Pakistan , Second Edition, Oxford University Press, p-68.)

Fig.X

BANGLADESH

AREAS NOT SUITABLE FOR AUS RICE
PRODUCTION WITHOUT IRRIGATION.

Areas.

0 20 40 80 120 160 200 KM

1. Deep red-brown terrace soils occupying about 40 per cent of the unit which is divided between level and closely dissected topography. These soils are moderately to rapidly permeable and of low moisture storage capacity.
2. Acid basin clay soils which occupy about 20 per cent of the unit, and
3. Shallow red-brown terrace soils occupying more than 10 per cent of the unit. These soils are strongly acidic in reaction and their moisture-holding capacities are low.

These factors, together with rolling relief, severely restrict the productivity of this unit.²⁸ About 60 per cent of this area is not suitable for Aus.

Acid-sulphate soils are found in the Khulna and Sunderban areas (Unit 12). These soils are tidally flooded with saline or brackish water for the year around. Major limitations for Aus cultivation are their high toxic acidity, pH 8.0, and poor drainage.²⁹ Most of these areas are flooded from 15.24 to 60.94 centimeters deep at high tide during the five to six months of the monsoon seasons, but up to 120 centimeters at high tides. Here, 90 per cent of the land is not suitable for rice cultivation.

Brown hill soils have been found in the northern and eastern parts of the country (Unit 20). Here the pH is 4.6. About 70 per cent of the land is not suitable for Aus. Major limitations for agricultural development are caused by the steep slopes, heavy monsoon rainfall and drought during the dry season.

4.9 Areas Not Suitable for Aus Rice Production With Irrigation

Soil Units 12, 15 and 20 cannot be used for irrigated rice (see Figure X). These units have been described in the previous section. In Soil Unit 11, development potential is limited by the low-bearing capacity of peaty top soils, deep flooding during the monsoon season, wetness even in the dry season, and the risk of peat shrinkage and hardening when drained. About 60 per cent of the land is not suitable for Aus cultivation³¹ under any circumstances.

4.10 Areas Not Suitable for Aman Rice Production without Irrigation

A major portion of the country's cultivated land is not suitable for Aman rice cultivation. These areas are shown in Figure XII. The major soil units are 10, 12, 15 and 20. In the previous section Soil Units 12, 15 and 20 have been described in the context of Aus production. Soil Unit 10 occupies the greater part of the Ganges Flood Plain. Dark grey clays occupy about 80 per cent of the unit and brown soil the remaining 20 per cent. In some parts of the Jessore district the soils are strongly alkaline and in central Rajshahi there is a larger amount of lime in the subsoils. Flooding is frequently deep in the western part where rice-cropping intensity is less in comparison with other parts of the country.³² Aman is least important in the Meghna depression areas where it cannot survive the high flood waters.

4.11 Areas Not Suitable for Aman Rice Production with Irrigation

About one-third of the country is not suited to irrigated Aman rice production. The major soil units are shown in Figure XIII. Each region has been demarcated on the basis of a soil unit, except Unit 4. Other

AREAS NOT SUITABLE FOR AUS RICE
PRODUCTION WITH IRRIGATION.

AREAS NOT SUITABLE FOR AMAN RICE
PRODUCTION WITHOUT IRRIGATION.

Areas.

0 20 40 80 120 160 200 Km

AREAS NOT SUITABLE FOR AMAN RICE
PRODUCTION WITH IRRIGATION.

units have been described in the previous section. Soil Unit 4 occupies important areas of Tista, Karatoya-Bengali, Jammuna, the middle Meghna and the Ganges tidal flood plain. Texture, hydromorphic condition, land use and agricultural potential also vary on different flood plains. Deep and early floods are the major limitation for rice production.³³

4.12 Areas Not Suitable for Boro Rice Production With Irrigation

A major portion of the country's cultivated land is not suited to Boro cultivation. These areas are shown in Figure XIV. Except for Units 1, 3, 13, 14 and 17, the others have been discussed in relation to Aus and Aman. Soil Unit 1 occupies, in the north, the old Himalayan piedmont plain. Most of this area is used for a single rice crop. Much of the land remains unutilized due to seasonal water logging, wetness in the early dry season, and in some areas rapid permeability and the hazards of floods in depression sites.³² Brown soils occupy about 30 per cent of this area. Most of the soils are sandy or silty loams, which are 38 to 50 centimeters thick. Only Aus can be grown in the Brown soil. Soil Unit 13 comprises very young alluvial land along the Brahmaputra and Jammuna rivers. Soils are mainly silty and sandy. Boro cultivation is limited due to erosion and the rapid flow of flood waters.³⁵ Soil Unit 17 occupies most of the Barind Tract. These are poorly-drained soils. Most are strongly acid in reaction when dry and, during the monsoon season, are neutral. Due to drought Boro rice cannot be grown in this region.³⁶

Fig. XIV

BANGLADESH

AREAS NOT SUITABLE FOR BORO
RICE PRODUCTION WITH IRRIGATION

Areas.

0 20 40 80 120 160 200 KM

When Aman, Aus and Boro rice have been correlated with different soil units, it is very apparent that each is not suitable for all varieties of rice. It is necessary to undertake more detailed investigations than have been undertaken to the present time regarding the major limitations for rice productivity in terms of soil-geomorphic conditions.

4.13 Agro-Hydrological Conditions for Rice Production

Agriculture in Bangladesh is mainly governed by the seasonal rhythm of flood encroachment and drainage. The main features of hydrology in Bangladesh are flooding of the vast major rice systems and availability of ground water at shallow depths. Of these, flooding is the more important feature. Because the nature and extent of rice cropping patterns are greatly influenced by annual inundation, the depth, duration of seasonal flooding, and amount of water logging of the soil during the monsoon, all determine whether a rice crop can be grown during that period. Total rice productive patterns are greatly influenced by the extent of annual inundation. Flooding characteristics are of vital significance for planning future agricultural development, especially in relation to areas suitable for the International Rice Research Institute's (IRRI) rice varieties, and identifying areas where benefits from drainage might most easily be obtained.

4.14 Main Features

Flooding is largely determined by monsoon rainfall and the role of major river systems of the country. Flooding starts in the north, as a result of heavy storms in the pre-monsoon season. The Brahmaputra river begins to rise early in March and April and does not

reach its peak until late August and early September. The middle Meghna flood plain is mostly affected by the early rise of river levels. The Ganges peaks in September. Transplanted Aman must be moved from nursery beds before the end of August if satisfactory yields are to be obtained.³⁷

4.15 Nature and Extent of Flooding

Water level depths vary considerably from one region to another, from 30 to 910 cms. Every year it is estimated that 30 per cent of the cultivated areas of Bangladesh are flooded, two-thirds at depths of more than 1.8 meters. Such areas cannot be cultivated for Aus and transplanted Aman crop during the monsoon season.³⁵ Figure XV shows the most vulnerable areas in terms of flood depths.

4.16 Distribution of Different Varieties of Rice in Inundated Areas

Different varieties of rice grown in inundated areas are grouped and termed 'deepwater rice'. The total acreage under cultivation is approximately two million hectares. According to the Bureau of Agricultural Statistics for the years 1969-70, 1970-71 and 1971-72, the total acreage of deepwater rice was between 1.8 and 2.1 million hectares respectively. From 1969-1972 there was a steady decrease in the acreage of deepwater rice as a result of an increase of Boro rice acreage.³⁹ The distribution of deepwater rice is shown in Table VIII and Figure XVI.

There are considerable areas in the Kishoreganj, Mymensingh, Rajshahi, Sylhet, Pabna and Faridpur districts in which deepwater rice cannot be

Fig.XV

BANGLADESH

FLOOD ENVIRONMENT IN 1971 *

(Source: Hydrology Department, Bangladesh Water And Power Development Authority.)

*In this environment Aus and transplanted Aman are not suitable for cultivation.

Table.VIII

AREA AND PRODUCTION OF DEEPWATER RICE IN BANGLADESH. (AVERAGE 5 YEAR DURING 1969-

District	Area In (1000 Hectares)	Production Clean Rice (1000 Tons)	Per Hectare Yield Of Clean Rice (Kilos.
Dacca	190.40	168.5	900
Mymensingh	79.19	73.5	945
Tangail	64.77	48.5	761
Faridpur	281.45	199.7	721
Chittagong	6.15	9.3	1646
Chittagong H.T.	.85	1.1	1257
Noakhali	71.82	60.2	980
Comilla	250.4	273.2	884
Sylhet	212.5	240.9	1154
Rajshahi	147.0	132.4	910
Dinajpur	29.1	29.0	1118
Bogra	8.8	10.2	1180
Pabna	155.1	89.8	578
Khulna	13.2	45.3	870
Bakerganj	67.9	52.3	779
Patuakhali.			1005
Jessore	129.8	124.1	967
Kustia	83.3	36.5	
TOTAL	1889.5	1711.7	1000 (Average)

(Source: Deepwater Rice In Bangladesh, Bangladesh Rice Research Institute, Dacca, Bangladesh, 1974, p.25; with metric conversion.)

Fig. XVI

BANGLADESH

DISTRIBUTION OF DEEP WATER RICE
AREAS IN BANGLADESH.

Deep water Rice Areas.

(Source: Deepwater Rice In Bangladesh, Bangladesh Rice Research Institute 1974, p24.)

grown due to excessive floods. These areas are, however, partially used for Boro rice cultivation during the winter season. Faridpur has the maximum area of over 281,457 hectares followed by Comilla, Sylhet, Dacca, and, finally, the Chittagong Hill Tract region has 445 hectares.

In 1972-73 the total acreage of all rices (Aus, transplant Aman, deep water rice and Boro) was 23,439,000 acres 9,450,560 hectares of which 4,621,820 acres 1,871,182 hectares (19.72%) was under deep water rice... The intensity of cultivation of deep water rice in nine districts is more than 20% of the total rice acreage of each district and they are: Faridpur (55.64%), Pabna (43.40%), Dacca (38.56%), Comilla (38.48%), Tanqail (33.40%), Jessore (31.18%), Sylhet (27.71%), Kushtia (23.30%) and Rajshahi (23.48%); five of the districts, viz., Noakhali (13.74%), Khulna (13.20%), Kishoreganj (12.71%), Bakerganj (11.71%) and Mymensingh (10.61%) are within the range of 10 to 15%; and the remaining districts, Rangpur (3.95%), Bogra (2.39%), Dinajpur (1.68%), Chittagong Hill Tracts (1.00%), Chittagong (0.26%) and Patuakhali (00.00%) are quite insignificant in deep water rice cultivation". 40

In some areas in the districts of Sylhet, Kishoreganj, Mymensingh, Rajshahi, Faridpur and Pabna, deep-water rice cannot be grown due to excessively deep water. The yield of deep-water or broadcast Aman rice is similar to that of transplanted Aman rice. Production is less than for other varieties. In 1972-73 the area covered by deep-water rice was 19.72 per cent of the total acreage, while production was 16.2% of the rice production. The yield per hectare was 0.83 tons in terms of clean rice, while the minimum was 0.66 tons per hectare in Khulna and the maximum 1.10 tons per hectare in the Chittagong district. Faridpur, the most intensive deepwater area, had the lowest yield per hectare -- 0.66 tons. 41

Every year floods are likely to affect the paddy plant at each stage of growth. About 9.63 million hectares of all varieties are sown annually. On the average 0.43 million hectares (1972-73) of sown land fail to harvest during the paddy (i.e., Aus and Aman) seasons, of which 0.4 million hectares, amounting to 20 to 25 per cent of the total area,

under deep water paddy is totally damaged each year due to abnormal floods in different areas of the country. The overall average yield is also highly affected; the average yield of rice is 1.1 tons per hectare but the average yield of deepwater rice is only about 0.48 tons per hectare. This problem of lower yields becomes even more serious for districts with a higher than average amount of the crop. For example, the extent of the deepwater rice area was 55 per cent of the total rice acreage in Faridpur, but it produced only 25 per cent of the total rice requirements of the district.⁴² Rice yields are directly related to the nature and extent of flooding. Moreover, food shortages in Bangladesh are directly related to the high area of deepwater paddy and all its associated problems.

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CHAPTER 5

IDENTIFICATION OF REGIONAL CONCENTRATIONS OF RICE PRODUCTIVITY

The purpose of this chapter is to identify the regional concentrations and productivity of rice through different time periods. In Bangladesh most soils are at least moderately fertile but rice production and distribution patterns are not homogeneous throughout the country. Though the total area devoted to rice increased by 1.21 million hectares by double and triple cropping between 1965 and 1974, and this trend has probably continued over the past two years, production has failed to keep pace with the food requirements of the country.

It is valuable to identify the regions where rice is less concentrated and less productive, at least in terms of the national average. In order to plan for the future and discover the best uses of agricultural land, and steady and optimum returns, it is necessary to measure the efficiency of rice productivity under the present set of physical conditions of the country.

Regional concentrations of rice, in terms of area, have been assessed on the basis of location quotients. If rice concentrations are less in certain regions or areas then it is assumed that the region is less fertile or possesses other physical constraints which retard its cultivation. For the calculation of the location quotient, values for Aman, Aus and Boro rice areas, covering a ten-year period from 1964-74, were

collected by the former East Pakistan and Bangladesh Ministry of Agriculture. All agricultural data are available on the basis of agricultural districts (Appendix VIII) and have been employed in the analysis below.

The percentages of Aman, Aus and Boro hectares have been calculated separately, compared, and expressed as a location quotient to identify the concentration of rice productivity. At the same time, the significance of location quotients (Aman, Aus and Boro), were expressed as Z-scores from which can be interpreted the concentrations of different varieties of rice (see also Appendices XII- XIV).

Of the three varieties, Aman is the most important and generally covers, in all districts, an area two-and-a-half times that of Aus, etc. The Aman area represents about 55 per cent of the total cropped area and 65 per cent of the total rice area of the country. It is widely cultivated in 336 thanas out of 409.² Though it is extensively grown it is not equally concentrated all over the country. In the present study, out of 20 agricultural districts, it is in Khulna, Barisal, Patuakhali, Noakhali, Chittagong, Sylhet, Rajshahi, Bogra and Dinajpur, totalling 180 thanas, that by far the greatest concentration of Aman is found.

When the location quotient values of Aman, Aus and Boro are 1.00, then it can be said that there is a normal distribution, while values over and under 1.00 reveal upper and lower deviations from the mean. For instance, if a value is 1.50, it means that a certain rice type is more concentrated than is usual. When the location quotient values are compared with other districts it is found that in nine districts Aman paddy is more concentrated. But in the other eleven districts, Rangpur, Padma, Kustia, Jessore, Faridpur, Mymensingh, Tangail, Kishorganj,

Fig. XVII

BANGLADESH

LOCATION QUOTIENTS FOR
AMAN RICE, 1965-74

Values

1.00-1.99

.51-.99

.01-.50

(Data Source : Ministry of Agriculture, Government of Bangladesh.)

Fig. XVIII

BANGLADESH.

Z -SCORES OF LOCATION QUOTIENT FOR AMAN RICE, 1965-7

0 20 40 80 120 160 200 KM

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

Comilla and Chittagong Hill Tract Aman paddy is less concentrated, i.e., below the normal level. The location quotient values for Aman paddy are shown in Figure XVI.

When significant location quotient values for Aman are expressed in Z-scores, it is found that out of nine districts four, namely Barisal +1.17, Patuakhali +0.81, Bogra +0.69, and Chittagong +0.53, possess the most significant concentrations of Aman paddy. The other 16 districts have less significant concentrations (Figure XVIII). It would seem that during the Aman season valuable agricultural land remains unutilized.

Aus is the second most important rice variety in Bangladesh and yields per hectare are lower than for Aman. Aus, usually grown in sandy loam,³ reaches its greatest importance as may be expected on both sides of the Old and New Jamuna and Tista rivers. It also dominates in the Moribund delta and Ganges levees in the west.⁴ Aus is mainly concentrated in Dinajpur, Rangpur, Mymensingh, Tangail, Jessore, Kustia, Faridpur, Barisal, Comilla, Noakhali and the Chittagong Hill Tract (see Figure XIX), where location quotient values are above the normal values. In these districts values are between 1.00-1.99. Out of 11 districts, 2 districts, namely Kustia and the Chittagong Hill Tract, reveal the most significant concentrations of Aus paddy, where the Z-scores of location quotient values are above 2.0 (Figure XX).

Other less important districts are Khulna, Patuakhali, Chittagong, Dacca, Rajshahi, Bogra and Pabna with values of between 0.51 and 0.99. The least concentration of rice is found in Kishorganj and Sylhet,⁵

Fig. XIX

BANGLADESH

LOCATION QUOTIENTS FOR
AUS RICE, 1965-74.

(Data Source : Ministry of Agriculture, Government of Bangladesh.)

Fig.XX

BANGLADESH

Z-SCORES OF LOCATION QUOTIENT FOR AUS RICE, 1965-74

0 20 40 80 120 160 200 KM

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

Fig. XXI

BANGLADESH

LOCATION QUOTIENTS FOR
BORO RICE, 1965-74.

Values

2.00 or < greater

1.00-1.99

.51- .99

.01- .50

(Data Source : Ministry of Agriculture, Government of Bangladesh.)

Fig.XXII

BANGLADESH

Z-SCORES OF LOCATION QUOTIENT FOR BORO RICE, 1965-74.

0 20 40 80 120 160 200 KM

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

because there areas are only suitable for Boro and Aman. Here, the location quotient values are below 0.50.

Boro is the least important of the country's three major rice varieties. However, Boro paddy comes into its own in the heart of the Meghna depression, in western Sylhet and the eastern Mymensingh region, in parts of which summer flooding is so severe that Aus and Aman cannot be grown and Boro becomes the staple food crop. It occupies only about one-seventh of the area of Aus.⁶ Boro reaches concentrations equal to those of Aus and Aman in only two districts, Kishorganj and Sylhet, and values are above 2.0. The next most important cropped areas are in the Dacca, Patuakhali and Chittagong districts where location quotient values are between 1.00-1.99 (Figure XX). Boro rice needs irrigation, due to the non-availability of water during the growing season, so it is less concentrated in Pabna, Kustia and Jessore districts, where the location quotient values are below 0.50, which is much below expected values. The least significant concentrations of Boro paddy can be seen in seven districts, namely Kustia (-0.69), Jessore (-0.71), Pabna (-0.58), Faridpur (-0.59), Tangail (-0.24), Chittagong Hill Tract (-0.59) and Khulna (-0.14). (Figure XXI.)

5.1 Regional Productivity of Paddy Crops

An attempt has been made to assess rice productivity on the basis of productivity co-efficients, i.e., Z-scores of yield per hectare of Aman, Aus and Boro and ranking co-efficients. Productivity co-efficients, and ranking co-efficients, can be used in the evaluation of land productivity for rice cultivation. For the productivity co-efficient, data i.e., yield per hectare of Aman, Aus and Boro, have been collected for the period 1964

to 1974. The relative importance of rice productivity for Aman, Aus and Boro has been mapped on the basis of ten-year average values of productivity co-efficients (Figures XXIII - XXV). In this section 12 variables have been used to measure rice productivity, namely:

1. Location quotient of Aman, in terms of area (Appendix IX).
2. Location quotient of Aus, in terms of area (Appendix X).
3. Location quotient of Boro, in terms of area (Appendix XI).
4. Z-scores of location quotient of Aman, in terms of area (Appendix XII).
5. Z-scores of location quotient of Aus, in terms of area (Appendix XIII).
6. Z-scores of location quotient of Boro, in terms of area (Appendix XIV).
7. Z-scores of yield of Aman per hectare (Appendix XV).
8. Z-scores of yield of Aus per hectare (Appendix XVI).
9. Z-scores of yield of Boro per hectare (Appendix XVII).
10. Aman cropping intensity (Appendix XVIII).
11. Aus cropping intensity (Appendix XIX).
12. Boro cropping intensity (Appendix XX).

Regional rice productive patterns have been assessed on the basis of ranking coefficients (Appendix XXI). These values have been grouped in quintiles, which are shown in Figure III. Four district regions have been demarcated on the basis of the ranking co-efficients which are shown below:

1. Region of High Rice Productivity 5.00 - 7.50
2. Region of Medium Rice Productivity 7.51 - 10.00
3. Region of Low Rice Productivity 10.01 - 12.50
4. Region of Lowest Rice Productivity 12.51 and higher.

Fig. XXIII

BANGLADESH

PRODUCTIVE COEFFICIENT OF
AMAN RICE, 1965-74.

0 20 40 80 120 160 200 KM

(Data Source : Ministry of Agriculture, Government of Bangladesh.)

Fig. XXIV

BANGLADESH

PRODUCTIVE COEFFICIENT OF
RICE, 1965-74.

0 20 40 80 120 160 200 KM

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

2 2
OF/DE

Fig. XXV

BANGLADESH

PRODUCTIVE COEFFICIENT OF
BORO RICE, 1965-74.

0 20 40 80 120 160 200 K.M.

(Data Source: Ministry Of Agriculture, Government of Bangladesh.)

TABLE XI

MAJOR RICE PRODUCTIVE ZONES

<u>RANKS ACCORDING TO PRODUCTIVITY</u>	<u>DISTRICTS</u>	<u>RANKING CO EFFICIENTS</u>
Highest	Chittagong, Comilla	5.00-7.50
Medium	Mymensingh, Noakhali, Dinajpur, Ranajpur, Bogra, Sylhet, Patua- khali	7.50-10.00
Low	Chittagong H.T., Rajshahi, Khulna, Barisal, Jessore, Kishoranj, Dacca, Tangail	10.00-12.50
Lowest	Kustia, Faridpur, Pabna	12.51 and higher

5.2 Regional Problems of Rice Production5.2.1 Regions of Highest Productivity

Each region has its own environmental setting so rice production patterns vary to a great extent from one zone to another. In this section, the major problems of each zone have been correlated with environmental and non-environmental factors.

On the basis of these results, Comilla and Chittagong have been found to be relatively high rice productive areas. In this region annual rainfall varies between 2,285-2,540 millimeters, quite sufficient for paddy cultivation. Cropping intensities, however, vary considerably from one region to another; Comilla's 154.60 compares to Chittagong's 135.43. Cropping intensities are positively correlated with share cropping and landless labourers. According to Morrison, landless labourers and share

croppers may be taken as a guide to the degree of care in cultivation. From this study it is found that the percentage of share croppers and landless labourers in Chittagong is 23 per cent, much higher than Comilla's 12 per cent. On the other hand, rice cropping intensity in Chittagong is 94 per cent (Figure XXV), which is much higher than Comilla's because some area farmers have adopted new methods of cultivation. In both cases the total rice cropping intensities are much higher than the national average.¹¹

5.2.2 Regions of Medium Rice Productivity

There include seven districts, namely, Mymensingh, Noakhali, Dinajpur, Rangpur, Bogara, Sylhet, and Patuakhali which cover over 34 per cent of the total area of the country. Rice production patterns are not uniform throughout the region, which can be divided into three distinct sections:

1. The northern and northwestern part
2. The northern and northeastern part; and
3. The southeastern part of the country which can be differentiated in terms of land form, climate, soil and land-use patterns.

The north and northwestern parts include the Dinajpur, Rangpur and Bogra districts. In the case of cropping intensities in Dinajpur at 122 they are much lower than in Rangpur at 176.65 and Bogra at 147, and are also below the country's average cropping intensity of 143.¹² In the northwestern part of Dinajpur the agricultural potential is limited by water-logging, rapid permeability and hazards of flood in depression sites. In these regions brown soils occupy about 50 per cent of the landscape.¹³ Productivity is generally low due to highly acidic reactions

Fig. XXVI

BANGLADESH

RICE CROPPING INTENSITY
(Aus, Aman and Boro)

Percent

101-or < greater
81-100
61-80

(Data Source : Ministry of Agriculture, Government Of Bangladesh.)

and, at the same time, moisture-holding capacity in the soil is low due to high porosity.¹⁴ In the rainy season, runoff is too quick and in winter the water level drops sharply, so it is difficult to irrigate during the dry season.¹⁵ Major limitations of this district include steep slopes and severe erodability, high monsoon rainfall and drought during the monsoon season. A single rice crop is the main characteristic of this region.¹⁶

The north and northeastern portions comprise Mymensingh and Sylhet districts where clay and clayey soils cover the major areas. Due to the non-porosity of the soil, water logging is common during the wet season and soils become hard and stiff during the dry season, hampering agricultural operations.¹⁷ Deep floods limit agricultural productivity in the northeastern part of Mymensingh and western part of Sylhet.¹⁸ Dry season drought is the major limitation for agricultural productivity in Mymensingh and in the eastern part of the Sylhet district.¹⁹

The south and southeastern part comprises Noakhali and Patuakhali districts, where agricultural productivity is limited by high salinity, resulting from tidal flooding. Most of the soil becomes saline during the dry season, due to the capillary movement of moisture to the surface from ground water.²⁰ In the southern part, salinity reduces the area of Aus crops and also reduces the yield of Aman.²¹ In the northeastern part of Noakhali, rice cropping is made uncertain by river erosion, buried by deposits caused by early floods and rapid flood flow, slow permeability, poor aeration and drought. There is limited potential for

irrigation on this type of land. Rice cropping intensities in Noakhali and Patuakhali are 95 and 106 respectively, much higher than the national average.

5.2.3 Regions of Low Rice Productivity

Eight districts are included in this region, namely: Rajshahi, Jessore, Khulna, Barisal, Chittagong Hill Tract, Kishorganj, Tangail and Dacca, which cover 45 per cent of the total area of the country. Cropping intensities and rice-cropping intensities vary considerably from one region to another. The major factor limiting agricultural productivity in Rajshahi is the deep flooding in Chalan Bill. At the same time, some soils in the central Rajshahi district have a layer of hard lime in the sub-soil which discourages rice cultivation.²² In the Jessore district the cropping intensity is 77, again much below the country's average. In this district agricultural potential is greatly reduced by strong alkalinity in the top soils and difficulties of ploughing in the dry season.²³ In the Khulna district, the cropping intensity is very low, 113, although the rice cropping intensity is close to the country's average. In the southern part of Khulna district, agricultural potential is limited due to high toxic acidity.²⁴ Land becomes flooded, between 15 and 70 centimeters, during high tides and water remains stagnant for five to six months during the dry season. Production is also affected by widespread salinity.

Cropping intensity in the Dacca district is 145, close to the country's average, but the rice cropping intensity is only 73, much below the national average. Major limitations for rice productivity in this region are deep flooding,²⁶ slow permeability in the old Meghna estuarine

flood plain, and the low moisture holding capacity of the soil during the dry season in the northern part of Dacca district.

In Tangail, cropping intensity is 152, which is comparatively higher than the country's average, but the rice cropping intensity is 75 which is below the country's average. In this region rice production is restricted due to strong acidity in the soil, low moisture-holding capacity and poor drainage. In the western part of the area the land is flooded up to 60 - 150 centimeters deep for periods varying from 10 days to 4 months creating unsuitable conditions for transplanted Aman rice cultivation.²⁷

Agricultural productivity is restricted, due to steep slopes and drought during the monsoon season. In this region both cropping intensities and rice cropping intensities are much below the national average.

5.2.4 Regions of Lowest Rice Productivity

The lowest rice productivity area comprises three districts:— Faridpur, Pabna and Kushtia. In this region most soils produce moderate to poor crop yields.²⁸ In the southwestern part of Pabna, and the southeastern part of Faridpur, rice productivity is restricted, especially transplanted Aman,²⁹ due to late flooding, which occurs in late August to early September. A single rice crop is the major characteristic of this region.³⁰ Rice cropping intensities in Kushtia are extremely low, only 64; in Pabna 69, and in Faridpur 72.

It is interesting to note that cropping intensities fluctuated to a considerable extent between 1969 and 1973 in comparison to rice cropping intensities (Figure XXVII). But in the case of rice a steady position was maintained from 1969 to 1973. From 1970 Aus and Boro areas considerably

Fig. XXVII

declined due to natural calamities (Figure XXVIII).

It is evident that Aman, Aus and Boro are not equally concentrated and productive patterns are not uniform all over the country. Aman is grown in all districts, but it is not equally concentrated all over the country. Aus is mainly grown in eleven districts, i.e., Kushtia, Jessore, Faridpur, Barisal, Dinajpur, Rangpur, Mymensingh, Tangail, Comilla, Noakhali and Chittagong, which cover half of the total area of the country. In those regions Aman and Boro rice are not as important as Aus rice. Among the three varieties Boro plays a minor role in terms of rice area.

On the basis of location quotient values, i.e., where rice is less concentrated, it may be suggested that in some areas land remained fallow during the rice cropping season, and also at the same time in many districts, e.g., Dacca, Kishorganj, Tangail, Faridpur, Pabna, Jessore, Chittagong Hill Tract and Kushtia, where rice cropping intensities are considerably lower in comparison to the country's average.

INTENSITY OF DIFFERENT VARIETIES OF RICE

— Aman Rice Cropping Intensity
 - - - Aus Rice Cropping Intensity
 - . - . - Boro Rice Cropping Intensity

Fig. XXVIII

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YEAR

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 Conclusions

Food shortages, low productivity, and spiralling populations are common features in developing countries, but these problems are very acute in Bangladesh. In this context, considerable research has been undertaken by demographers, economists and sociologists. As yet no systematic studies have been undertaken of the major factors resulting in low productivity and, in particular, the impact of the environment. This thesis has attempted to investigate the major limitations to food production, particularly rice, and to identify the areas where the potential of the land has not been optimally utilized.

Different interpretations have been presented concerning the agriculture of Bangladesh and the reasons for its sluggish progress in comparison to other developing countries. From a historical perspective, it is apparent that Bangladesh has inherited one of the most defective agricultural systems in the Indian sub-continent. Until the present, no basic advances have taken place in the agricultural sector.

The second part of this study was mainly concerned with the present food grain situation, relating food shortages directly to natural calamities. However, food production could be improved by increasing cropping intensities or by raising the yields of different rice varieties. Land

utilization patterns were briefly discussed in the third chapter. Some limited scope for opening up agricultural land for rice cultivation still exists, especially in the northeastern and northwestern parts of the country.

In Chapter 4 the relationship between rice productivity and physical parameters was investigated, and land productivity in terms of different environmental settings was assessed. This chapter also dealt with the investigation of productive and unproductive regions for rice, in terms of cropping patterns. The extent to which land is fully utilized in terms of agro-ecological conditions has been investigated.

An attempt has been made to explore major limitations for rice production under different agro-economical conditions. Where rice production patterns have been correlated with agro-climatic zones, it was found that the western parts of the country are less productive than the eastern ones. The reason is that the former suffer from severe drought during the dry seasons. If irrigation is introduced then it may be possible to increase the production of rice during that period. Alternatively, the double cropping system may be introduced during the wet season to bolster cropping intensities. It was found that about a quarter of the total land remained unutilized for production from November to April due to drought. Where rice productivity for different varieties has been assessed in terms of soil conditions, it would seem that a major part of the country is not suitable for all varieties of rice production. At the same time, rice cropping patterns, and intensities, differ considerably from one soil unit to another. Low yields and failure of rice production are directly related

to hydrology; in particular, the intensity and widespread nature of flooding should be emphasized. In Bangladesh floods are a recurrent feature and a part of everyday life almost everywhere. In an average crop year, approximately 0.43 million hectares of sown land are destroyed by flood during two paddy seasons. At the same time, one variety of rice is grown in a flooded environment; that is, floating paddy (broadcast Aman), which is of comparatively low yield in comparison to Aus, transplanted Aman and Boro. Therefore, problems of low yield and production become even more serious for district with higher than average areas of floating paddy.

In the fifth chapter, analysis was confined to identification of the regional productivity of rice, employing 12 variables. It was found that, overall, rice cropping intensity is low, i.e., 83 per cent and at the same time cropping intensities are not uniform in all districts. Hence it is assumed that less than 50 per cent of the cropped land is used for rice cultivation during the cropping season (Appendix XXV).

Today, there is a most urgent need in Bangladesh to focus on the agricultural sector in order to lessen, and hopefully close, the gap between food production and population growth. There appears to be no alternative but to adopt more intensive types of agricultural land utilization, in addition to modernizing production techniques.

6.2 Recommendations for Further Research

Most data were collected at the district level. Unfortunately no detailed information was available at a lower level than that of the district. Analysis was, therefore, confined to the district level. This study was based on secondary data. Without field work it is very difficult

to draw conclusions regarding major limitations for rice production in terms of the different physical and economic conditions of the country. Hence a major effort is required in this direction.

No major coefficients have been developed to measure agricultural productivity. Kendall and Elahi have measured productivity of different varieties of crops and this study has attempted to adapt their methodologies to rice growing areas. However, the techniques employed require much refinement.

APPENDIX I

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS-DINAJPUR

Month	Percent daytime hours	Average temp	Precipitation 90% dry	Average precipitation	Consumptive use factor	Consumptive use with difference	
						coefficient	1.0
January	7.49	64.1	0	.37	4.80	6.72	4.80
February	7.12	66.8	0	.57	4.76	6.66	4.76
March	8.40	76.4	0	.63	6.41	8.97	6.41
April	8.64	83.4	0	2.10	7.21	10.09	7.21
May	9.38	85.3	3.0	6.83	8.00	11.20	8.00
June	9.30	83.7	6.2	13.85	7.78	10.89	7.78
July	9.49	83.8	7.8	15.25	7.95	11.13	7.95
August	9.10	83.4	5.6	13.19	7.59	10.63	7.59
September	8.31	83.8	4.9	12.40	7.96	9.74	6.96
October	8.06	80.0	.4	5.36	6.45	9.03	6.45
November	7.36	72.6	0	.34	5.31	7.43	5.31
December	7.35	66.7	0	.03	4.87	6.82	4.87

Note :

CONSUMPTIVE USE SEASONAL COEFFICIENT:

Aus I. 0; Transplanted Aman I. 40; and Boro I. 40.

(Source : EastPakistan Water Power Development Authority, (E.P.W.P.D.A), Master Plan, supplement B .Agriculture, International Engineering Company Inc San Francisco California, Dec 1964 Page Bv11-35.)

APPENDIX JI

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS-CHITTAGONG

Month	Percent daytime hours	Average temp	Precipitation 90% dry	Average preci- pitation	Consumptive use factor	Consumptive use difference	
						coefficient	1.0
January	7.65	67.3	0	0.35	5.14	7.20	5.12
February	7.21	71.6	0	1.09	5.16	7.22	5.16
March	8.40	78.3	0	2.37	6.58	9.21	6.58
April	8.56	83.1	0.5	5.74	7.11	9.95	7.11
May	9.21	83.9	3.5	10.07	7.73	10.82	7.73
June	9.10	82.6	10.3	20.67	7.52	10.53	7.52
July	9.31	82.1	12.2	25.31	7.64	10.69	7.64
August	9.00	81.7	12.8	22.50	7.35	10.29	7.35
September	8.30	82.2	7.8	13.95	6.82	9.82	6.82
October	8.12	81.3	2.5	8.60	6.60	9.24	6.60
November	7.50	74.7	0	2.07	5.60	7.84	5.60
December	7.55	69.2	0	0.53	5.22	7.31	5.22

Note;

CONSUMPTIVE USE SEASONAL COEFFICIENT :

Aus 1.0; Transplanted Anan 1.40; and Boro 1.40.

(Source: E.P.W.P.D.A., page B VII-40.)

APPENDIX III

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS-PABNA

Month	Percent daytime	Average temp	Precipitation 90% dry	Average precipitation	Consumptive use factor	Consumptive use with difference coefficient	Consumptive use with difference coefficient
January	7.58	65.4	0	.38		6.96	4.96
February	7.17	70.4	0	.77		7.06	5.04
March	8.40	79.2	0	1.71		9.31	6.65
April	8.60	85.7	0.4	2.88		10.37	7.37
May	9.30	86.0	3.5	7.07		11.20	8.00
June	9.20	85.0	5.9	11.45		10.95	7.82
July	9.41	84.1	5.7	10.53		11.06	7.90
August	9.05	84.3	5.3	10.85		10.68	7.63
September	8.31	84.7	3.6	8.82		9.79	6.94
October	8.09	82.2	0.2	5.73		9.31	6.65
November	7.43	74.3	0	6.1		7.73	5.52
December	7.46	67.9	0	.12		7.08	5.06

Note:

CONSUMPTIVE USE SEASONAL COEFFICIENT,

Aus 1.0 Transplanted Aman 1.40; and Boro 1.40.

(Source : E.P.W.P.D.A., page B VII-37.)

APPENDIX IV

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS-SYLHET

Month	Percent daytime hours	Average temp	Precipitation 90% dry	Average precipitation	Consumptive use factor	Consumptive use with difference	
						coefficient	1:0.
January	7.58	65.7	0	0.36	4.98	6.97	4.98
February	7.17	68.7	0	1.28	4.92	6.89	4.92
March	8.60	80.9	4.0	11.90	9.74	9.74	6.95
April	8.60	80.9	4.0	11.90	6.96	9.74	6.96
May	9.30	80.5	10.75	23.20	7.49	10.49	7.49
June	9.20	82.0	16.7	32.75	7.54	10.56	7.54
July	9.41	83.8	11.3	26.00	7.88	11.03	7.88
August	9.05	82.8	13.8	24.80	4.49	10.49	7.49
September	8.31	82.5	11.3	20.15	6.86	9.60	6.86
October	8.09	79.8	2.5	10.61	6.46	9.04	6.46
November	7.43	72.9	0	1.43	5.42	7.59	5.42
December	7.46	67.5	0	0.14	5.04	7.06	5.04

Note:

CONSUMPTIVE USE SEASONAL COEFFICIENT:

Apr 1.0; Transplanted Aman 1.40; and Boro 1.40.

(Source: E.P.W.P.D.A., page B VII-39.)

APPENDIX V

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS-RANGAMATI

Month	Percent daytime hours	Average temp	Precipitation 90% dry	Average precipitation	Consumptive use factor	Consumptive use/with difference coefficient	
						1.4	1.0
January	7.65	66.3	0	34	5.07	7.10	5.07
February	7.21	70.4	0	87	5.08	7.11	5.08
March	8.40	78.4	0	1.96	6.59	9.23	6.59
April	8.56	84.8	1.0	5.32	7.26	10.16	7.26
May	9.21	85.7	5.0	10.00	7.89	11.05	7.89
June	9.10	81.9	10.5	18.35	7.45	10.43	7.45
July	9.31	83.5	10.8	19.70	7.77	10.88	7.77
August	9.00	83.0	9.2	17.86	7.47	10.46	7.47
September	8.30	83.5	6.7	12.49	6.93	9.70	6.93
October	8.12	81.9	2.5	6.28	6.65	9.31	6.65
November	7.50	74.6	0	1.73	5.60	7.84	5.60
December	7.55	69.3	0	0.59	5.23	7.32	5.23

Note:

CONSUMPTIVE USE SEASONAL COEFFICIENT:

Aus 1.0; Transplanted Aman 1.40; and Boro 1.40.

(Source; E.F.W.P.D.A., page B VII-40.)

APPENDIX VI

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS - DACCA

Month	Percent daytime hours	Average temp	Precipitation 90% dry	Average precipitation	Consumptive use factor	Consumptive use with difference coefficient	
						1.4	1.0
January	7.58	65.5	0	0.40	4.96	6.96	4.96
February	7.17	69.9	0	1.01	5.01	7.01	5.01
March	8.40	79.3	0	2.17	6.66	9.32	6.66
April	8.60	85.7	1.75	5.84	7.37	10.32	7.37
May	9.30	84.6	4.00	9.48	7.87	11.02	7.87
June	9.20	83.3	5.8	13.46	7.66	10.72	7.66
July	9.41	83.5	7.4	12.72	7.86	11.00	7.86
August	9.05	83.5	7.3	13.43	7.56	10.58	7.56
September	8.31	83.2	4.8	9.15	6.91	9.67	6.91
October	8.09	80.8	1.0	5.57	6.54	9.16	6.54
November	7.43	72.9	0	0.72	5.42	7.59	5.42
December	7.46	66.4	0	0.17	4.95	6.93	4.95

Note:

CONSUMPTIVE USE SEASONAL COEFFICIENT.

Aus I.0; Transplanted Aman I.40; and Boro I.40.

(Source: E.P.W.P.D.A., page B VII-38.)

APPENDIX VII

CLIMATIC DATA AND CONSUMPTIVE USE WATER REQUIREMENTS - RANGPUR

	Percent daytime hours	Average temp	Precipitation 90% dry	Average preci- pation	Consumptive use factor	Consumptive use with difference coefficient	Consumptive use with difference coefficient
						1.4	1.0
January	7.49	63.7	0	.40	4.77	6.68	4.77
February	7.12	67.3	0	.64	4.79	6.71	4.79
March	8.40	75.1	0	1.00	6.31	8.83	6.31
April	8.40	75.1	0	3.35	7.18	10.05	7.18
May	9.38	82.4	5.5	11.61	7.73	10.82	7.73
June	9.30	82.9	9.4	19.64	7.71	10.79	7.71
July	9.49	84.5	6.5	16.22	8.02	11.23	8.02
August	9.10	84.6	5.0	13.54	7.70	10.78	7.70
September	8.31	83.7	4.6	12.77	6.96	9.74	6.96
October	8.06	80.1	0.5	6.76	6.46	9.04	6.46
November	7.36	72.2	0	.29	5.31	7.43	5.31
December	7.35	66.7	0	.06	4.90	6.86	4.90

Note: CONSUMPTIVE USE SAASONAL COEFFICIENT.
 Aus 1.0; Transplanted Aman 1.40; and Boro 1.40.
 (Source: F.P.W.P.D.A. page B VII-36.)

APPENDIX VIII

BANGLADESH

NAME OF DISTRICT

0 20 40 80 120 160 200 K.M.

APPENDIX IX

LOCATION QUOTIENT OF AMAN RICE, 1965-74.

Districts	1965	66	67	68	69	70	71	72	73	74
Dacca	.84	.87	.86	.87	.91	.79	.83	.85	.87	.85
Wishorganj	.86	.83	.80	.80	.77	.79	.78	.84	.77	.79
Mymensingh	.91	.88	.90	.85	.86	1.24	.97	1.05	.94	.94
Tangail	*	*	*	*	*	*	.69	.97	.83	.90
Faridpur	.84	.82	.80	.82	.82	.75	.79	.79	.82	.84
Chittagong	1.27	1.23	1.12	.99	1.15	1.01	1.13	1.23	1.13	1.08
Chittagong Hill Tract	.37	.37	.37	.39	.36	.36	.44	.46	.30	.50
Noakhali	1.02	1.04	1.07	1.21	1.08	1.08	1.05	1.21	1.14	1.15
Comilla	.97	.97	.93	.97	.95	.92	.99	1.06	1.01	1.00
Sylhet	1.01	1.07	.96	1.12	1.08	1.01	1.08	1.10	1.03	1.11
Rajshahi	1.06	1.08	1.10	1.13	1.06	1.03	1.14	1.08	1.10	1.01
Pinajpur	1.09	1.13	1.13	1.07	1.04	1.06	1.12	1.29	1.22	1.18
Rangpur	1.03	.99	.98	.97	.90	.89	.97	1.03	.97	.96
Dogra	1.06	1.18	1.26	1.14	1.17	1.13	1.29	1.34	1.21	1.17
Barua	.82	.80	.86	.93	.76	.76	.83	.85	.79	.74
Khulna	1.41	1.63	1.66	1.64	1.62	1.54	1.67	.37	1.63	1.65
Barisal	1.28	1.36	1.41	1.29	1.88	1.86	1.08	1.15	1.11	1.12
Patuakhali	---	*	*	*	*	*	1.62	1.70	1.62	1.61
Jessore	.92	.81	.76	.79	.71	.71	.72	.83	.78	.79
Kustia	.49	.33	.33	.32	.42	.36	.39	.18	.40	.38

* Data are not available.

(Data Source; Ministry of Agriculture, Government of Bangladesh.)

APPENDIX X

LOCATION QUOTIENT OF AUS RICE, 1965-74.

Districts	1965	66	67	68	69	70	71	72	73	74
Dacca	1.07	.97	.93	.89	.68	.90	.83	.87	.82	.89
Kishorganj	.62	.62	.58	.68	.51	.51	.60	.63	.59	.76
Mymensingh	1.21	1.22	1.22	1.26	1.13	1.58	1.18	1.24	1.23	1.31
Tangail	*	*	*	*	*	*	1.02	.92	1.21	.98
Faridpur	1.23	1.08	1.20	1.10	1.02	.97	.99	1.00	1.16	1.11
Chittagong	1.01	.97	.92	1.21	.69	.95	.86	.77	.96	1.06
Chittagong H.	1.89	1.70	1.69	1.59	1.59	1.43	1.76	1.60	.73	1.56
Noakhali	1.37	1.29	1.21	1.12	1.46	1.25	1.51	1.29	36	1.26
Comilla	1.17	1.06	1.09	.95	1.01	.94	1.04	.97	1.02	1.07
Sylhet	.62	.58	.27	.59	.38	.52	.56	.58	.48	.67
Rajshahi	.81	.81	.84	.76	.84	.77	.83	.88	.84	.92
Dinajpur	1.21	.91	1.01	.97	1.19	1.02	1.11	1.07	.88	1.12
Rangpur	.86	1.31	1.21	1.19	1.36	1.17	1.25	1.26	1.20	1.21
Sogra	1.05	.86	.81	.85	.84	.89	.80	.81	.98	.99
Pabna	1.07	1.12	.90	.91	1.13	.97	.98	.99	.96	.90
Khulna	.57	.25	.19	.34	2.58	.32	.27	.35	.27	.36
Barisal	.72	.68	.71	.94	1.34	1.22	1.17	1.10	1.14	1.21
Patuakhali	*	*	*	*	*	*	.54	.49	.47	.55
Jessore	1.21	1.39	1.54	1.49	1.61	1.43	1.60	1.56	1.60	.28
Kustia	1.80	2.01	2.04	1.91	1.70	1.54	1.58	1.85	1.61	1.94

* Data are not available.

(Data Source: Ministry of Agriculture, Government of Bangladesh)

APPENDIX XI

LOCATION QUOTIENT OF BORO RICE, 1965-74.

Districts	1965.	66	67	68	69	70	71	72	73	73
Dacca	1.25	1.25	1.59	1.35	.92	.68	.78	.82	.82	1.33
Kishorganj	6.24	5.69	5.17	4.82	3.07	.72	.71	.77	.78	3.44
Mymensingh	.75	.73	.70	.80	.51	1.22	1.00	1.15	1.05	.77
Tangail	*	*	*	*	*	*	.47	.88	.78	.72
Faridpur	.23	.22	.19	.18	.15	.62	.50	.37	.55	.35
Chittagong	.18	.71	1.53	1.89	1.58	1.39	1.36	1.46	1.50	1.83
Chittagong H.T.	.25	.22	.82	1.08	1.04	.52	.62	.55	.31	.83
Noakhali	.07	.22	.44	.45	.33	1.05	.90	.99	1.12	1.14
Comilla	.46	.47	.66	.93	.75	1.02	1.12	1.05	1.09	1.43
Sylhet	5.93	5.60	6.81	4.50	3.00	1.11	1.35	1.10	1.04	2.67
Rajshahi	.45	.66	.57	.59	.58	1.08	1.40	.88	1.01	.71
Dinajpur	.02	.02	.01	.04	.04	1.04	1.37	1.26	1.36	.10
Rangpur	.05	.04	.04	.09	.10	.98	1.33	1.30	1.19	.22
Bogra	.05	.07	.13	.26	.23	1.07	1.65	1.45	1.32	.52
Pabna	.16	.14	.18	.12	.15	.66	.66	.54	.61	.67
Khulna	.24	.35	.46	.38	.35	1.43	1.10	1.04	1.22	.46
Barisal	.11	.16	.13	.14	.13	1.85	.58	.91	1.12	.98
Patuakhali	*	*	*	*	*	*	.79	1.35	1.45	.96
Jessore	.02	.07	.07	.09	.07	.64	.65	.70	.71	.19
Kustia	.03	.03	.03	.05	.34	.33	.42	1.56	.37	.07

APPENDIX XII

Z-SCORES OF LOCATION QUOTIENT FOR AMAN RICE, 1965-74.

Districts	1965	66	67	68	69	70	71	72	73	74
Dacca	-47	-31	-32	-30	-17	-49	-47	-33	-36	-41
Kishorganj	-39	-45	-51	-53	-58	-48	-61	-36	-65	-68
Mymensingh	-18	-27	-19	-36	-33	-78	-03	.22	-14	-15
Tangail	---	*	---	*	*	*	-89	-01	-46	-28
Faridpur	-49	-47	-50	-46	-43	-59	-60	-50	-52	-49
Chittagong	1.23	.84	.49	.11	.49	.15	.47	.75	.45	.31
Chittagong H.F.	-2.33	-1.92	-1.85	-1.89	-1.69	-1.66	-1.68	-1.45	-2.10	-1.62
Neakhal	.23	.24	.33	.82	.28	.33	.22	.69	.47	.52
Comilla	.04	.03	-.09	-.03	-.08	-.11	.04	.27	.07	.94
Sylhet	.19	.34	-.01	.54	.29	.15	.32	.37	.15	.41
Rajshahi	.43	.36	.43	.56	.25	.20	.50	.31	.37	.08
Dinajpur	.52	.52	.52	.36	.18	.28	.45	.90	.74	.63
Rangpur	.30	.08	.05	.02	-.22	-.19	-.03	.19	-.05	-.11
Bogra	.40	.68	.94	.58	.55	.46	.96	1.07	.70	.59
Pabna	-.54	-.54	-.32	-.11	-.59	-.57	.46	-.35	-.59	-.83
Khulna	1.80	2.15	2.21	2.23	1.79	1.61	2.12	-1.72	2.00	2.16
Barisal	1.27	1.27	1.41	1.08	2.50	2.48	.30	.52	.39	.44
Patuakhali	*	*	*	*	*	*	1.99	2.09	1.95	2.03
Jessore	-1.14	-.51	-.63	-.56	-.72	-.69	-.81	-.39	-.64	-.64
Kustia	-1.87	-2.04	-1.97	-2.72	-1.52	-1.65	-1.82	-2.26	-1.79	-2.01

APPENDIX XIII

Z-SCORES OF LOCATION QUOTIENT FOR AUS RICE, 1965-74.

Districts	1965	66	67	68	69	70	71	72	73	74
Dacca	-0.00	-1.18	-2.22	-4.0	-7.5	-3.5	-3.7	-3.6	-5.2	-2.9
Kishorganj	-1.25	-1.02	-9.7	-9.7	-1.06	-1.43	-1.09	-9.9	-1.13	-6.5
Nymensingh	.39	.42	.41	.59	-1.72	1.58	.40	.60	.53	.77
Tangail	*	*	*	*	*	*	-.02	-.25	.47	-.07
Faridpur	.44	.08	.36	.17	-1.15	.16	-.10	-.02	.33	.25
Chittagong	-.16	-.19	-.23	.44	-.73	-.20	-.44	-.65	-.18	.13
Chittagong H.T.	2.24	1.57	1.41	1.46	.77	1.14	1.88	1.55	1.80	1.41
Noakhali	.82	.60	.82	.21	.61	.63	1.25	.74	.85	.65
Comilla	.27	.05	.12	-.26	-.18	-.24	.05	-.10	-.02	.14
Sylhet	-1.23	-1.11	-1.64	-1.22	-.28	-1.40	-1.21	-1.14	-1.40	-.89
Rajshahi	-.71	-.57	-.40	.75	-.48	-.71	-.50	-.34	-.47	-.23
Dinajpur	-.16	-.32	-.05	-.20	.13	-.02	.21	.14	-.37	.23
Rangpur	-.59	.63	.39	.41	.43	.43	.57	.65	.45	.69
Bogra	-.06	-.50	-.48	-.51	-.47	-.36	-.57	.53	-.11	.05
Pabna	-.02	.17	.28	-.35	.03	-.14	-.11	-.06	-.16	-.30
Khulna	-1.38	-1.91	-1.81	-1.87	2.56	1.97	-1.96	-1.76	-1.93	1.59
Barisal	-.98	.88	-.68	-.27	.39	.57	.38	.24	.29	.52
Patuakhali	*	*	*	*	*	*	-.1.26	-1.38	-1.42	-1.19
Jessore	.38	.83	1.10	1.21	.87	1.16	1.48	1.44	1.48	-1.89
Kustia	1.99	2.30	2.17	2.33	1.03	1.47	1.42	2.21	1.50	2.40

* Data are not available. (Data Source: Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XIV

Z-SCORES OF LOCATION QUOTIENT FOR BORO RICE, 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	.18	.19	.27	.25	-.04	-.76	-.41	-.57	-.45	.42
KISHORGANJ	2.79	2.73	2.19	2.68	1.71	-.67	-.60	-.72	-.56	2.87
MYMENSINGH	-.09	-.11	-.21	-.13	-.37	.66	.17	.42	.23	-.23
TANGAIL	*	*	*	*	*	*	-1.25	-.39	-.55	-.23
FARIDPUR	-.36	-.40	-.48	.57	-.66	-.94	-.18	-.1.03	-.1.22	.69
CHITTAGONG	-.39	-.12	.24	.63	.50	1.13	1.13	1.39	1.54	1.05
CHITTAGONG H.T.	-.35	-.41	-.14	.06	.06	-1.21	-.85	-1.37	-1.92	.97
NOAKHALI	-.44	-.26	.35	-.37	-.51	.23	-.11	-.05	.43	.29
COXILA	-.24	-.26	.23	-.04	-.17	.15	.48	.14	.36	.53
SYLHET	2.63	2.67	3.07	2.45	1.66	.39	1.11	.28	.24	1.98
RAJSHAHI	-.24	-.15	-.28	-.28	-.68	.30	1.24	-.39	.13	-.31
DINAJPUR	-.47	-.52	-.57	.66	-.50	.19	1.17	.78	1.15	-1.02
RANGPUR	-.46	-.51	-.56	-.63	-.70	.04	1.04	.90	.64	-.87
BOGRA	-.45	-.49	-.51	-.51	-.60	.27	1.91	1.34	1.01	-.54
PABNA	-.40	-.45	-.48	-.60	-.66	-.82	.42	-1.42	-1.05	-.36
KHULNA	-.35	-.33	-.34	-.42	-.50	1.24	-.95	.09	.72	-.59
BARISAL	-.42	-.44	-.51	-.59	-.68	2.37	-.41	-.29	.44	-.09
PATUAKHALI	*	*	*	*	*	*	*	1.03	1.41	-.02
JESSORE	-.47	-.49	-.54	-.62	-.72	-.89	-.79	-.93	-.76	-.71
KUSTIA	-.46	-.51	-.57	-.65	-.51	1.69	-1.39	1.68	-1.75	-1.05

*Data are not available.

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XV

PRODUCTIVE COEFFICIENT OF AMAN RICE, 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	- .47	.56	.53	-.32	-1.18	-.58	-.05	-.11	-.35	-.13
KISHORGANJ	-.76	-.04	-.65	-.66	.00	-.05	.20	.20	.79	1.24
MEHENSINCH	-.18	-.65	-.65	-1.12	.23	-.05	.20	.20	.79	1.24
TANGAIL	*	*	*	*	*	*	-.97	.20	-.35	.50
FARIDPUR	-2.49	1.65	-2.11	-1.35	-2.25	-.79	-1.22	-1.17	-1.98	-2.57
CHITTAGONG	2.27	.86	1.73	1.50	1.54	1.85	.79	.39	2.26	1.01
CHITTAGONG H. T.	.53	.66	1.73	1.27	1.30	2.17	1.54	.43	.30	-1.67
NOAKHALI	.68	.04	-.78	.13	.11	-.05	-.38	-.38	-.02	-.14
COMILA	.39	.35	-.52	1.16	.35	.58	-.53	-.02	.62	1.15
SYLHET	-.04	2.78	.80	.93	.47	.47	.95	-.02	.13	.06
RAJSHAHI	.32	-1.05	.14	-1.12	.47	.26	.87	-.38	-.51	-.91
DINAJPUR	-.04	-.44	.40	.24	.59	-.05	.87	-.71	.79	.27
RANGPUR	.97	-.34	.27	.01	.23	.47	1.38	.53	1.60	1.67
BOGRA	.97	.96	.00	-.09	1.07	-.26	1.04	.16	.62	.48
PABNA	-1.19	-.85	-.92	-1.58	-1.54	-2.49	-.63	-.80	-1.33	-.54
KHULNA	-.04	1.05	1.20	1.27	.47	-.37	-1.06	3.86	-1.49	-.30
BARISAL	-.47	.35	-.78	-.89	-.59	.05	-1.48	-.48	.13	.10
PATUAKHALI	*	*	*	*	*	*	-1.73	-.43	-.51	-.86
JESSORE	.39	-.04	.27	-.32	-.23	-.47	-.80	-.34	-.51	-.86
KUSTIA	-.18	-.34	-.92	.93	-1.07	-.37	.37	-.29	-.35	.09

* Data are not available.

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XVI

PRODUCTIVE COEFFICIENTS OF WIS RICE 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	-20	-45	.58	.14	.52	.19	.00	.69	-.82	1.58
KISHORGANJ	-1.07	-.66	.25	-.68	-.67	-1.76	-.48	-1.04	-.22	-.29
MYMENSINGH	-1.21	-.25	-1.20	-1.20	.43	-.94	-.57	.25	-1.42	-.02
TANCAIL	---	---	---	---	*	*	---	.22	-1.12	.95
FARIDPUR	-1.77	-.90	-2.37	-1.40	-1.65	-1.15	-1.18	.88	-1.12	-.77
CHITTAGONG	.21	-.25	1.86	1.34	1.37	1.59	-1.35	2.00	2.72	.26
CHITTAGONG H.T.	.35	1.40	1.96	1.89	1.79	1.72	2.01	.85	-.52	-2.08
MOAKHALI	-.48	.02	-.21	-.17	-1.05	-.56	.04	-.25	1.27	-.72
COMILLA	.36	.51	-.44	-.31	.51	.59	.02	.22	.07	.82
SYLHET	.21	-.45	-.07	1.06	.25	1.58	.97	1.17	.37	1.30
RAJSHAHI	.71	1.81	.48	-.86	-.46	1.13	1.62	-.41	.37	1.59
DINAJPUR	-.34	-.45	-.38	.28	1.32	.43	.10	.22	-.52	-.52
RANGPUR	.21	-.03	-.07	.20	.64	.01	.47	-.41	.37	1.14
BOGRA	-.90	.06	.33	-.49	.99	-.40	.78	-.73	.07	-1.30
PABNA	-.34	-.92	.27	-1.83	1.59	-1.52	-.15	-.88	-.22	-.25
KHULNA	.87	.41	.44	1.24	-.32	.82	-1.08	1.65	-1.12	-1.17
BARISAL	-.55	-2.15	-.40	.56	-.32	.41	.80	-.73	.97	-.19
PAHUAKHAKLI	---	---	---	---	---	-.78	.04	-.41	.07	-.75
JESSORE	1.72	.45	-.07	.30	.16	-.24	-1.94	-.09	-.22	.27
KUSTIA	2.22	1.87	-.97	-.03	-.97	-1.59	-.13	-1.52	.97	-.40

Data are not available.

Data Source: Ministry of Agriculture, Government of Bangladesh.

APPENDIX XVII

PRODUCTIVE COEFFICIENT OF BORO RICE, 1965-74.

Districts	1965	66	67	68	69	70	71	72	73	74
Dacca	35	1.46	.70	-.12	-2.62	-.40	-.23	.44	.21	1.93
Kishorganj	1.26	1.58	1.48	.10	-.34	-.74	-1.17	-1.08	-1.52	-.29
Nymensingh	.80	.27	.59	-.18	-.63	.63	.34	.57	-1.13	.95
Tangail	*	*	*	*	*	.27	-.06	-.51	.58	-.05
Faridpur	-1.69	-1.74	-1.51	-.98	.07	.10	.59	.55	1.08	2.77
Chittagong	-.44	-.31	-.62	.10	.53	.90	1.26	1.52	1.30	-.35
Chittagong H. T.	1.60	.99	.92	1.07	.27	-.11	-.56	-.46	+1.13	-1.12
Noakhali	1.23	-1.50	.92	-1.26	-.60	1.75	1.64	1.90	.74	-.13
Comilla	.35	.75	1.37	-.18	-.34	-.06	.04	-.29	-.63	-.48
Sylhet	.80	1.11	.70	-.98	-1.01	-1.42	-1.11	-1.47	-1.80	-.56
Rajshahi	.01	-.91	-.51	-.98	-.81	-1.31	-.78	-.68	-.74	.11
Dinajpur	-1.31	-.31	-.62	1.87	1.52	.00	-1.55	.10	1.35	.24
Rangpur	.35	.75	.70	.21	.59	-.17	-.67	-.29	-.41	.26
Bogra	.80	.27	.59	-.52	-.50	-1.25	-.28	-1.02	-.52	-1.04
Pabna	.80	-.43	-.85	.27	-.34	-.63	.21	.27	-.03	.55
Khulna	-.89	-.55	-.62	1.63	-.50	-.97	-.73	-1.25	-.30	-1.02
Barisal	-1.69	-1.38	-1.85	-1.43	.05	1.98	1.53	1.51	1.13	-.79
Patuakhali	*	*	*	*	1.57	1.19	1.42	1.28	1.35	-1.42
Jessore	.01	.03	-.96	1.82	.59	1.30	1.48	.77	.69	.30
Kustia	.01	-.07	-.40	1.13	1.16	.22	-.67	.68	-.19	-.15

APPENDIX XVIII

RICE CROPPING INTENSITY AMAN VARIETY 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	44.46	43.23	41.61	40.53	43.31	37.70	37.24	37.39	40.43	39.78
KISHORGANJ	45.50	41.01	38.57	37.31	36.81	37.81	35.21	36.94	36.11	36.19
MYRENSINGH	48.33	43.84	43.66	39.68	40.62	59.68	43.66	45.55	43.82	43.33
TANGAIL	-*	-*	-*	-*	-*	-*	31.11	42.32	38.89	41.53
FARIDPUR	44.25	40.66	38.81	38.24	38.86	35.97	35.31	34.78	38.09	38.60
CHITTAGONG	67.03	60.93	54.07	46.10	54.73	48.68	51.09	54.06	52.93	49.83
CHITTAGONG H.	19.73	18.33	18.04	18.12	17.24	17.38	19.57	20.21	13.93	22.79
NOAKHALI	53.76	51.61	51.61	56.50	51.13	51.78	47.19	53.02	53.02	52.72
COMILA	51.23	48.40	45.06	45.31	44.91	44.20	44.61	46.57	47.00	46.11
SYLHET	53.23	53.17	46.36	52.42	51.23	48.65	48.74	48.10	48.14	51.19
RAJSHAHI	56.38	53.50	53.18	52.77	50.52	49.51	51.30	47.18	51.57	46.58
DINAJPUR	57.60	55.92	54.46	49.94	49.48	50.98	50.54	56.36	57.13	54.34
RANGPUR	54.75	49.14	47.29	45.05	42.55	42.84	43.67	45.39	45.16	44.01
BOGRA	56.04	58.43	61.01	53.07	55.76	54.14	58.02	58.92	56.63	53.79
PABNA	43.57	39.64	41.59	43.29	36.12	36.32	37.41	37.19	36.99	33.86
KHULNA	74.59	81.03	80.56	76.41	77.02	73.99	74.94	16.04	75.36	75.83
BARISAL	67.60	67.46	68.18	60.05	89.35	89.07	48.47	50.58	51.87	51.60
PATUAKHALI	-*	-*	-*	-*	-*	-*	73.02	74.63	75.55	73.96
JESSORE	48.84	40.07	36.84	36.96	33.86	34.12	32.31	36.47	36.71	36.53
KUSTIA	25.84	16.46	16.14	14.77	20.05	17.51	17.58	17.71	18.72	17.33

* Data are not available.

(Source : Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XIX

RICE CROPPING INTENSITY AUS VARIETY 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	24.90	24.09	22.29	23.32	16.60	24.59	22.10	22.26	19.75	21.1
KISHORGANJ	14.36	15.42	13.93	17.74	12.37	14.02	15.09	15.15	14.08	18.0
MDINENSINGH	28.26	30.24	29.29	32.96	31.64	43.30	29.46	31.59	29.53	30.5
TANGAIL	*	*	*	*	*	*	25.45	23.33	29.01	25.2
FARIDPUR	28.69	26.69	28.73	28.84	24.98	26.41	24.65	25.56	27.67	25.9
CHITTAGONG	23.56	23.99	22.13	31.52	16.90	25.95	21.38	19.50	22.88	24.5
CHITTAGONG H.T	43.95	42.08	40.39	41.46	37.93	39.02	43.84	40.77	41.39	36.40
NOAKHALI	31.90	32.09	33.84	29.24	35.64	34.09	37.70	32.51	29.51	32.9
COMILLA	27.26	26.38	26.06	24.71	24.63	25.63	26.07	24.77	24.44	24.9
SYLHET	14.52	14.43	6.38	15.32	9.37	14.32	13.94	14.72	11.50	15.67
RAJSHAHI	18.94	19.99	20.20	19.94	20.38	21.08	20.80	22.47	20.23	21.39
DINAJPUR	23.62	22.57	24.12	25.25	28.99	27.78	27.67	27.15	21.13	26.19
RANGPUR	19.95	32.39	29.06	31.20	33.20	32.10	31.10	32.11	28.78	29.91
BOCRA	24.46	20.78	19.36	22.22	20.59	24.42	20.11	20.69	23.51	23.21
PABNA	24.81	27.70	21.54	23.78	26.59	24.58	25.16	23.11	23.11	20.96
KHULNA	13.22	6.27	4.52	8.98	6.21	8.82	6.71	8.93	6.56	8.47
BARISAL	16.66	16.88	17.13	24.55	32.61	33.28	29.31	28.08	27.31	28.37
PATUAKHALI	*	*	17.13	*	*	*	13.44	12.44	11.30	12.96
JESSORE	28.14	34.47	36.98	39.01	39.30	39.25	39.89	39.77	38.42	6.63
KUSTIA	41.82	49.87	48.92	50.00	41.44	42.19	39.39	47.16	38.53	45.26

* Data are not available.

(Source :Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XX

RICE CROPPING INTENSITY-BORO VARIETY, 1965-74.

DISTRICTS	1965	66	67	68	69	70	71	72	73	74
DACCA	4.57	4.80	7.59	6.54	8.55	15.38	14.70	15.56	15.09	11.29
KISHORGANJ	22.79	21.78	24.63	23.40	28.60	16.14	13.39	15.55	14.34	29.00
MYMENSINGH	11.27	2.74	2.81	3.32	3.90	4.74	27.32	18.74	23.21	19.36
TANCAIL	*	*	*	*	*	*	8.87	17.70	14.40	9.16
FARIDPUR	.85	.84	.92	.86	1.42	13.87	9.32	7.46	10.16	3.18
CHITTAGONG	.64	2.73	7.30	9.17	14.77	31.24	25.42	29.60	27.72	15.83
CHITTAGONG H.T.	.90	.83	3.92	5.23	9.72	11.59	11.59	11.15	5.74	6.90
NOAKHALI	.27	.83	2.08	2.21	3.08	23.68	16.81	20.00	20.66	9.62
COMILA	1.69	1.79	3.14	4.50	7.04	23.01	20.90	21.26	20.18	12.03
SYLHET	21.63	21.44	32.46	21.83	22.76	25.02	25.33	22.24	19.25	22.50
RAJSHAHI	1.66	2.54	2.70	2.86	3.93	24.24	26.24	17.74	18.75	5.98
DINAJPUR	.07	.06	.06	.18	.29	23.36	25.75	25.54	25.21	.81
RANGPUR	1.81	.15	.21	.42	.96	22.04	24.83	26.32	21.96	1.87
BOGRA	.19	.28	.62	1.24	2.16	24.00	30.86	29.26	24.34	4.30
PABNA	.58	.54	.88	.60	1.44	14.86	12.37	10.87	11.28	5.61
KHULNA	.48	1.35	2.18	1.85	3.23	32.11	20.61	20.94	22.52	3.90
BARISAL	.40	.63	.60	.68	1.23	41.64	10.91	18.39	20.70	8.22
PATUAKHALI	*	*	*	*	*	*	10.91	18.39	20.70	8.22
JESSORE	.08	.27	.35	.45	.69	14.28	12.09	14.10	13.08	11.61
KUSTIA	.21	.12	.13	.25	3.18	7.52	7.85	.29	6.78	.62

* Data are not available

(Source: Ministry of Agriculture, Government of Bangladesh.)

APPENDIX .XVI

RANKS ACCORDING TO RICE PRODUCTIVITY, 1965-74.

Districts	Location Quotient (L.Q.)			Z-score of L.Q.			Z-score of yield			Rice Cropping Intensity			Ranking
	Aman	Aus	Boro	Aman	Aus	Boro	Aman	Aus	Boro	Aman	Aus	Boro	
Becca	13	15	5	12	16	12	14	7	7	13	14	11	11.1
Kishorganj	17	18	2	16	19	2	12	8	15	17	17	2	12.06
Myensingh	12	5	9	7	6	9	9	19	12	10	5	8	9.25
Tangail	14	10	11	8	11	15	10	12	10	15	11	5	11.0
Faridpur	15	7	17	14	7	16	20	20	16	16	7	19	14.3
Chittagong	5	14	3	4	13	3	1	1	3	5	13	4	5.58
Chittagong H.T.	19	2	13	19	1	17	2	2	6	19	2	18	10.1
Meakhal	7	4	6	13	4	11	11	10	4	7	4	15	8.00
Comilla	10	8	7	5	9	6	4	7	5	10	3	7	7.1
Sylhet	9	19	1	9	20	1	3	3	18	9	18	1	9.25
Rajshahi	8	16	8	10	15	8	6	4	19	8	16	10	10.67
Dinajpur	6	9	15	15	10	7	8	9	8	6	9	12	9.5
Rangpur	11	6	16	6	5	10	5	6	9	11	6	14	8.75
Logra	4	13	12	3	14	5	6	14	17	4	15	6	9.42
Pabna	16	12	18	11	12	18	19	17	14	14	12	10	14.12
Khulna	2	17	10	8	18	14	7	5	20	2	20	9	11.0
Bārisal	3	11	14	1	8	13	18	16	13	3	10	13	10.50
Patuakhali	1	20	4	2	17	4	17	15	2	1	19	3	8.75
Jessore	18	3	19	17	3	20	13	11	1	18	3	17	11.0
Kustia	20	1	20	20	2	19	15	13	11	20	1	20	15.1

APPENDIX XVII

SAMPLE CALCULATION OF LOCATION QUOTIENT

	<u>DISTRICT A</u>	<u>COUNTRY</u>
Total Rice Acreage	3,500 (R1)	28,000 (R)
Total Cropped Area	17,500 (N1)	280,000 (N)

Location Quotient

$$\frac{R1}{N1} \cdot \frac{N}{R} = \frac{3500}{17500} \cdot \frac{280000}{28000} = \frac{20}{10} = 2$$

From the calculation it can be seen that District A's percentage of 20, compared to the country's percentage of 10% results in a location quotient of 2.0. The value of 2 indicates that the total rice land in District A is twice the country's percentage. Therefore, the location quotient value indicates an important degree of concentration.¹

¹ MacLeod, P.K., 1972, A Study of Concentrations of Scottish Settlement in Nineteenth Century Central Ontario, Unpublished M.A. Thesis, Geography Department, Carleton University, p. 37.

APPENDIX XVIII

CALCULATION OF PRODUCTIVE COEFFICIENT (Z-SCORE) OF YIELD
PER HECTARE OF THREE DIFFERENT VARIETIES OF RICE

$$\int_0^Z = (2)$$

$$Z = \left(\frac{x - \bar{x}}{s} \right)$$

0 Signa always positive

Z is positive if $x > \bar{x}$

Z is negative if $x < \bar{x}$

positive value of Z indicates the significant concentration of location equation values, when it is considered in terms of productivity, i.e., yield per hectare is increasing from the mean value, then Z will be given positive sign. When Z gives negative sign it means that it is less productive or less significant because the value is below the mean value. Productivity co-efficients for Aman, Aus and Boro have been processed through a computer and are shown in Appendices XV - XVII. The relative importance of Aman, Aus and Boro productivities have been mapped on the basis of ten-year average value of productivity co-efficients. These maps are shown in Figures XXII and XXIV.

APPENDIX XXIV

CALCULATION OF RANKING CO-EFFICIENTS

Kendall's method of ranking co-efficients has been used in modified form. Ten years' average of location quotient values; Z-scores of location quotients, productivity co-efficient values (i.e., Z-scores of yield per hectare) are Rice Cropping Intensities of Aman, Aus and Boro, have been calculated on the basis of districts (Appendix XVIII - XX).

These co-efficients have been marked in each case and are shown in Appendix XXI. Ranking co-efficients have been calculated by arranging all the ranks of each district¹ which are shown in Appendix XXI. For example, in the case of Dacca district the ranks according to location quotient values, Z-scores of location quotients, productivity co-efficient values, and Rice Cropping Intensities of Aman, Aus and Boro are entered in each column from 1 to 12. The summation of entries from Columns 1 to 12 is 139; when it is divided by the number of cases (12) it gives 11.58 as the ranking coefficient of Dacca district. In this way ranking co-efficients have been computed for 20 districts.

¹ Maryam, K.E. (1963) "Efficiency of Agriculture in West Pakistan", Pakistan Geographical Review, Vol. 20, No. 2.

NOTE: This is one of the important methods of weighting agricultural regions.

APPENDIX XXV

DEFINITION OF INTENSITY

INTENSITY IS DEFINED AS:

$$I = \frac{RA}{CA} \times Y \times 100$$

where I = Intensity

RA = Area planted with rice

CA = Total area capable of supporting cultivation

Y = Number of rice crops planted per year.

In one year two varieties of rice can be grown in the same field.

If the crop is fully utilized for rice production, then rice cropping intensities will be 200%; in spite of two crops ($Y = 2$), it is known that rice cropping intensities are 83%, i.e., less than 50% of the cropped land is utilized for rice production.

AMAN RICE CROPPING DENSITY,
1965-71.

(Data Source : Ministry of Agriculture, Government of Bangladesh.)

APUDIPIN, NAW TI

BANGLADESH

APS RICE CROPPING INTENSITY,
1965-71.

Percent

40-59

21-39

01-20

(Data Source: Ministry of Agriculture, Government of Bangladesh.)

APPENDIX XVIII

BANGLADESH

BORO RICE CROPPING INTENSITY
1965-74.

Percent

21-39

01-20

0 20 40 80 120 160 200 KM

(Data Source ; Ministry of Agriculture, Government of Bangladesh.)

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