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IRRIGATION WATER DISTRIBUTION PROCESS IN SPATIALLY STRATIFIED AREAS OF THE GANGES-KOBADAK PROJECT OF BANGLADESH

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by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Engineering

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ABSTRACT

A study was conducted in the Ganges-Kobadak (G-K) irrigation project of Bangladesh during the Kharif-I (dry) season of 1978. Different aspects of water use for lowland rice and the corresponding irrigation water supply in the selected areas of the project were studied.

Results of the study revealed that seepage and percolation losses varied from 3.88 to 6.96 mm/day and the net water use i.e. evapotranspiration plus seepage and percolation ranged from 7.82 to 10.90 mm/day in different areas. Water supplied through the canals was found to be much more than the actual requirement and comparatively higher water supply was observed at the upstream areas. Also, no definite schedule of water supply was found to exist in the system. High water use efficiency was found at the downstream areas compared to the upstream areas indicating excessive loss of the supplied water at the upstream areas. On the other hand, the water adequacy was observed to be higher in the areas nearer to the source of water.

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I INTRODUCTION AND OBJECTIVES

A. Introduction

Irrigation has historically been proved to be an essential input for successful crop production. Moreover, the development of the modern varieties (MV) of rice has enhanced the importance of irrigation water for achieving their high yield potentials.

Rice, like all other crops, requires an adequate supply of water to grow, develop and produce at its potential rate. But unlike other crops, lowland varieties of rice are grown in flooded soil. The main reasons for this practice are: a) weed growth is drastically reduced under flooded conditions, and b) nutrient availability is generally higher in flooded soil than in upland soil (De Datta, et. al., 1970). Due to this continuous flooding practice, a well managed distribution of irrigation water is a crucial need for increasing the effectivity of the water developed in an irrigation system where rice is the dominant crop grown.

Rice being the staple food in most of the South and South-east Asian countries, the irrigation systems of these countries are mostly concerned with the rice production. Hence, the modern varieties of rice and the modern rice technology have placed these irrigation systems in a new dimension due to the great concern of the farmers as well as the national government to increase crop production through intensive and extensive development and utilization of the irrigation systems. It is estimated that irrigated rice crop area in the South and South-east Asian region has increased from about 20% of total crop area in mid-1960's to about 32% in the mid-1970's. During the same period rice production in the irrigated areas has increased from about 40% to 50% of total rice production (Palacpac, 1978).

Bangladesh is one of the major rice producing countries of Asia and has been struggling to meet up her annual food shortage. Although the annual rainfall in the country ranges from 2030 mm to 5070 mm, its distribution is unfavorable in nature. About 80 to 90% of the total rainfall is confined during 6 to 7 months of the year leaving the most productive winter season with quite inadequate precipitation for crop production. At the present time, only about 12% of the 8.9 million hectares of cultivable land in the country are supplied with irrigation water to meet full or partial demand (Bhuiyan, 1977). This development of irrigation has been achieved mostly during the last one and a half decade. Recent development in the small scale tubewell (both deep and shallow) and power pump irrigation schemes has been quite intensive in a number of districts of the country. But the total area irrigated by them still remains as small fraction of total irrigated area. Among the different large scale gravity irrigation systems of the country which are under operation, the followings are remarkable: a) Ganges-Kobadak (G-K) project, b) Dacca-Narayanganj-Demra (D-N-D) Project, and c) Chanpur project. But in most of these systems, farmers' complaint about the irrigation water delivery and inadequacy of water supply is very common. This reflects the fact that there is either not enough water to meet the requirements of the system or the distribution of the available water supply to the different parts of the system is not proper or both.

B. Justification

The Ganges-Kobadak (G-K) Irrigation Project, Phase-1, with a potential irrigable area of 48,583 hectares came under operation from the year 1962. But to date, a maximum area of about 27,503 hectares and 14,170 hectares of land were possible to bring under irrigation during the Kharif-II (wet) and Kharif-I (dry) seasons respectively in any one year since 1962.

The poor performance of the G-K Project compared to its potential is generally supported by the notions: 1) Water requirement of crop has increased since the introduction of modern varieties (MV), 2) the farmers are non-co-operative, and 3) diversion of Ganges water at Farakka in India leaves a low water level at the pump intake, and thus pumps cannot supply adequate water to the main canal, etc. The first of these notions does not have any scientific background. Studies have shown that MVs do not use significantly higher amount of water to meet evapotranspiration needs. The second point is debatable, especially because of lack of any studies and sustained and concentrated efforts to organize the farmers. The third point was certainly valid for three years (1974-1976), but the project performance during years before and after that have not been any different.

Actually, what are the problems with this system in relation to water supply and water use have not been anybody's guess in detail. Several times in the past decade, committees of experts visited the project areas and made recommendations to improve its performance, But those recommendations were either not found feasible or not tried at all. Moreover, the project has hardly been studied to find out the field level water distribution and utilization pattern in the project service area.

C. Objectives

The purposes of this study were to evaluate the water use efficiency and corresponding land use patterns in the service areas under the project's normal irrigation water distribution system. More specifically the objectives are:

1. To quantify irrigation water distribution in selected areas through intensive monitoring of flow;

2. To relate the flow at the tertiary level and beyond to the area irrigated; and

3. To evaluate the possible usefulness and benefits of an improved system of measurement and control in the water distribution network in the study area.

D. Scope of the Study

The scope of this study would be limited to the Phase-1 service area of the project. Also, the study was conducted during the dry season. Study areas were selected on the basis of service areas of canals scattered at the first, middle and last sections of the project. It was assumed that the results to be obtained at different areas would represent for that of the respective sections.

II PROJECT DESCRIPTION AND OPERATION

A. Background and Features of the Project

The Ganges-Kobadak (G-K) Project is an irrigation cum flood control scheme. According to the master plan, the project has to be completed in three units consisting of six phases to provide irrigation to an area of 714,547 hectares spreading over the Kushtia, Jessore and Khulna district. The Kushtia unit of the project consists of two phases; Phase-I and Phase-II. The Phase-I was completed in the year 1969 and it has an irrigable area of 48,582 hectares out of a gross area of 85,000 hectares.

Phase-II with an irrigable area of 93,117 hectares is about 70% complete. The other phases of the remaining two units of the project are yet to be started.

The G-K project phase-I is bound by the rivers Ganges, Gorai and Kumar (Figure 2.1). The river Ganges is the source of water of the irrigation system. The water from the Ganges is brought through a 2.40 km long intake channel and then pumped into the main canal to distribute the water through a network of gravity canals system.

(1) Pumping Plant

The pumping plant consists of 3 main pumps, each with a capacity of 36.8 cms and 12 subsidiary pumps each of capacity 3.54 cms. The maximum total pumping capacity is thus 153 cms. But 16 years of service has decreased the pumping efficiency by about 15%. There is a power plant having generation capacity of a 8 Mega-Watt to run the pumping plant. This thermal power plant is no longer being used since power has been made available for the pumping plant through Goalpara-Bheramara Grid system.

(2) Flood Protection

The left bank of the Kushtia main canal acts as the flood embankment to protect the flood water from the river Gorai to enter the Project area. The length of this embankment is about 108 km.

(3) Drainage System

A network of drainage channels exists for removal of drainage congestion, water logging, and reclamation of swamps and beels. The off takes of the pre-project flowing rivers and their tributaries within the project area have been closed and they are now being used as the main drainage channels. For smooth operation of the drainage system, some artificial drainage channels have also been excavated which have ultimately joined the main drainage channels forming a drainage channel network. In-spite of the drainage system, sometimes drainage water congestion and water logging in the low-lying area are observed which may be due to excessive seepage water from the canal and irrigated farms and also overland flow of irrigation water.

(4) Soil

Soil in the project area falls under the Gangetic alluvium class of the soil classification of Bangladesh. The soil type ranges from the sandy loam to clayey loam which is quite favourable for growing the cereal crops.

(5) Meteorology

The meteorological features of the Project area are more or less the average for the country as a whole. The cooler weather starts from the end of November until the end of March. During this period temperature ranges from 10.5°C to 33.6°C. From the end of March warm weather continues until the end of June. Temperature ranges from 18.7°C to 35.5°C during this period. From the end of June to the end of October is the monsoon season with the temperature varying from 22.4°C to 32.9°C. About 75% of the annual total of about 1550 mm rainfall occurs during this monsoon period. The relative humidity is obviously much higher during this period than any other months of the year. Daily evaporation rate is higher during the first six months of the year. Total annual evaporation is about 1350 mm.

(6) Crops grown

Main crops grown in the Project area are the modern varieties of rice and wheat. Rice is grown twice in a year (in Kharif-I and II i.e. dry and wet season, respectively). Wheat and pulses are grown during the Rabi (November to February) season. Before the establishment of the project, the cropping intensity in the project area was about 125%. Up-to date, a cropping intensity of 165% has been achieved against a target of 250%. Some important physical features of the project are shown in Table 2.1.

For operation and management of the project, the organizational set up consists of personnel to render services to two distinguished disciplines such as operation and maintenance (O&M) and agricultural extension service. The organizational structure of the system operation and management is shown in Figure 2.2.

B. Water Management Status

(1) Water distribution

Pumped irrigation water is distributed to the farm by conveying it through a network of gravity canals consisting of the main, secondary, tertiary and the field channels. The project was designed and constructed to operate as an automatic downstream control system. In this system the flow regulators should function automatically and the water levels downstream of the regulators would control and operate them. But the system was soon converted into the manually operated upstream control type because of several problems encountered with the downstream control system.

Since the maximum irrigated area of 27,309 ha was only achieved once to date, which is very low compared to the target of 48,582 ha and because of the continuous complaints of the tailend farmers of inadeuqate

Table 2.1 Description of some physical features of the G-K Project, Phase-1; Bangladesh

Irrigation Canals

a) Main - canal - 1 no.; 73.48 km
b) Secondary canal - 17 nos.; 214 km
c) Tertiary canal - 154 nos.; 5103 km
d) Field channel - 1,722 nos.

Drainage channels:

a) Main - 181.93 mm
b) Minor - 209,30 km

Hydraulic structure

a) Regulator - 146 nos.
b) Escap - 7 nos.
c) Syphone - 277 nos.
d) Aquiduct - 5 nOs.
e) Checks & drops - 70 nos.
f) Outlet & tail structures - 836 nos.
g) Outfall sluice - 14 nos
h) Boosting pump station & regulation shed - 94 nos.

Bridges & culverts:

a) On Irrigation canals - 1268 nos.
b) On Drainage channels - 235 nos.
c) On Field channels - 653 nos.

Source: Synopsis on Ganges-Kobadak Project, Kushtia Unit, Phase-I, Kushtia; March, 1977.

supply of water, the project authority formed 'outlet' committees at the field channel level consisting of the lowest level officers from Engineering, Extension, Agriculture and Civil Administration to improve the situation. The function of these 'outlet' committees was to assist the farmers in voluntary procurement of land for field channel construction, supervise digging and maintenance of field channels to level and size their land and to develop irrigation block. The main reason may be that there was no schedule of water supply and continuous supply was the order when plenty of water was being pumped.

There is no system for measured quantity of water supply for different canals to fulfill the requirement of the command area. Thus, there is enough supply of water and sometimes not enough supply for quite long periods.

When the farmers are able to obtain water after a long interval, they try to provide unauthorized checks in the canal to get their land irrigated and stock as much water as they can leaving the tailend to suffer from water shortage. Thus, the tailenders are to suffer most of the time due to the uneven distribution of water.

(2) Control, measurement, allocation and application of water

There are regulators in the main and secondary canals and check structures in the tertiary canals to control the flow of water. Project staff are assigned to operate these control structures as per the directions of sectional officers, sub-divisional engineers and executive engineers. During the period of water crisis, the affected farmers sometimes control the gates at their will, paying no heed to the order of the project officials. Some project officials of the upstream area may control the regulators for benefits to their own area of jurisdiction without considering the condition of the tailend. Unauthorized checks are very common at the tertiary canals and field channels.

There is no water-measuring device or system in the project to measure the quantity of water flowing through different canals. For irrigation purposes, the project staff normally get an indication of the water flow from the water level in the canals indicated by the staff gauges or graduation marks in the regulator structures. They try to maintain a supply level which, they think is sufficient head of water for irrigating the entire service area beyond that structure. Sometimes discharge measurements downstream of a regulator are taken with the help of current meter as per directions of the higher authority and no rating curve seems to have been developed for quantifying the flowing water.

Water to be allocated in different canals largely depends upon the availability of the supply of water. The weekly requirement of water for different farms is estimated by the extension service personnel and the indent of water supply is placed one week ahead to the engineering section which deals with the water supply aspect.

Water application at the farm is done by the flooding method. Mostly modern varieties of rice are grown in the project area. Water applied at one farm is distributed to other farms mostly by paddy to paddy movement. In some cases plot channels are present for application to the individual plot or paddy. Sometimes the water supplied in the paddies goes continuously to the nearly drainage channel or ditches as overland flow. Most of the time the farmers are observed to be reluctant in controlling this overland flow and the farmers adjacent to the water source are mainly responsible for this type of water loss. The bunds along the periphery of a farm are usually poor and little effort is made to hold water more efficiently. Crop area and land area irrigated in different years are shown in Table 2.2.

C. Water fee

The farmers were receiving water without giving any fee up to the year 1976. Water fee has been imposed from the wet season of 1976 at the rate of

3% of the excess yield/crop[1]. Every year the project authority calculate the equivalent amount of Taka incurred for water fee. For the wet season (Kharif-II) of 1967 an estimated amount of 1 million taka[2] has been assessed. Much trouble is being faced in realizing the water fee since the farmers think it is an extra burden imposed upon them.

D. Agricultural Extension Service & Farmers' Co-operatives

(1) Primary Co-operative Society

The main function of the extension service of the project is to help grow more food by the farmers by providing them the recent information regarding the MV, use of fertilizer, insecticides and different aspects of water management.

To promote the above activities under the guidance and leadership of the extension officers, primary co-operatives have been formed by the farmers based on villages and field channel basis. Thana based central co-operative associations have also been formed federating the primary co-operative societies within a Thana, managed through a Board of Directors elected by the members of the primary societies.

Table 2.2 Net land area and crop area irrigated from 1962 to 1977

Year	Area Irrigated (ha)	
	Land area	Crop area
1962-63	1,803	1,809.71
1963-64	17,707.28	22,895.14
1964-65	20,219.02	27,287.04
1965-66	22,077.32	24,662.75
1966-67	23,228.34	25,756.27
1967-68	25,488.25	20,440.08
1968-69	27,503.23	31,724.69
1969-70	27,039.67	32,985.02
1970-71	27,309.31	33,819.43
1971-72	18,810.12	21,445.34
1972-73	21,002.42	23,953.92
1973-74	21,790.28	29,172.87
1974-75	20,829.55	27,950.60
1975-76	21,603.64	27,980.97
1976-77	21,994.12	27,577.59
1977-78	26,156.68	-

1/ Excess yield = yield with irrigation - yield without irrigations.

2/ Approximately Taka 15 = US $1.

(2) Chashi clubs

Besides primary co-operative societies, chashi clubs were constructed at different villages in the project area with the object of getting together for mutual understanding including farmers to work on self help basis and in mutual co-operation, developing leadership and team spirit as well as to identify the agricultural problems of the farmers through mutual discussions, referring unsolved ones later to the research centres and communicating the results to the farmers.

E. Other accessories of the project

(1) Farm management

Application of research findings at the farmers' field, investigation and observation of problems at the farm level are done by the farm management section of the agricultural extension service of the project. This section is run by a farm management officer (F.M.O.) who is assisted by a number of Assistants.

(2) Amla Experimental Farm

The soil of this farm is, representative of the project as a whole. This farm is primarily supposed to assist the "two-way function" of the Extension service. The problems found at the farmer's level are to be carried to the experimental farm by the extension workers for investigation and the findings of the farm to be communicated to the farmers. Besides this, different research studies in the soil, water and plant related aspect are carried out in this farm. This farm is headed by the Deputy Chief Agronomist (DCA) and is assisted by numerous personnel.

(3) Irrigation Extension Training Centre

With a view to provide training to the farmer and the project personnel in the field of irrigation and water management, this training centre was established. 'Patwaris'. 'Ziliaders' - the irrigation booking staff and overseers and the farm level extension workers are generally given training at this training centre.

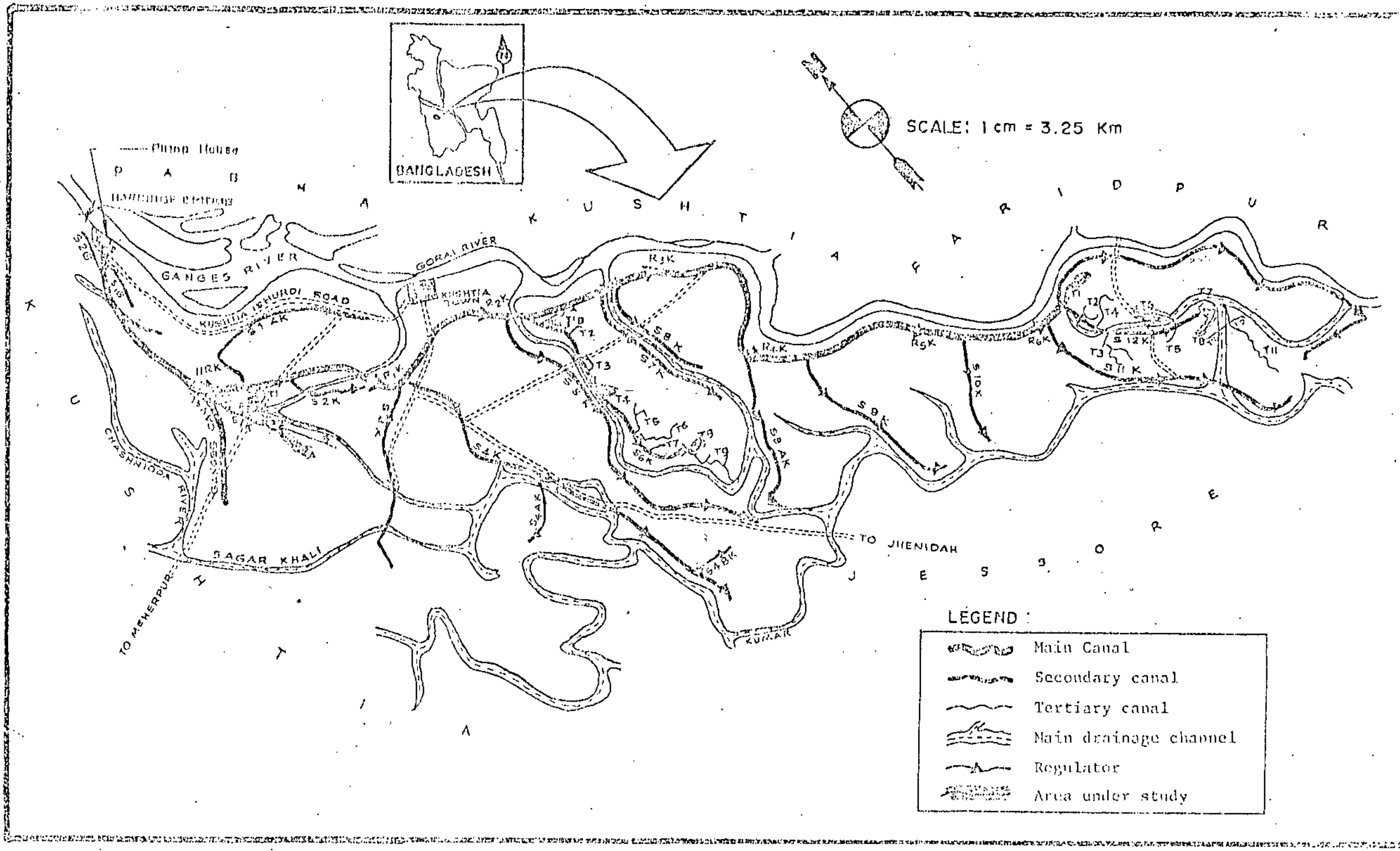

Fig. 2.1 The Ganges-Kobadak Project, Phase-1 showing the selected areas under study.

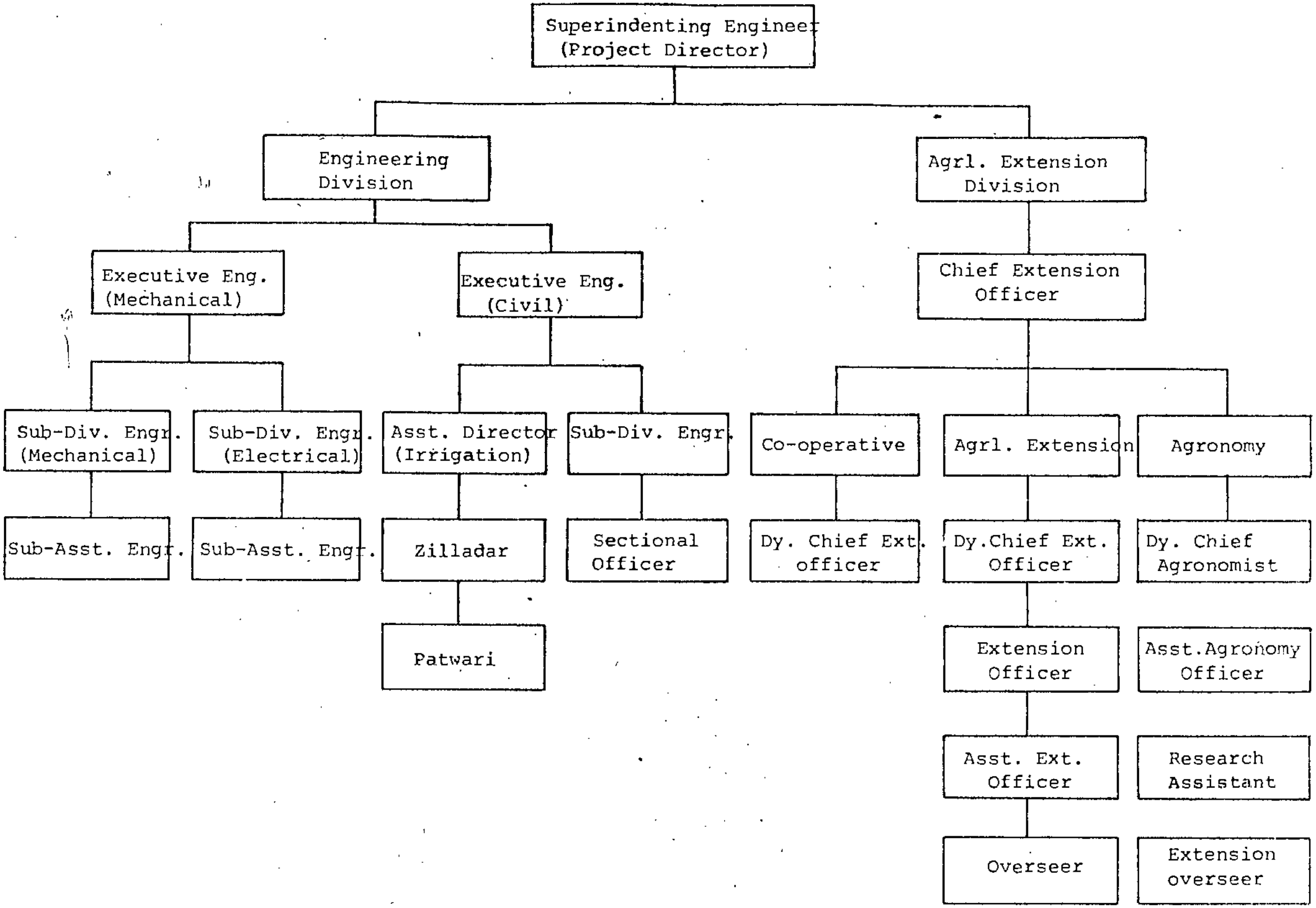

Fig. 2.2. Organization set-up of the G-K Project (Adapted from "Water Management in Ganges-Kobadak Project" by Md. I.H. Talukder)

III LITERATURE REVIEW

A. Consumptive use of water

Consumptive use of water is generally defined as the total amount of water required for transpiration by the plant, building of plant tissue and the evaporation that takes place from the surrounding area of the plant. The term evapotranspiration and consumptive use are generally considered synonymous because water used for plant tissue build-up is very small, less than 5% of total consumptive use (Bleney, 1952; Schwab, et. al.1955). But the term potential evapotranspiration differs from evapotranspiration. It is defined as the evapotranspiration that would occur where there is an adequate water supply at all times (Linsley, et al.,1958).

(1) Factors affecting evapotranspiration (ET)

The evapotranspiration is affected by many factors. Some factors are man-made, while others are related to natural influences and the environment (Blaney, 1952). The important natural factors are the meteorological factors such as: solar radiation, air temperature, vapour pressure, wind and atmospheric pressure (Linsley, et. al., 1958). In general low values of evapotranspiration are registered on days which are rainy, humid, cloudy and not windy (Doorenbos and Pruitt, 1975). The natural factors related to soil that affect evapotranspiration include moisture supply, slope and water table depth which condition moisture availability in the soil (Ekern, et .al.,1967).

The human factors, many of which are inter-related with the natural factors include water supply, water quality, date of sowing or planting, plant spacing, crop species, land and water management, size of the field, nature of the surroundings and addition of chemicals by sprays. All of these factors may influence plant growth and thereby the evapotranspiration (Erie, et. al., 1965).

(2) Determination of evapotranspiration

Different methods that have been used to determine evapotranspiration are: (i) Tank and lysimeter experiment, (ii) field experimental plot method, (iii) soil moisture study method, (iv) analysis of climatological data, (v) integration method, and (vi) inflow-outflow method (Schwab, et al., 1966).

(a) Water balance method - A generalized equation for the determination of evapotranspiration based on water balance method using some of the basic hydrologic equation accounting for the inflow-outflow of water is given by (Angus, 1959).

$$RF + IR = ET + SP + SR + W \qquad (3.1)$$

whre:

RF = rainfall;
IR = net irrigation water supplied;
ET = evapotranspiration;
SP = seepage and percolation;
SR = surface runoff; and
W = change in water content of the soil

By measuring or estimating all but one component in the above equation the remaining one can be found out. Supply of irrigation and rainfall are not difficult to measure in the field. Under flooded rice culture condition, 'W' is usually zero during normal growth period of the crop. Measurement of surface runoff often becomes complicated because the runoff usually occurs at various points in the experimental plot. Such measurement becomes quite difficult when heavy rainfall occurs. Estimation of both ET and SP usually involves separately experimentation for the soil-crop system concerned.

(i), Seepage and percolation - Seepage in an inner paddy occurs due to the lateral movement of water under or through the paddy bunds. Seepage loss depends on water level, soil permeability and area perimeter ratios (Johnson, 1963). On the other hand, percolation is related to the texture of the soil and the depth of water table. For heavy soils and high water table, percolation losses are often negligible (Wickham and Singh, 1977).

Lysimeter and tanks with and without bottom can be used to measure seepage and percolation directly (Lenka, 1975; Dastane, 1974). But these methods are often unrepresentative of actual seepage and percolation losses due to disturbed soil profile and modified flow conditions and measure only the deep percolation losses neglecting the seepage losses (Giron and Wickham, 1976).

To estimate the seepage and percolation losses from lowland rice fields, a new technique has been developed at the International Rice Research Institute which involves the measurement of the rate of water level subsidence from the observation paddy from which the estimated evapotranspiration is subtracted. The difference can be assumed as the seepage and percolation provided there is no inflow into or outflow from the paddy (IRRI, 1976). For lowland rice field, seepage and percolation losses are reported to vary within the wide range from 0.2 to 15.6 mm/day (Yoshida, 1978).

Estimation of evapotranspiration from climatological parameters like temperature, daylight hours, humidity, solar radiation and wind velocity has been done by many workers. Among the different methods, radiation method by Jensen, a combination method by Penman and Blaney criddle method have been ranked highest in their degree of accuracy of prediction (ASCE, 1973).

(3) Estimation of evapotranspiration

Most of the empirical estimates of evapotranspiration have limited applicability because of the uniquencess of the conditions under which they are observed. Also they used a crop co-efficient to convert the calculated potential ET to actual ET. This co-efficient varies from crop to crop, season, to season and for different stages of crop growth. Kampen and Levine (1970) developed linear regression equations relating potential ET with the daily evaporation rates from Class A pan in lowland rice conditions at different growth stages of crop for the Philippines. Their equations are:

Wet season -

Vegetative growth period;	$ET = 0.8(EV) + 0.3$	(3.2)
Reproductive growth period;	$ET = 0.9(EV) + 0.2$	(3.3)

Dry season -

Vegetative growth period:	$ET = 0.8(EV) + 0.5$	(3.4)
Reproductive growth period;	$ET = 0.9(EV) + 0.5$	(3.5)

where, ET and EV are potential evapotranspiration and evaporation from U.S. Weather bureau Class A pan respectively in mm/day. From the above equations, it is apparent that ET is very close to pan evaporation.

Ratio of potential evapotranspiration ET, to Class A pan evaporation EV, was found to be almost constant for all stages of crop growth under lowland rice condition by Vamadevam (1971). Tomar and O'Toole (1978) stated that the ET/EV ratio lies in between 1.0 and 1.3 from transplanting to maximum tillering stage of lowland rice. They demonstrated a generalized relationship between daily average evapotranspiration and pan evaporation from monsoonal Asia research for many types of experimental installation and methodologies and irrespective of season as follows:

$$ET = 1.2\ EV \qquad (3.6)$$

Yoshida (1978) has mentioned that potential ET is less than the evaporation from the free water surface. He also mentioned that for most places in monsoonal Asia, the daily water consumption in lowland rice varies from 60 to 10 mm.

From the above mentioned works, it may be concluded the the average ET/EV over the growing season of rice crop more or less remains close to unity. It is therefore quite reasonable for the purpose of this study, to assume potential evapotranspiration equal to pan evaporation.

Evapotranspiration for rice crop was studied in Amla Experimental Station of the G-K Project in Bangladesh. The seasonal average evaportranspiration rate to be 6 mm/day and the seepage and percolation loss to vary from 1.5 to 2.0 mm/day (Huizing, 1970).

B. Water Use

In crop production the term "Water Use" is generally referred to as the evapotranspiration or consumptive use of water. The seepage and percolation from the soil is generally considered to be a loss of water supplied. But in lowland rice culture, seepage and percolation is inevitable due to the practice of continuous flooding. Hence the term "water use" under lowland rice cultivation has been defined as the water used by evapotranspiration plus the loss due to seepage and percolation (IRRI, 1972).

(1) Water use efficiency (WUE)

The concept of water use efficiency has various implications depending upon the differences of veiwpoint of the researchers (Henderson, 1959). Agronomists have used it as the weight of the net crop production per unit of water supplied. This definition has the limitations that it is not unitless and as a result cannot be expressed in percentage term, like other efficiency terms.

From irrigation water management point of view, the terminology must give a definite perspective of water utilization for crop production. Israelsen and Hansen (1962) have defined WUE as the ratio of water that is beneficially used by the crop to that of total water supplied. In the case of lowland rice, water use efficiency can thus be expressed as:

$$WU = \frac{ET + S\&P}{RN + IR} \tag{3.7}$$

$$= \frac{RN + IR - SD}{RN + IR} = 1 - \frac{SD}{IR + RN} \tag{3.8}$$

where, RN, IR and SD are rainfall irrigation and surface drainage respectively (Wickham, 1976). The different terms of the equation are shown in Fig. 3.1 diagrammatically. It is evident from equation (3.7) that excessive irrigation would reduce the WUE if other terms remain the same. In equation (3.8), it is evident that the greater is the surface drainage, the lower is the WUE.

Experiments in a Philippine irrigation system showed the WUE to be 40% and 68% during the wet and dry season respectively. The experiment also revealed that - high moisture stress and hence higher rice yield loss is associated with higher WUE (IRRI, 1972). In other words, a low supply of water tends to make more efficient use of the water, but this situation creates water stress and consequent loss of rice yield.

C. Water distribution

Inequitable distribution and application of irrigation water leads to overirrigation in water abundant areas and moisture stress to crops in water-short areas. Moreover, the adequate amount of water alone can not produce the expected yield unless timely applications are assumed (Kung and Charin, 1968).

Uneven distribution of irrigation water along the canals of gravity -irrigation systems is a very common feature. Tabbal (1975) found in his study in a Philippine irrigation system that the farm located close to the canal got much more water than that located far away from the canal. Similar situations have also been reported from other gravity systems. The complaints of the tailend farmers of the G-K irrigation project of Bangladesh regarding the shortage of water supply for irrigating their lands have been reported by Rahman (1970). A typical pattern of irrigation water distribution along the canal as described by Takase and Wickham (1976) has been shown schematically in Fig. 3.2.

D. Water Adequacy

The term water adequacy refers to how adequately the intended service area has been supplied with water. Water adequacy is very important from the viewpoint of proper water management.

Water adequacy shortcomings stem basically from two sources: inadequate water at the source and poor distribution of available supplies (Wickham, 1971). Tabbal (1975) studied the irrigation water distribution and water adequacy in a Philippine irrigation system and concluded that the physical 'location' factor i.e. the location of the farm with respect to water source, was the most significant of all possible factors affecting water adequacy condition.

Generally, water adequacy and water use efficiency have an inverse relationship. A study in the D-N-D project of Bangladesh showed lower WUE and higher water adequacy at the upstream section and the reverse result at the downstream sections of the project (Khan, 1978). Similar results were also reported earlier from studies conducted in Philippine irrigation systems.

(1) Depth of flooding

Generally the farmers want to have their land irrigated under a continuous standing water condition in growing lowland rice. Some farmers near the source consider the water sufficient only when it is flowing freely over the paddy, while those far from the source are often satisfied with just enough water to saturate their farms.

De Datta and Williams (1968) found that depth of flooding between 2.5 and 10 cm does not give significantly different yields. They also found that for the depth of flooding beyond 10 cm, there is a decrease in the numbers of tillers and ultimately the yield. At moisture content below the soil saturation and depths of standing water over 10 to 15 cm, yield reduction occurs for rice (Levine, 1971).

Wickham (1973) has used the working approximation that the supply of water can be considered essentially adequate for all days in which standing water can be observed on the paddy and for the first three days after the standing water is depleted.

(2) Moisture stress and yield reduction

The relative rate of plant growth is a function of the mean soil moisture stress in the active root zone (Robins, et.al., 1967). Moisture stress in the soil qualitatively denotes the water potential in the plant. It is generally associated with the reduction in the available moisture in the soil root zone to a point wherein the evapotranspiration demand exceeds the rate at which plant roots can absorb and/or transmit water to the above ground plant parts. Kohnke (1968) stated that soil moisture stress is characterized by the matric suction or the atreaction of the soil particles for water and by the osmotic pressure components present.

The effect of moisture stress on grain yield have been mentioned by many researchers. Moisture stress at some stages of crop growth affect the grain yield significantly. The three critical periods, such as transplanting period, the tillering stage, and the period from about a fortnight before to a week after panicle initiation reduce substantial grain yield if moisture stress occurs during these periods (Shaki, 1973).

De Datta and Williams (1968) found in their experiment that the plots drained for one week during panicle initiation and during the tillering to the beginnign of the reproductive stage had the yeild reduction by 13% and 62% respectively. In general, it is established by the innumerable studies that yield reduction due to moisture stress during the reproductive stage is strongly pronounced in lowland rice culture.

(3) Moisture stress measurement

Measurement of moisture stress is very important in describing the water adequacy at the farm level. Hiler and Clark (1971) have shown that the 'stress day' index concept can provide a quantitative means for determining the water stress imposed on sorghum and peanuts during their growing season. They determined the 'stress day' index from a stress day factor and a crop susceptibility factor. The stress day is a measure of the degree and duration of plant water deficit, while the crop susceptibility factor depends on the species and stage of development of a given crop and indicate the plant susceptibility to a given water deficit.

For lowland rice, Wickham (1973) has described some important elements of stress measurement in describing the farm level water adequacy. These are the intensity of stress, its duration and the stages of growth of the crop during which the stress occurs. According to him a good measure of these elements can be accomplished from the daily observation of the presence and absence of standing water in the paddy. The 'stress days' to be counted as the number of days in excess of 3 for which a paddy is continually without standing water and the total number of 'stress days' is the sum of those days during the growth period and 15 days before harvest.

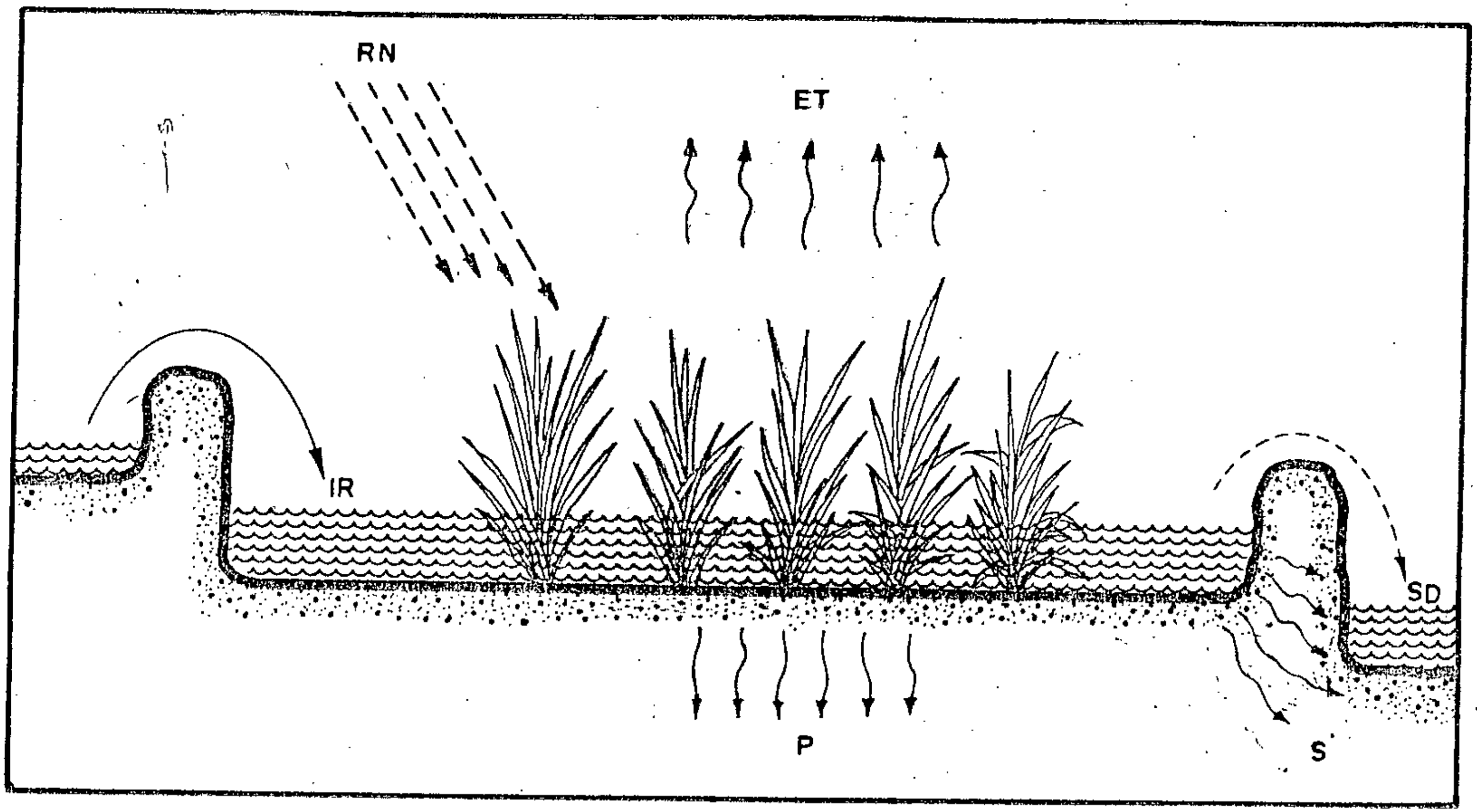

Fig. 3.1 Water balance model for lowland rice.

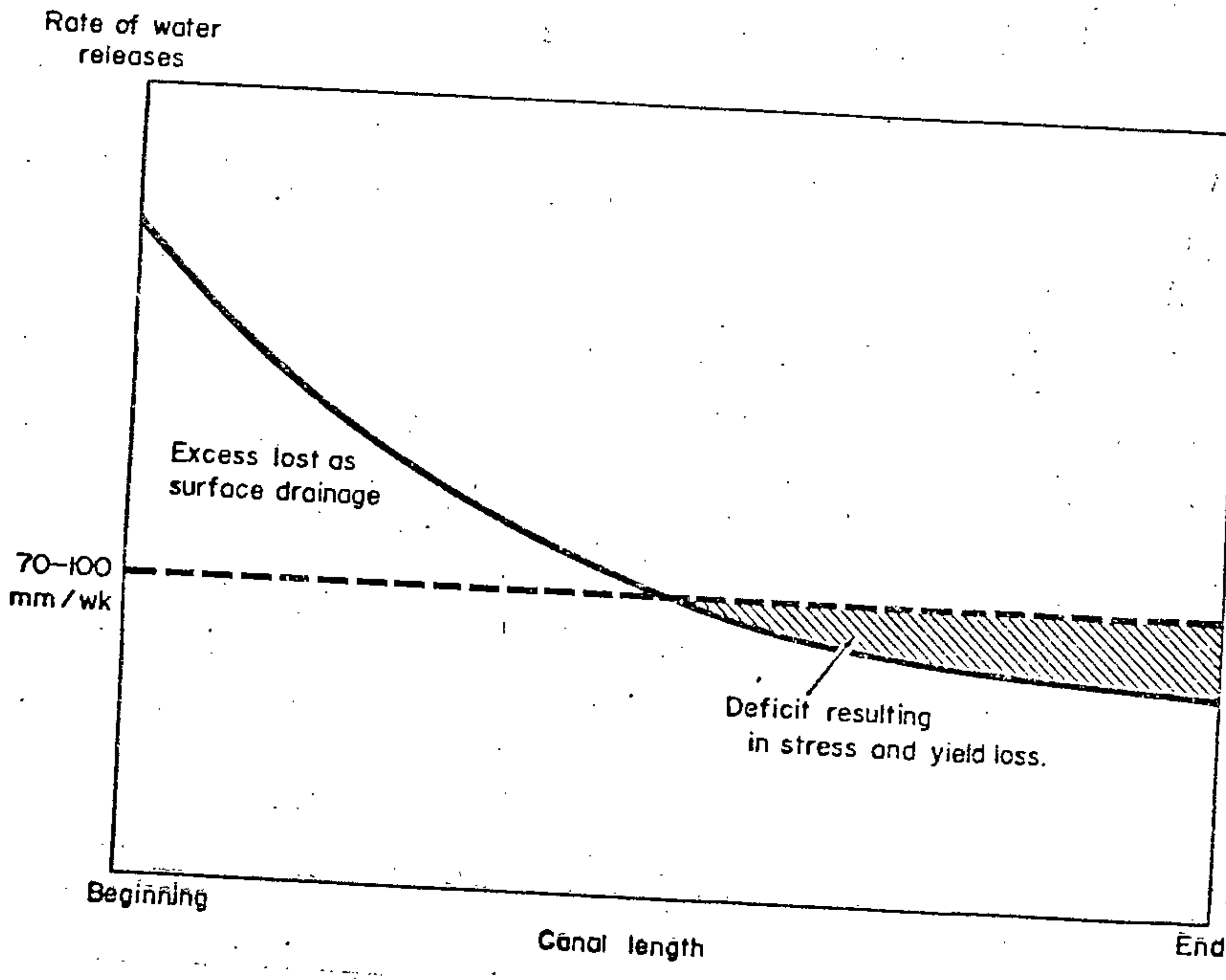

Fig. 3.2 Hypothetical distribution of the rate of water releases along the length of an irrigation canal, and the estimated minimum rate (70-100 mm/wk) required for ideal rice production.

IV METHODOLOGY AND MEASUREMENTS

This chapter describes the field implementation of the study. The collection of data and the measurements taken are described systematically.

A. Selection of Study Sites

To fulfill the objectives of this study, it was important to select the sites for sample water flow and distribution such that the results obtained would reflect the average conditions within the unit of analysis. Viewing this point, a logical basis of site selection was made by stratifying the whole project in the first, middle and last section of each level of conveyance.

(1) Selection of canals

Secondary canals S_1K[1/], S_6K and $S_{12}K$ were selected from the first,middle and last sections respectively. Tertiary canals were considered as the study unit; three tertiaries were selected from each of the secondaries on the same basis as in the case of selecting the secondary canals. Flow measurements were taken at the off-takes of the selected secondary and tertiaries and the service area of each tertiary was considered for water use considered for water use efficiency (WUE) and water adquacy (WA) studies.

(2) Selection of observation paddies

To have a knowledge of seepage and percolation from the fields located at different parts of the project, 3 observation paddies were selected from each of the tertiary canal service area. Thus, a total of 27 observation paddies were selected for all the 9 selected tertiary canals.

The variability of water distribution within a service area is indicated by the measurement of water adequacy within smaller areas. The individual paddy is the logical unit of analysis for this purpose. For through study of water adequacy, the service area of T_4/S_6K was selected. A total number of 36 paddies were then selected spacially distributed in the first, middle and last section of the canal service area. In selecting the observation paddies for seepage and percolation, the points considered are: (i) the paddies were uniformly scattered throughout the canal service area, (ii) soil of the paddies were representative of the soil of the tertiary service area, (iii) the paddies were well bound by paddy bunds; and (iv) the paddies were well leveled. The observation paddies for water adequacy measurement were selected considering that (i) they were distributed uniformity over the service area and (ii) the topographical features were same as those of the others around.

1/ S_1K indicates the first secondary canal of the Kushtia main canal.

B. Canal flow measurement

To quantify the flow of water in the selected canals during the whole crop season was a major task to fulfill the requirements of the objectives of this study. This was furnished by taking the flow measurements by staff gaging method for there were no flow measuring structures in the system.

(1) Staff-gauges and their installation - Staff gages are inexpensive, easy to install and provides a high degree of accuracy in flow computation at the free flow condition in an open channel. To serve the purpose a total of 14 staff gauges were used of which 9 for the 9 selected tertiaries and 3 for their upstream secondaries, 1 for T_1/S_6K and the remaining 1 for measuring the flow contributing to the $T_1\ S_{12}/K$ by a pipe directly from the secondary canal $S_{13}K$.

The staff gauges were installed downstream of the offtake structures of the respective canals. In selecting the location for the installation of staff gauges, the following points were considered: (i) a substantial straight lengthy section of the canal; (ii) the canal cross-section be a stable one with less possibility of scouring or silt deposition; (iii) the point being far away from the turbulence area at the down-stream of the off-take structure.

(2) Current meter measurement

Price meter type current meter was used for calibrating the staff-gauges. The rotating element of this meter is a set of cups turning about a vertical axis. Electric contacts driven by the revolving cups close a circuit through batteries. This current meter was used for the following advantages: (i) it can be used for a substantial range of velocity, and (ii) measurements can be taken near the edges of the channel.

At least 4 flow measurements were taken corresponding to different high and low gauge readings for each staff gauge. The following steps were observed in taking the meter measurements.

(i) A fairly regular and stable cross-section in the channel either upstream or downstream but very close ot the staff gauge was selected for flow meausrement.

(ii) A tape was stretched across the channel and the surface width was divided into a number of equal sections in such a way that the width of each section did not exceed the mean depth of flow in the section. The mean depth was estimated by lowering the attached rod of the current meter in the canal water across the channel cross-section.

(iii) Current meter was then attached to the rod and lowered in each section to measure the revolution of the cups for a period of time not less than 40 secs. Current-meter measurements were taken at 0.6 depth or at 0.2 depth and 0.8 depth depending upon the depth of the section less or greater than 0.45 meter respectively.

(iv) Corresponding velocities for each meter measurement were estimated from the table supplied for the current meter. Two velocities at the same section were averaged to obtain the mean velocity at that section.

From the mean velocities obtained for all the sections, the flow passing through the cross-section was calculated as follows:

(i) The average velocity in the vertical in each section was multiplied by the area of section extending half way to adjacent verticals. The area was taken as the measured depth at the vertical times the width of the section.

(ii) The total discharge or flow was then computed by adding the flows in different sections.

(3) Calibration of the staff-gauge

Flow measurements at different gauge reading from low to high were taken as mentioned above for each of the canals under flow measurement. These computed flows were then used to produce the rating-curve (stage-discharge realtionship) for each of the staff-gauges.

(4) Recording to stages

Staff-gauges readings were taken two times daily (8:00 A.M. and 5:00 P.M.) during the whole Kharif-I season to monitor the flow through the canals. Recording to the gauge readings were continued from the 15th March to the end of July, 1978, the flow period for Kharif-I season. This period was considered as Kharif-I since there was no land preparation record for Kharif-I crop before the 15th March and about 40% of the Kharif-I crop was harvested by the 29th of July. Before and after this period, there was flow in the canal for irrigating the wheat and Kharif-II crop (Aman rice) respectively and hence it was very difficult to recognize the initiation and termination point of the Kharif-I period.

C. Farming activities

The farming activities in the selected tertiary canals were recorded on weekly basis as soon as the season started with land soaking until the crop of the farm was harvested. In included the areas under different activities like land soaking, plowing and harrowing, ready for transplanting, normal irrigation, terminal drainage and ready for harvest and harvested. These data were collected to relate the weekly flow in the canals with the area irrigated.

D. Measurement of seepage and percolation (S&P)

In measuring the seepage and percolation rate for the different farm soils, daily records of water level subsidence from the observation paddies were collected. The technique used for measuring S&P was rather indirect estimation from the water level subsidence record of the observation paddies and the evaporation data. Wooden peg about 45 cm long having a top flat area (8cm x 8cm) was driven in the soil of each of the observation paddies such that the flat top coincided the soil surface of the paddy. The rate of vertical subsidence of water level was masured daily by a scale graduated in cm and mm using the flat top of the peg as the base.

E. Water adequacy

Unlike the measurement of water which applied to the whole site; assessment of the degree of water adequacy requires the nalaysis of smaller areas, due to the veriability of water distribution within the site. Keeping the above argument in view, the T_4/S_6K being located at the middle area of the project. The presence or absence of water in the observation paddies were recorded each alternate day. Stress day concept was used in evaluating the water adequacy in the sample paddies.

F. Measurement of rainfall and evaporation

Rainfall and evaporation are the two important factors in relation to irrigating the crops. The project area being quite large, it was presumed that there might be variation in evaporation and rainfall values at different sites of the project. On that basis, rainfall and evaporation records from 3 different sections (first, middle and last) of the project were collected.

For measuring rainfall, tru-check rain-gauge; a non-recording precision type instrument was used. The unit has wedge-shaped well on which an easily read scale is imprinted. The size of the opening of 6.35 x 5.84 cm. The measurement of rainfall can be recorded through a range of 0.0254 cm to 15.24 cm. According to the instruction by the manufacturer it was secured to a post by mounting bracket in a true vertical position at eye level. Evaporation pans used were U.S. Weather Bureau Class A pans. The rain-gauges and the evaporation pan for S_6K and $S_{12}K$ area were installed in such a location so that it represented the average field condition. For the safe-keeping and proper maintenance they were installed very close to the field office of the project and provided with fencing. For the S_1K area, the record from the Amla Weather Station was collected. Daily readings of raingauge and evaporation pan were taken at 9:00 a.m. during the whole season.

G. Problem of abnormally low flow period in the canals

Unlike previous years, a very low flow period occurred during the transplanting stage of Kharif-I crop due to the problem with the pump house. This period continued for around one month and the transplantation of seedlings was hampered. Besides, the paddies which were already transplanted suffered from moisture stress. Consequently, problems were faced in collecting the seepage and percolation and water adequacy data during that period. However, the canal flow measurement were taken throughout the period, although there was very low flow. Hence, the data analysis in measuring the WUE , S&P and WA was done for the period of data collected during the normal water supply period only.

V RESULTS AND DISCUSSION

In this chapter, different important aspects of the analyzed data and their implications have been discussed.

A. Water supply

(1) Canal flow

The daily and the weekly flow rate are shown in Tables A.1-A 12 and A.13-A.15 respectively. The rating curves (stage vs. discharge) produced by calibrating the staff gauges with the help of a current meter were found to be parabolic in shape which is the expected shape of the rating curves (Fig. 5.1-5.4). The average daily flow rate for the week was calculated by summing up the daily flow rate and then divided by 7.

The average daily flow rate for each week in the selected tertiaries and the weekly total rainfall have been plotted for the crop growing period and they are shown in figures 5.5-5.7. It is observed from the figures that good amount of rainfall well distributed over the season took place. This was somewhat unexpected during this season. From the figure, it is also evident that during a week with a substantial quantity of rainfall, there was a tendency of low flow in the canals also. It indicates that the flow was controlled to some extent during heavy rainfall period. Daily and the weekly rainfall records throughout the whole season are tabulated in Appendix Tables A.16-A.18 and A.22 respectively, The weekly maximum, minimum and the average water flow rates throughout the whole season for each of the selected tertiaries are shown in Table 5.1. The variation of flow rates in each tertiary was very high.

During the period of very low flow, i.e. from 15th to 19th week attempts were made to distribute the available water to as many tertiary canals as possible by controlling flow through the gate. The flow rates shown in Tables A.1-A.2 for the same period indicate the imposition of some kind of irregular rotation system. Average daily water flow records show that there be a pattern of rotational water supply from the 15th week to 19th week of the year (i.e. 9th April to 13th May).

The flow in T_8/S_6K was very poor throughout the whole season. It was learnt from the project authority that this tertiary and the tertiaries beyond, suffer every year from shortage of water supply.

B. Water supply vs. area irrigated

(1) Land preparation and transplantation

Land preparation and simultaneous transplantation activities were started in the selected canal areas from the 11th week of the year. The duration of land preparation with simutaneous transplantation, crop growth and harvesting period have been shown for the different tertiaries in Figure 5.8.

Table 5.1 Recorded weekly maximum, minimum and seasonal weekly average flow rate in the selected canals; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Name of Canal	Minimum flow rate(CMS)	Maximum flow rate(CMS)	Average flow rate(CMS)
S_1K	0.155	1.366	0.569
T_1/S_1K	0.017	0.589	0.179
T_2/S_1K	0.013	0.195	0.084
T_3A/S_1K	0.016	0.173	0.087
S_6K	0.147	1.923	1.124
T_1B/S_6K	0.00	0.436	0.172
T_4/S_6K	0.009	0.432	0.225
T_8/S_6K	0.002	0.141	0.046
$S_{12}K$	0.153	1.494	0.930
$T_1/S_{12}K$	0.00	0.223	0.112
$T_6/S_{12}K$	0.010	0.165	0.074
$T_8/S_{12}K$	0.002	0.174	0.046

Transplantation at the tailend started about one week ahead of the upstream section. Also, the tailend farmers were ahead in their progress in transplanting operation compared to headend farmers (Tables A.23-A.31). It was possible because the tailend farmers raised their seedlings in the drainage channels, ponds, ditches, etc., before they received irrigation water. Although, a few farmers at the upstream section raised their seedlings. Hence, their progress of transplantation was quite slow.

Among the selected tertiaries, it was observed that there was gradually a reduction in transplanted area in percent of the programmed area for irrigation for each of the three sets of tertiaries starting from the nearest one to the source to the farthest one (Table 5.2). T_1B/S_6K was found to achieve nearly the announced target (programmed) area. Its achievement was 93.84% of the programmed area. On the other hand, T_8/S_6K covered only 9.74% of the programmed area, the lowest value among the selected tertiaries.

(2) Water Supply for Transplanted Areas

For the normal irrigation period, an estimate was made for the water supplied per hectare of the area transplanted. For this purpose the 20th to 25th week of the year were considered and the result obtained is shown in Table 5.3. It reveals from the table that (i) the canals at the upstream sections of the project carried relatively higher quantity of water to irrigate each hectare of land then the canals farther from the source, and (ii) within each secondary - the farthest tertiary got a higher quantity of water per hectare from the respective middle tertiaries. This was due to the fact that the area transplanted in the upstream sections was comparatively high and the water supply received was also high enough. On the other hand, the farthest tertiary canals of each secondary suffered from water shortage particularly during the abnormal low flow period resulting in low transplanted area. But during the normal irrigation period - the water supply was not curtailed to meet the requirement of the transplanted area only. Thus the supply per hectare was high in the farthest tertiaries.

Among the tertiaries, T_8/S_6K was found to receive the maximum water per hectare (5.21 lit/sec). Water supply at this tertiary was close to what T_6/S_{12} K received for an area more than four times its irrigated area. $T_1/B/S_6K$ being located at the mid of the system seems to have a reasonable supply i.e. 1.06 lit/sec and the area irrigated was the highest among the selected tertiaries. During the 20th to 25th week period, there was also a substantial quantity of rainfall, 540 mm to 618 mm, in different sections. Canal supply being quite sufficient during this period, much of the rainfall contributed to the surface runoff.

C. Water use

The term water use refers to the different amount of water used in a unit service area for evapotranspiration and seepage & percolation .

(1) Evapotranspiration (ET)

The potential ET for rice was assumed to be equal to the Class A pan-evaporation. Daily and weekly total evaporation obtained from Class A pan measurement from the three different section areas throughout the whole season are shown in Appendix Tables A. 19-A.21 and A.22 respectively. The ranges of weekly sum and seasonal daily average evaporation values are tabulated in Table 5.4. Seasonal daily average evaporation rates varied through a range of 3.78 to 4.69 mm/day. The maximum and the minimum rates of evaporation were found at the middle and first section areas respectively.

(2) Seepage and percolation (S&P)

Seepage and percolation was estimated from the water level subsidence record from the observation paddies and then subtracting from it the potential ET value. In other words the water level subsidence for the days in which no inflow and outflow had taken place was due to these two component uses ET and S&P.

Table 5.2 Programmed area for transplantation and the area transplanted in the service areas of the selected tertiary canals; G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Name of canal	Programmed area for transplantation (ha)	Area transplanted (ha)
T_1/S_1K	101.21	82.18
T_2/S_1K	76.92	50.22
T_3A/S_1K	66.39	50.22
T_1B/S_6K	114.97	107.89
T_4/S_6K	106.85	94.33
T_8/S_6K	157.66	15.35
$T_1/S_{12}K$	85.02	63.15
$T_6/S_{12}K$	101.21	70.06
$T_8/S_{12}K$	66.7	23.08

Table 5.3 Average rate of water supply per hectare of irrigated land for the selected tertiary canals during the normal irrigation period,1/ G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Name of canal	Area irrigated (ha)	Average rate of water supply (lit/sec)	Rate of water supply per hectare (lit/sec)
T_1/S_1K	82.18	250	3.04
T_2/S_1K	50.22	134	2.66
$T_3/A/S_1K$	32.80	088	2.68
T_1B/S_6K	107.89	117	1.06
T_4/S_6K	94.33	244	2.58
T_8/S_6K	15.35	080	5.21
$T_1/S_{12}K$	63.15	119	1.88
$T_6/S_{12}K$	70.06	099	1.41
$T_8/S_{12}K$	23.08	041	1.80

1/ 20th to 25th week of the year was consideredas the normal irrigation period.

The average value of the S&P obtained from the three observation paddies in each selected tertiary service area was considered to be the value for that area and similarly the average value from the three selected tertiary of each secondary canal was considered valid for the S&P of the service area of the secondary.

The S&P values for each of the observation paddies varied mostly depending upon the antecedent moisture status and soil type of the paddy. Estimated weekly and daily average S&P rates for different selected tertiary canal service areas are shown in Tables A.32-A.34. It is observed from the Table that the daily average S&P from different selected service areas varied from 3.88 mm to 6.08 mm, the highest and the lowest values being in T_2/S_1K and $T_6/S_{12}K$ service area respectively. It also reveals from the tables that high rate of S&P was observed in all the three tertiary areas of the first section - with an average of 5.95 mm/day. S&P rates for different selected areas were estimated during the normal irrigation period i.e. 20th to 28th of the year.

Table 5.4 Ranges of weekly total and seasoned daily evaporation observed at three different sections of the G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Section	Weekly evaporation in mm		Seasonal daily average evaporation mm/day
	Minimum	maximum	
First	18.10	36.50	3.78
Middle	19.50	48.00	4.69
Last	16.00	44.40	4.47

D. <u>Water use efficiency (WUE)</u>

Weekly water use efficiency (WUE) for each selected tertiary service area was determined by dividing the actual water used by the total supplied through irrigation and rainfall in a week during the normal irrigation period. The actual water used consisted of water transpired by the soil-crop system plus that used by seepage and percolation. Water used by S&P during each week was calculated by subtracting from the mean potential water use for the week the daily average S&P rate times the weighted average stress day occurred during the week. It was assumed that ET remained the same both during the non-stressed and stressed periods. Conveyance loss through the tertiary canals was neglected in calculating the WUE; a part of this loss would usually be available to the adjoining farms along the canals.

The WUE during the normal irrigation period with standing crop was calculated for each tertiary for the weeks between 20th and 28th when no normal irrigation continued. The calculated weekly WUE values are shown in Appendix Tables A.35 - A.43.

The weekly WUE in a tertiary service area was seen to vary over a wide range (Table 5.5). These variations may be due to the wide range of variations in water supply and rainfall from week to week. Moreover, the supplied water might have been misused as overland or surface flow from the farm or a part directly contributed to the drainage channels resulting the low WUE values. The weeks having a substantial quantity of rainfall resulted the low values of WUE. It may be commented that the heavy rainfall resulted a lower amount of effective rainfall.

Among the selected areas the average WUE during the normal irrigation period varied from a minimum of 15.81% in T_8/S_6K service area to a maximum of 47.86% in $T_1/S_{12}K$ service area. The average values of WUE were found to be 24.47%, 29.03% and 42.97% for the tertiaries of first, middle and last section respectively. It is noticed that the higher WUE was associated with farther sections from the source of water (Table 5.6). This suggests that better utilization of water was found in downstream service areas compared to the upstream sections.

E. Water adequacy

The extent to which the water supply was adequately distributed through out a service area was analyzed by finding the field water status of the crop at various locations within a service area. Stress-day concept was used as the measure of water adequacy to characterize the occurrance of water shortage during the crop growth period. In this concept water adequacy is inversely proportional to stress days, which means that the fewer the stress day, the more adequately the crop is irrigation.

To understand the pattern of water adequacy in the field with respect to the source of water, 36 observation paddies were selected in the service area of T_4/S_6K for the measurement of stress days. These paddies were distributed evenly in the first, middle and the last section of the tertiary canal. It should be mentioned here that T_4/S_6K is the middle tertiary of the middle secondary out of these were selected for the study.

(1) Water adequacy and stress days

The assumptions made for determining the adequacy of water in the irrigated area are; (i) each observation paddy represents 1/36th of the total service area, (ii) adequately irrigated paddies are those paddies in which no stress day occurred during the season. Since during the abnormal period of water supply almost all the paddies suffered from moisture stress a normal water supply period from 20th to 25th week of the year was considered for water adequacy measurement.

The number of stress days that occurred in the different sections and the percent of adequately irrigated areas during the 20th to 28th week period are shown in Fig. 5.9. It is evident from the figure that the area at the upstream section has got high water adequacy than the farther sections

Table 5.5 Ranges of weekly WUE, weekly average WUE and average of the weekly average WUE in selected tertiary canal service areas. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Service area of canal	Range of Weekly WUE in %	Weekly average WUE %	Average of weekly average WUE[1/]
T_1/S_1K	10.20-35.71	23.56	
T_2/S_1K	13.34-31.86	24.46	24.47
T_3A/S_1K	15.25-32.95	25.41	
T_1B/S_6K	21.07-71.68	43.31	
T_4/S_6K	15.85-59.69	27.99	29.03
T_8/S_6K	8.43-44.02	15.-1	
$T_1/S_{12}K$	14.50-52.81	47.84	
$T_6/S_{12}K$	13.33-73.74	46.32	42.97
$T_8/S_{12}K$	7.52-47.77	34.77	

Table 5.6 Distances of the service areas of the selected secondary canals from the source of water[2/] and their respective WUE values. G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Service area of secondary canal	Distance in KM		total distance	Average WUE in %
	Average distance from the main canal	Distance along the main canal		
S_1K	2.20	1.61	3.81	24.47
S_6K	6.49	23.42	29.91	29.03
$S_{12}K$	5.87	63.41	69.28	42.97

1/ Average of the weekly average WUE for the tertiary service areas of a secondary canal was considered as the WUE for the respective secondary canal service area.

2/ Head regulator (HRK) of Kushtia main canal has been considered as the source of water.

tertiary canal. Thus it is seen that the water adequacy within a farm is analogous to that of the distribution of water in the canal systems at different sections and it has the inverse relationship with the WUE.

F. Period of low water supply and its effects

It is already mentioned in chapter IV that there was an unexpectedly low water supply period in the system during the land preparation and transplantation phases. The low flow period affected the different aspects of the system operation and management and they are discussed as follows:

(1) Water supply

It is clear from the daily flow record (Tables A.1-A.12) and Figures 5.5-5.7 that from the 15th week to 19th week there were very low flows in the selected canals. During this period, the project authority started sharing the water supply in Phase-I and II on a rotation basis. They also tried to introduce rotational system of water supply among the secondary and tertiary canals of Phase-I which is evident from daily flow record. Field observations indicated that the introduced rotation system could not solve the farmers' water problems.

During the water crisis period, the canals at the tail section received comparatively less quantity of water than those of upstream sections (Table 5.7). This happened due to the fact that the farmers at the upstream areas did not allow the project authority to supply a proportionate quantity of water for the tailenders. After a few days of water shortage in the tailends when some transplanted paddies and seedling were going to be damaged. The upstream farmers did not allow the project officials or staff to move in the field and try to better distribute the water. They also started controlling the canal regulators at their wills. Thus the rotational system of water supply was not very effective. A substantial amount of rainfall, 61.10 mm to 126.80 mm, occured in the 16th week in all the three different sections of the project. However, this rainfall was not sufficient at all to compensate the low canal flow.

From the Table 5.7 it appears that during the low flow period, T_1/S_1K canal received 32.14% increase in flow from that in the previous period. It was possible because there was a large area of standing wheat crop in the service are of T_1/S_1K before the 15th week and hence little water was supplied through that canal for irrigation. On the other hand as soon as wheat was being harvested, water was also supplied as much as possible for land preparation which caused a substantial increase of water supply of the canal during the disturbed period.

The tertiary canal T_8/S_6K received a great reduction in water supply among the selected canals of the first and middle sections. It was reported by the project personnel that T_8/S_6K and the canals beyond did not get enough water during the previous normal seasons also. The problem of water supply in this tertiary may be due to physical limitations associated with the off-take structure, canal alignment or slope. No investigation has been done on this.

Table 5.7 . Decrease in weekly average water flow rate in the selected canals during the abnormal period in percent of the average flow rate available prior to the disturbance, G-K Project, Bangladesh; Kharif I(dry) season, 1978.

Name of canal	Weekly average flow rate before the 15th week (CMS)	Weekly average flow rate during 15th to 19th week (CMS)	Water flow decrease in %
S_1K	0.350	0.214	38.85
T_1/S_1K	0.056	0.074	-32.14*
T_2/S_1K	0.046	0.035	23.91
T_3A/S_1K	0.095	0.054	42.73
S_6K	1.341	0.788	41.20
T_1B/S_6K	0.276	0.136	50.43
T_4/S_6K	0.344	0.165	51.97
T_8/S_6K	0.054	0.005	89.25
$S_{12}K$	1.210	0.448	62.92
$T_1/S_{12}K$	0.132	0.039	69.92
$T_6/S_{12}K$	0.106	0.044	58.49
$T_8/S_{12}K$	0.114	0.008	92.45

(2) Transplanted area

Both the progress of transplanting and area transplanted were affected due to the occurrence of the low flow during the land preparation and transplanting stages. Transplantation period was extended upt ot 14 weeks (11th to 24th week) because of this. The longest period was taken for transplanting in the T_1 and T_2 tertiary service areas of S_1K although this area being located at the head reach received a substantial quantity of water even during the abnormal period (Fig. 5.8). T_8/S_6K canal being badly affected from water supply during the water crisis period, its service area made the poorest progress in transplanting and the ultimate area transplanted (Table A.28).

Due to the long period of water shortage, none of the selected tertiary service areas could transplant hundred percent of the programmed area. From the Tables A.23-A.31, it is seen that the upstream areas achieved relatively greater success in transplanting in percent of the programmed area than the downstream areas.

(3) <u>Water use efficiency and water adequacy</u>

The WUE during the normal irrigation period was found to be higher at the tailend areas. Moreover, Table A.23-A.31 show that the tailend area made a remarkable progress in transplanting during the low flow period. The WUE was perhaps also higher in the tailend areas during the water crisis period. A greater transplanted area was found to be damaged in the tailend areas than that in the upstream areas due to the long period of moisture stress during this period which indicates the low water adequacy in the downstream (Table 5.8).

During the normal irrigation period, the water supplied per hectare of land was seen to vary from 1.06 lit/sec to 5.21 lit/sec (Table 5.3) in the selected tertiary canal off-takes. This supply was really much too greater than what was actually required to fulfill the ET + S&P. From the Tables A.32-A.34, it is observed that the weekly net water use (ET+S&P) in the three different sections of the project varied from 62.46 mm to 66.02 mm. If this water requirement is to be fulfilled only, then the water to be supplied at the tertiary off-take should range from 1.03 lit/sec per ha. to 1.09 lit/sec per ha. If 10% conveyance loss is considered through the tertiaries, then these values of water supply would range from 1.13 lit/sec per ha to 1.19 lit/sec per ha respectively. This measured supply would suffice the field requirement provided there is no loss of water as surface or overland flow into the drainage ditches. The potential area that could be served by the supplies which were available at the selected canal off-takes during the normal irrigation period have been estimated considering no loss of water from the farms and they are shown in Table 5.9.

But due to improper control and unmeasured water supply, excess water was supplied to the farms which was ultimately misused. The water supplied during the land preparation period was also not properly utilized.

The normal attitude of the individual farmer is to have his farm irrigated at a high level of water adequacy. This high water adequacy can be achieved either by supplying more than necessary water or by providing close to required amount along with a high degree of on-farm water management practices. In the former case, high water adequacy
b

would be achieved at the cost of heavy loss of the water resulting in a very low WUE. And in the latter case, high values could be achieved for both provided there is a good system of water control, distribution and allocation to the farm.

Table 5.8 Damaged transplanted area during the water shortage period and the area retransplanted in the service areas of selected canals. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Service area of canal	Damaged transplanted area (ha)	Retransplanted area (ha)
T_1/S_1^K	00	00
T_2/S_1^K	0.22	0.22
T_3S/S_1^K	0.35	0.35
T_1B/S_6^K	0.38	0.38
T_4/S_6^K	0.40	0.30
T_8/S_6^K	1.50	0.50
T_1/S_6^K	1.00	0.55
T_6/S_{12}^K	1.28	0.50
T_8/S_{12}^K	1.60	0.45

Table 5.9 Irrigated area and the potential area for irrigation in the selected tertiary canals service areas: G_K Project, Bangladesh. Kharif-I (dry) season, 1978.

Name of canal	Average flow rate[1/] (CMS)	Potential area for irrigation[2/] (ha)	Actual area Irrigated (ha)
T_1/S_1^K	0.250	232.43	82.18
T_2/S_1^K	0.134	121.37	50.22
T_3A/S_1^K	0.088	80.34	32.80
T_1B/S_6^K	0.117	117.13	107.89
T_4/S_6^K	0.244	239.02	94.33
T_8/S_6^K	0.080	74.16	15.35
T_1/S_{12}^K	0.119	126.53	63.15
T_6/S_{12}^K	0.099	109.30	70.06
T_8/S_{12}^K	0.041	32.48	23.08

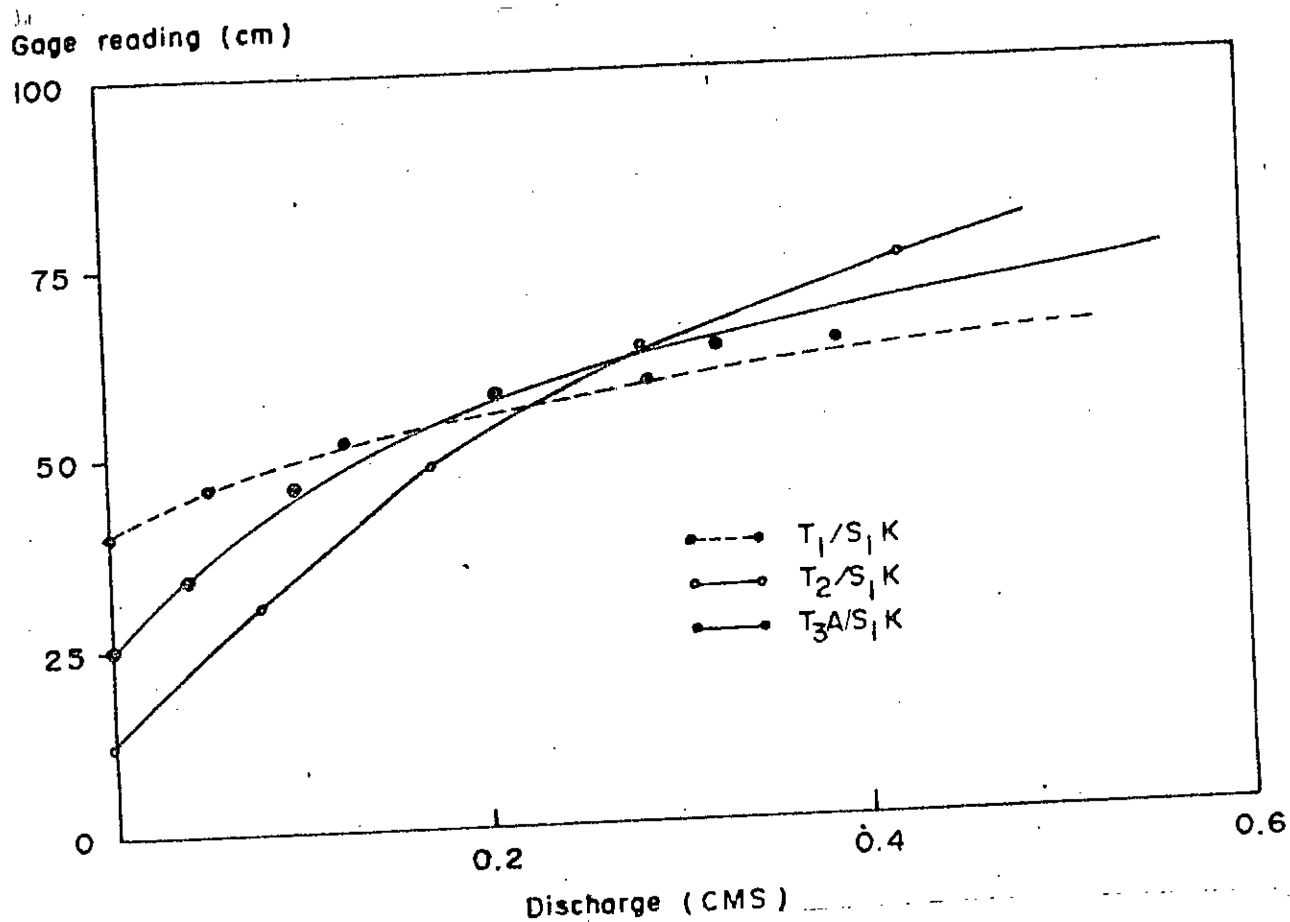

Fig. 5.1 Rating curves for the selected tertiary canals of S_1K, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

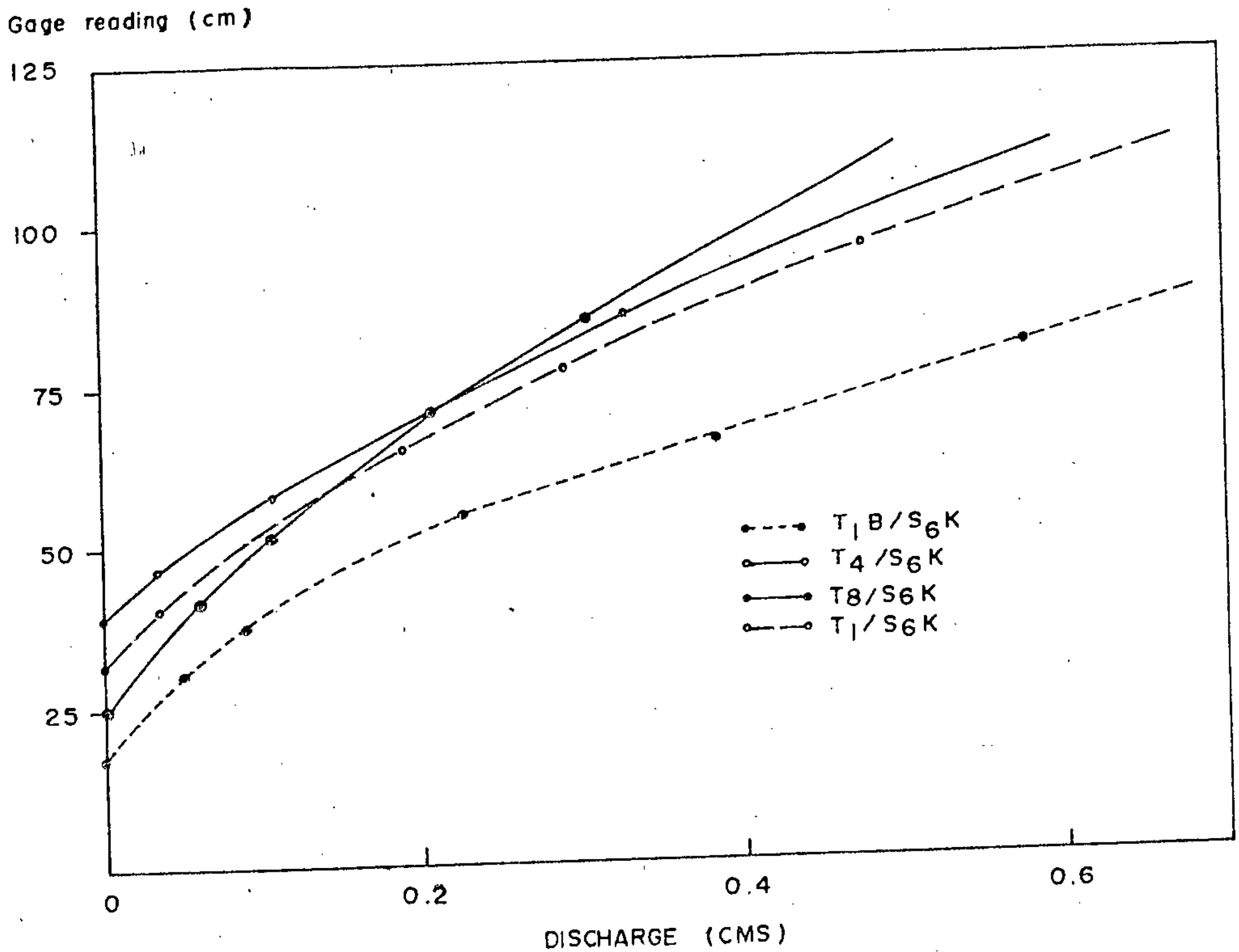

Fig. 5.2 Rating curves for the selected tertiary canals of S_6K, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

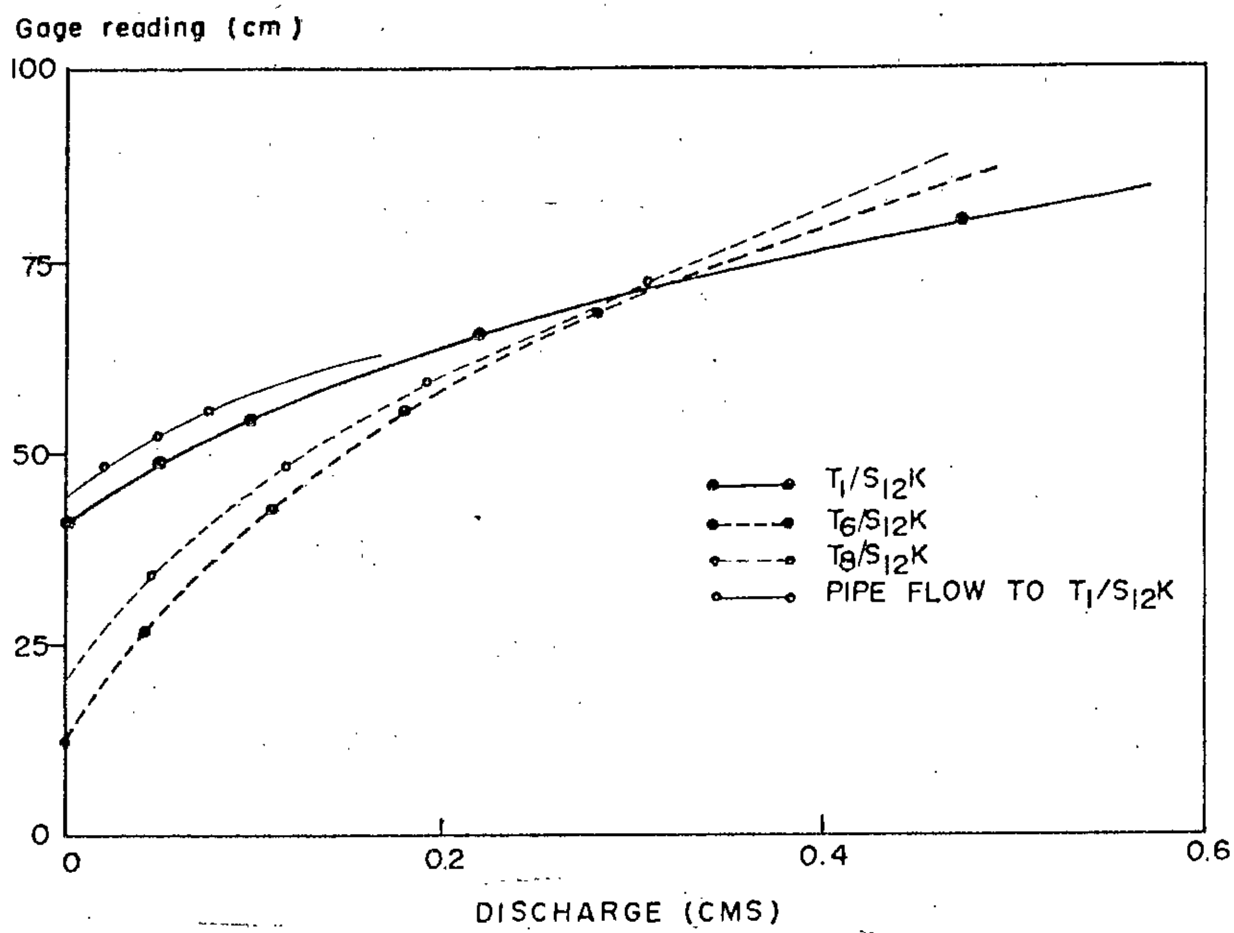

Fig. 5.3 Rating curves for the selected tertiary canals of $S_{12}K$, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

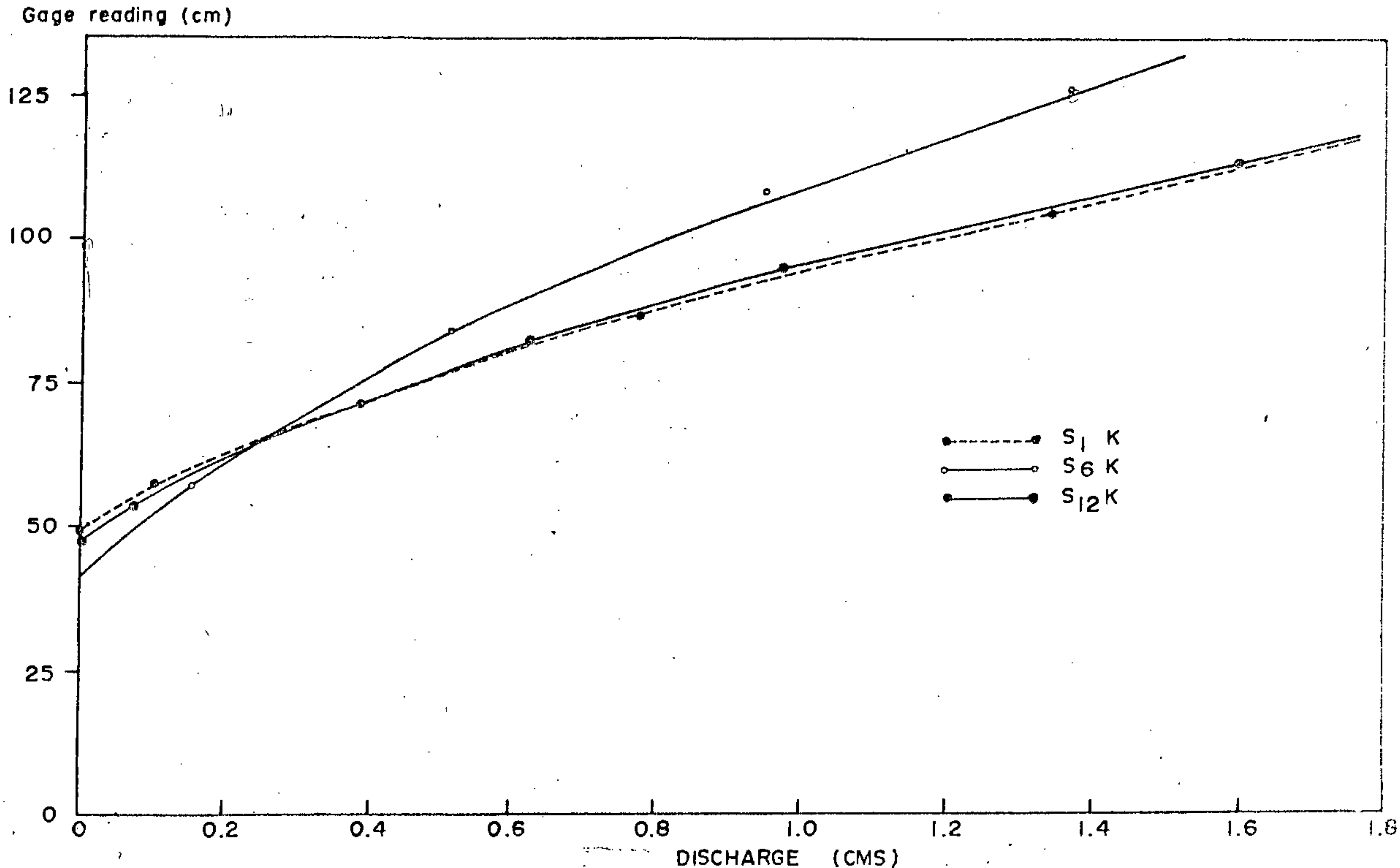

Fig. 5.4 Rating curves for the selected secondary canals of the G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

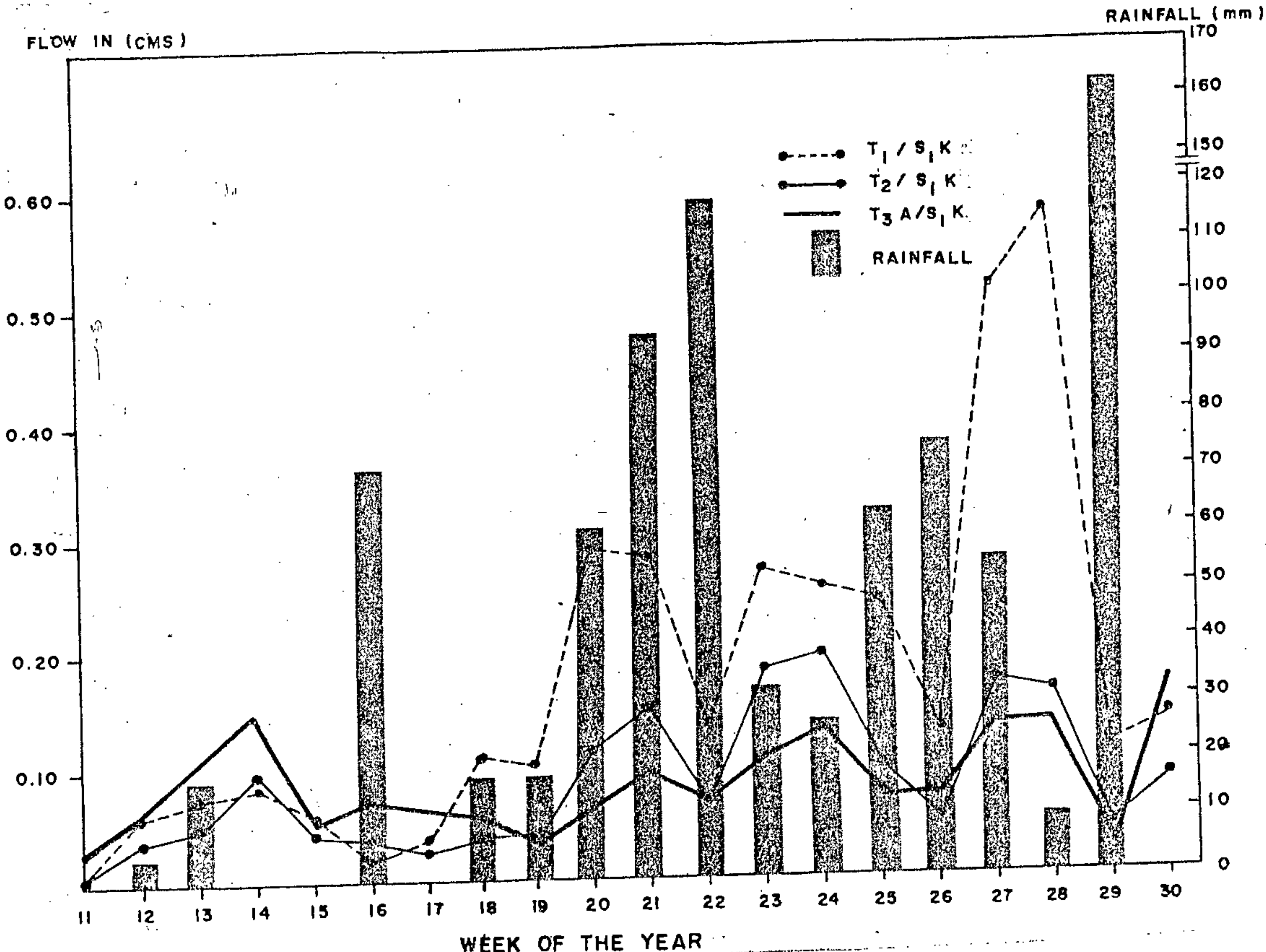

Fig. 5.5 Average weekly discharge rate in the selected tertiary canals of S_1K and the weekly observed rainfall distribution, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

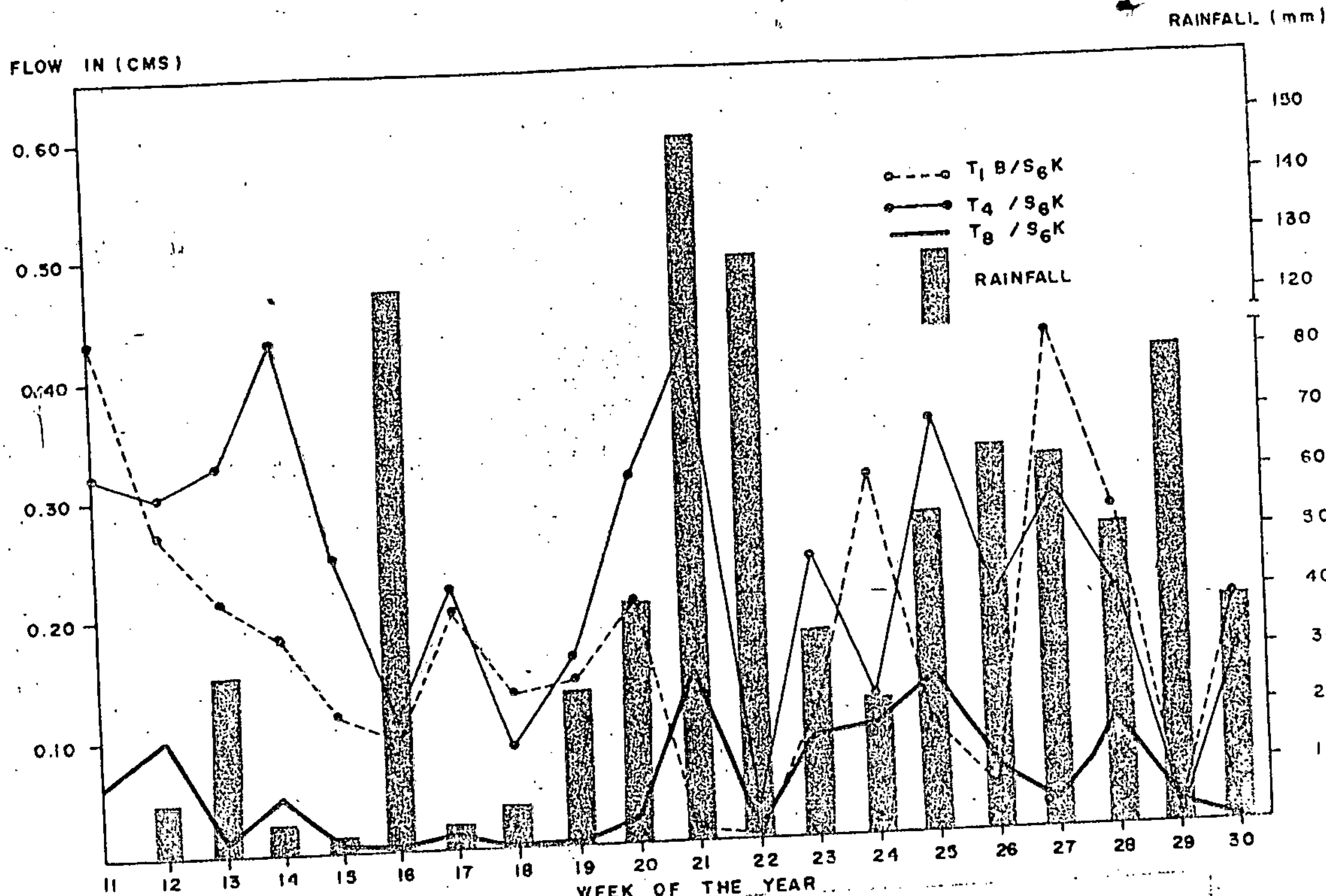

Fig. 5.6 Average weekly discharge rate in the selected tertiary canals of S_6K and the weekly observed rainfall distribution. G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

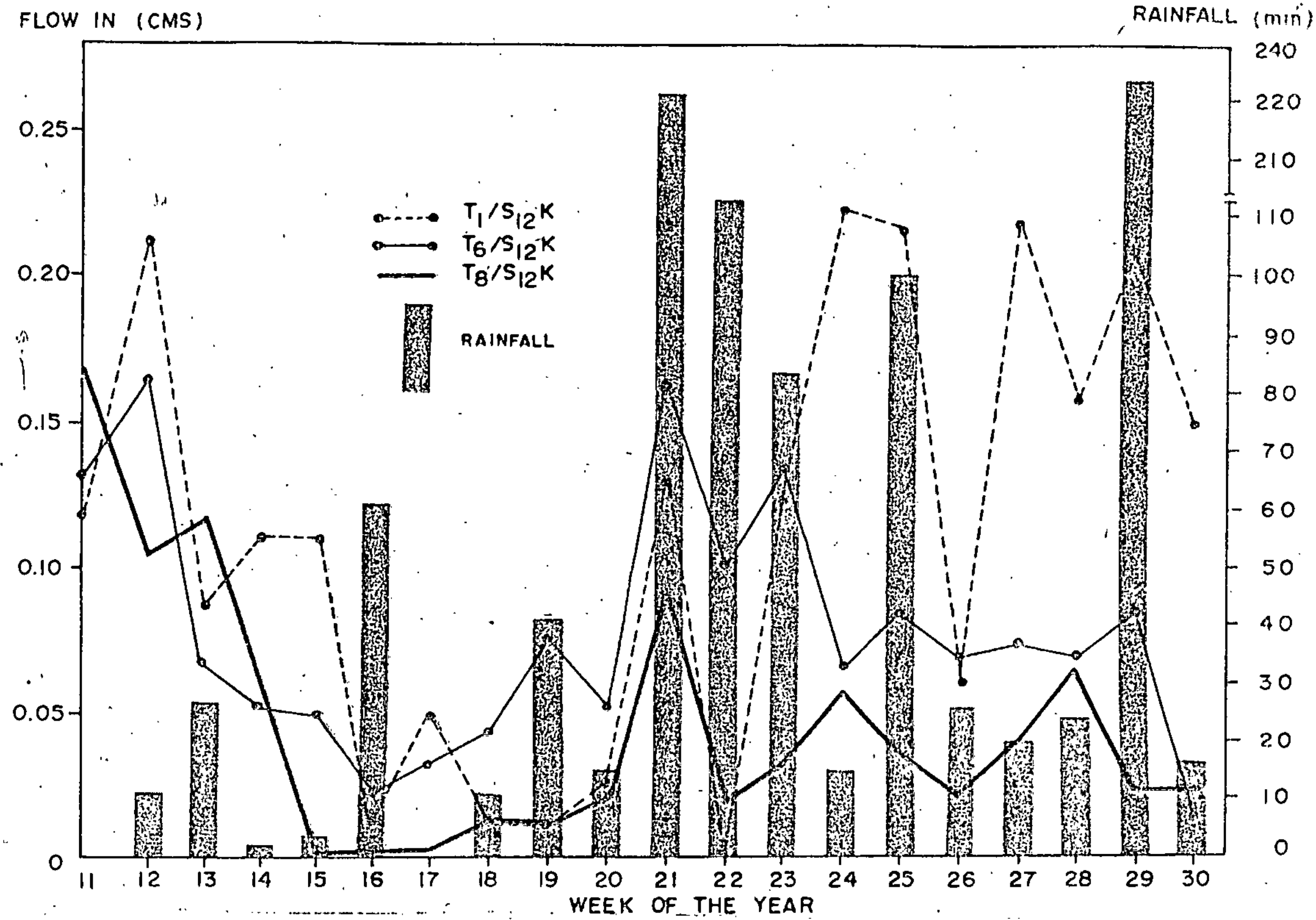

Fig. 5.7 Average weekly discharge rate in the selected tertiary canals of $S_{12}K$ and the weekly observed rainfall distribution. G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

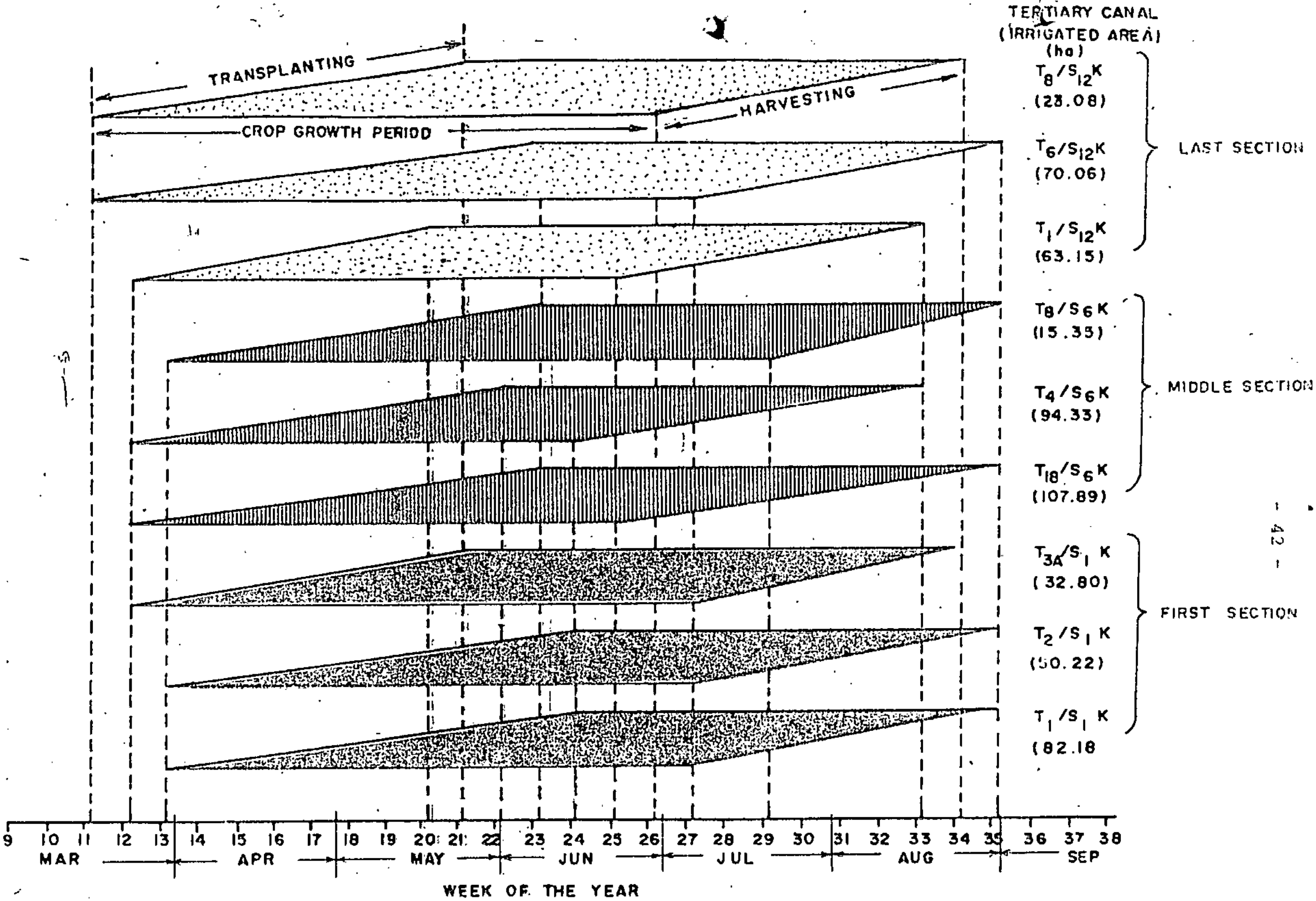

Fig. 5.8 · Transplanting, crop growth and harvesting period in the selected tertiary canal service areas. G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

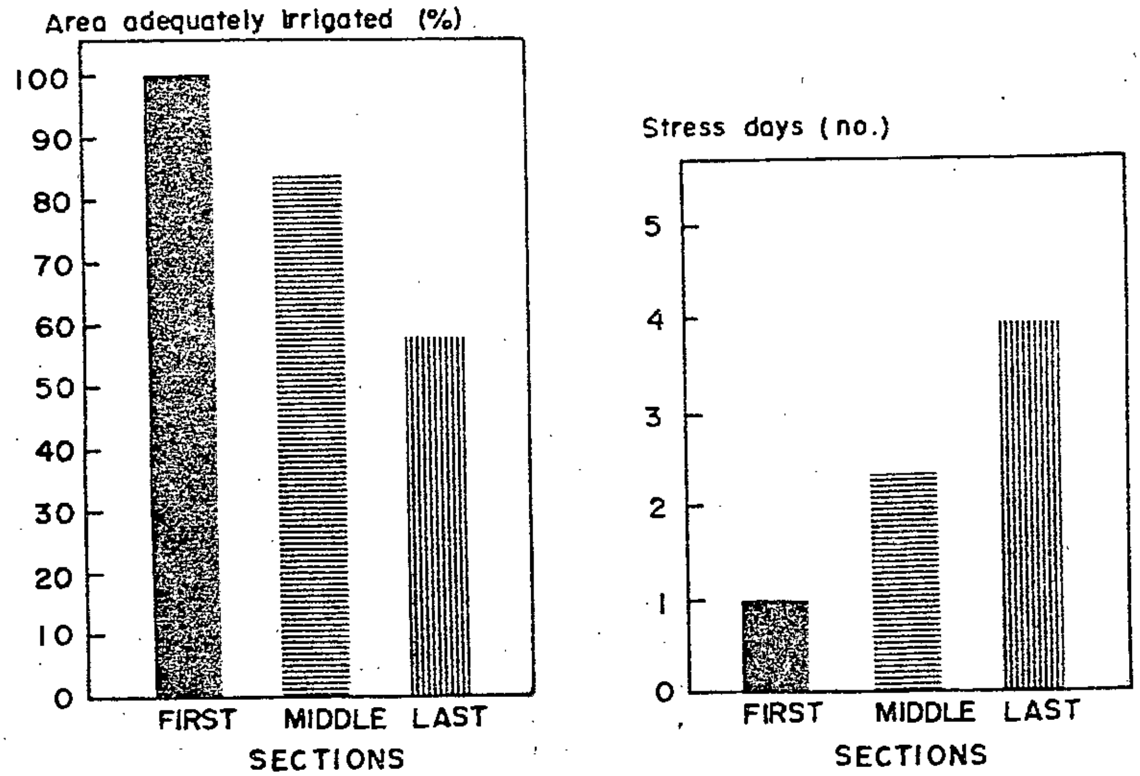

Fig. 5.9 Percent adequately irrigated area and average number of stress days in first, middle and last sections of the T_4/S_6K service area. G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

VI CONCLUSIONS

Conclusions from this study should be qualified in recognition of experimental difficulty that had to be faced due to the abnormally short supply of water specially during the transplantation phase for a period of around one month. Despite this shortcoming, the study was carried out to provide practical information regarding the performance of the project. The following conclusions can be drawn from this study.

1. Unequal water distribution was observed in the different parts of the selected areas. Irrigation water supply rate per hectare of irrigated land ranged from 1.20 lit/sec to 4.70 lit/sec at the selected tertiary canal off-takes which were quite sufficient for the requirement of rice crop growth. The average rate of water supply per hectare of irrigated land was higher at the upstream areas due to improper regulation sand control of water in the canal which allowed more than required amount of water in the tertiary canals and farm ditches. The excess usually went to the drains directly or lost through overapplication in the nearby farms.

2. Transplantation at the downstream areas started earlier than those of the upstream areas. The rate of progress of transplanting in the downstream areas of the project was also found to be relatively higher although these areas received proportionately less water supply compared to the upstream areas. However, a higher percent of the programmed area was transplanted in the upstream sections compared to the lower sections.

3. Seasonal average water requirements for evapotranspiration plus seepage and percolation were found to vary within 7.82 to 10.90 mm/day in the selected areas of three sections with a mean value of 9.10 mm/day. Seasonal average seepage and percolation losses ranged from 3.88 to 6.96 mm/day with a mean value of 5.25 mm/day.

4. Average weekly water use efficiency (WUE) at the tertiary level was found to vary from 15.81% to 47.84%. Mean WUE for different sections was found to have a range from 24.47% to 42.97%, gradually higher WUE being found away from the source of water.

5. Percent of adequately irrigated area was found higher near the water source than farther from it. The number of stress days occurred at different areas were found to have an inverse relationship with percent of adequately irrigated area.

6. Water supplied at full supply level during seedling raising period through the whole system was found to be misused to a great extent. Alternative methods of water supply for seedling raising should be introduced to minimise the loss of a great quantity of water.

7. Finally, on the basis of the findings of this study, it may be concluded that by improving the controlling, measuring and distribution system of the project, more area could be brought under irrigation along with higher degree of water adequacy.

VII RECOMMENDATIONS FOR FUTURE STUDY

Future study in the project is recommended along the following lines:

1. Study on the improved systems of water scheduling aimed at increasing water use efficiency as well as better distribution within the service area;

2. Study on the water requirement of wheat crop which has already found good popularity in the project area;

3. Study on the physical constraints exist in each canal and its service area which restrict the proper irrigation water supply and water management; and

4. Study on the farmers' behaviour and institutional activities influencing the water management in the project.

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APPENDIX

Table A.1. Average daily water flow in the S_1K secondary canal; G-K Project, Bangladesh; Kharif-I(dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	00	18	0.069	22	0.871	25	0.666
16	0.460	19	0.092	23	1.042	26	00
17	0.271	20	00	24	1.028	27	00
18	0.157	21	0.762	25	0.548	28	00
19	00	22	0.628	26	1.356	29	0.069
20	0.157	23	0.662	27	0.913	30	1.085
21	0.492	24	00	28	0.362	July 1	0.956
22	0.556	25	0.085	29	0.278	2	1.099
23	00	26	0.057	30	0.169	3	1.256
24	0.385	27	00	31	0.169	4	1.513
25	0.299	28	0.092	June 1	0.685	5	1.570
26	00	29	0.192	2	0.828	6	1.356
27	0.628	30	0.003	3	0.956	7	1.399
28	0.571	May 1	00	4	0.506	8	1.156
29	0.678	2	0.757	5	00	9	1.156
30	0.249	3	0.837	6	0.656	10	1.162
31	0.207	4	00	7	1.199	11	1.299
Apr. 1	0.316	5	00	8	1.513	12	1.062
2	0.316	6	00	9	1.727	13	1.085
3	0.656	7	0.260	10	1.799	14	1.162
4	0.699	8	0.756	11	1.799	15	1.899
5	0.656	9	0.506	12	1.513	16	00
6	0.656	10	0.359	13	1.213	17	00
7	0.542	11	00	14	0.913	18	00
8	0.212	12	00	15	1.199	19	0.366
9	00	13	00	16	1.413	20	0.369
10	00	14	0.071	17	1.513	21	00
11	0.160	15	1.199	18	1.656	22	0.723
12	0.316	16	1.071	19	0.326	23	0.714
13	0.262	17	1.142	20	00	24	0.671
14	0.653	18	0.614	21	00	25	0.913
15	00	19	0.371	22	0.803	26	0.635
16	00	20	0.762	23	0.769	27	0.250
17	00	21	0.999	24	0.656	28	0.310
						29	00
						30	00
						31	0.025

Table A.2. Average daily water flow in the T_1/S_1K tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	00	18	00	23	0.599	27	00
16	0.035	19	00	24	0.506	28	00
17	0.035	20	00	25	0.085	29	00
18	00	21	0.089	26	00	30	0.293
19	00	22	0.039	27	0.103	July 1	0.371
20	0.025	23	00	28	0.071	2	0.307
21	0.085	24	00	29	0.035	3	0.371
22	0.114	25	00	30	00	4	0.371
23	00	26	0.014	31	00	5	0.464
24	0.073	27	00	June 1	0.077	6	0.656
25	0.099	28	0.035	2	0.371	7	0.756
26	00	29	0.199	3	0.371	8	0.685
27	0.289	30	0.005	4	0.264	9	0.699
28	0.035	May 1	00	5	00	10	0.549
29	00	2	0.435	6	0.071	11	0.564
30	0.035	3	0.510	7	0.721	12	0.414
31	0.151	4	00	8	0.756	13	0.721
Apr. 1	00	5	00	9	0.092	14	0.756
2	0.037	6	00	10	00	15	0.423
3	00	7	0.114	11	0.156	16	00
4	0.117	8	0.371	12	0.371	17	00
5	0.157	9	0.228	13	0.371	18	00
6	0.157	10	0.187	14	0.032	19	0.262
7	0.042	11	00	15	00	20	0.264
8	0.058	12	00	16	0.267	21	00
9	00	13	00	17	0.642	22	0.293
10	00	14	0.016	18	0.642	23	0.264
11	0.037	15	0.599	19	00	24	0.278
12	0.085	16	0.506	20	00	25	0.371
13	00	17	0.556	21	00	26	0.125
14	0.278	18	0.071	22	0.417	27	00
15	00	19	0.071	23	0.278	28	00
16	00	20	0.371	24	0.371	29	00
17	00	21	0.371	25	0.221	30	00
18	00	22	0.271	26	00	31	0.050

Table A.3. Average daily water flow in the T_2/S_1K tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar 15	00	19	0.009	24	0.154	28	00
16	0.035	20	00	25	0.115	29	0.010
17	0.017	21	0.125	26	0.194	30	0.114
18	00	22	0.113	27	0.194	July 1	0.145
19	00	23	0.116	28	0.071	2	0.128
20	0.045	24	00	29	0.045	3	0.162
21	0.095	25	0.001	30	00	4	0.194
22	0.056	26	0.017	31	00	5	0.174
23	00	27	00	June 1	0.077	6	0.174
24	0.033	28	0.008	2	0.154	7	0.194
25	0.011	29	0.035	3	0.154	8	0.182
26	00	30	0.001	4	0.115	9	0.174
27	0.064	May 1	00	5	00	10	0.194
28	0.085	2	0.122	6	0.071	11	0.197
29	0.039	3	0.141	7	0.174	12	0.137
30	0.045	4	00	8	0.274	13	0.137
31	0.029	5	00	9	0.308	14	0.154
Apr. 1	0.071	6	00	10	0.342	15	0.114
2	0.071	7	0.004	11	0.274	16	0.002
3	0.113	8	0.121	12	0.257	17	00
4	0.137	9	0.071	13	0.174	18	00
5	0.137	10	0.066	14	0.154	19	0.122
6	0.125	11	00	15	0.154	20	0.095
7	0.061	12	00	16	0.174	21	00
8	00	13	00	17	0.194	22	0.122
9	00	14	0.016	18	0.171	23	0.137
10	00	15	0.174	19	0.112	24	0.154
11	0.028	16	0.214	20	00	25	0.171
12	0.061	17	0.154	21	00	26	00
13	0.029	18	0.071	22	0.154	27	00
14	0.145	19	0.071	23	0.132	28	0.135
15	0.017	20	0.099	24	0.114	29	00
16	00	21	0.154	25	0.092	30	00
17	00	22	0.071	26	00	31	00
18	0.007	23	0.154	27	00		

Table A.4. Average daily water flow in the T_3A/S_1K tertiary canal ; G-K Project, Bangladesh; Kharif-I (dry), 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	00	19	0.187	24	0.119	28	00
16	0.134	20	00	25	00	29	00
17	0.145	21	0.207	26	0.121	30	0.179
18	0.010	22	0.099	27	0.137	July 1	0.103
19	00	23	0.148	28	0.032	2	0.114
20	0.105	24	0.123	29	0.015	3	0.140
21	0.098	25	00	30	0.011	4	0.128
22	0.163	26	0.005	31	00	5	0.113
23	00	27	00	June 1	0.098	6	0.158
24	0.001	28	0.084	2	0.248	7	0.140
25	0.032	29	0.084	3	0.070	8	0.137
26	00	30	00	4	0.095	9	0.137
27	0.185	May 1	00	5	00	10	0.147
28	0.049	2	0.204	6	0.111	11	0.189
29	0.134	3	0.194	7	0.094	12	0.124
30	0.154	4	00	8	0.089	13	0.140
31	0.154	5	00	9	0.132	14	0.189
Apr. 1	0.067	6	00	10	0.197	15	0.019
2	0.139	7	00	11	0.102	16	00
3	0.126	8	0.079	12	0.093	17	00
4	0.237	9	0.151	13	0.141	18	00
5	0.222	10	00	14	0.112	19	0.097
6	0.083	11	00	15	0.124	20	0.154
7	0.095	12	00	16	0.209	21	00
8	0.132	13	00	17	0.141	22	0.105
9	00	14	00	18	0.158	23	0.379
10	00	15	0.069	19	0.111	24	0.274
11	00	16	0.082	20	00	25	0.317
12	0.131	17	0.072	21	00	26	0.110
13	0.072	18	0.053	22	00	27	0.083
14	0.077	19	0.048	23	0.229	28	0.050
15	0.080	20	0.153	24	00	29	00
16	00	21	0.117	25	0.231	30	00
17	00	22	0.052	26	00	31	00
18	00	23	0.098	27	00		

Table A.5. Average daily water flow in the S_6K secondary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	1.684	19	00	24	1.370	28	0.913
16	2.005	20	00	25	1.834	29	0.971
17	2.162	21	1.542	26	0.423	30	0.692
18	1.866	22	1.748	27	00	July 1	0.350
19	1.263	23	1.510	28	00	2	0.240
20	1.728	24	0.017	29	00	3	1.175
21	1.306	25	00	30	00	4	1.509
22	1.727	26	1.480	31	00	5	1.850
23	1.454	27	0.945	June 1	.00	6	1.710
24	1.018	28	1.813	2	0.699	7	2.032
25	0.599	29	00	3	0.942	8	1.767
26	0.377	30	0.412	4	0.478	9	1.880
27	0.398	May 1	.00	5	0.471	10	1.320
28	1.670	2	1.756	6	0.671	11	1.256
29	1.313	3	2.484	7	2.175	12	1.028
30	0.763	4	0.031	8	1.798	13	1.425
31	0.909	5	00	9	1.485	14	1.565
Apr. 1	1.063	6	00	10	2.214	15	0.964
2	0.863	7	0.007	11	0.891	16	0.828
3	1.546	8	2.444	12	1.841	17	0.114
4	1.420	9	2.155	13	1.649	18	00
5	1.454	10	2.224	14	1.428	19	0.050
6	1.191	11	00	15	2.368	20	0.040
7	1.531	12	00	16	2.362	21	00
8	0.600	13	00	17	2.453	22	00
9	00	14	0.206	18	1.785	23	1.044
10	00	15	2.052	19	1.770	24	1.545
11	1.662	16	1.309	20	1.642	25	1.795
12	1.635	17	2.351	21	2.256	26	1.877
13	1.232	18	1.228	22	2.256	27	1.598
14	0.041	19	2.009	23	1.213	28	0.824
15	0.904	20	1.986	24	0.199	29	0.523
16	0.083	21	1.492	25	0.649		
17	00	22	1.566	26	1.185		
18	00	23	1.399	27	1.006		

Table A.6. Average daily water flow in the T_1B/S_6K tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	0.499	19	00	24	00	28	00
16	0.464	20	00	25	00	29	00
17	0.516	21	0.289	26	00	30	00
18	0.267	22	0.357	27	00	July 1	0.267
19	00	23	0.248	28	00	2	0.174
20	0.242	24	00	29	00	3	0.137
21	0.321	25	00	30	00	4	0.442
22	0.471	26	0.310	31	00	5	0.449
23	0.516	27	0.357	June 1	00	6	0.499
24	0.028	28	0.335	2	00	7	0.528
25	0.314	29	0.203	3	00	8	0.378
26	0.214	30	00	4	00	9	0.357
27	0.077	May 1	0.353	5	00	10	0.399
28	0.528	2	0.552	6	00	11	0.414
29	0.312	3	00	7	0.345	12	0.208
30	00	4	00	8	0.132	13	0.174
31	0.255	5	00	9	00	14	0.283
Apr. 1	0.103	6	00	10	0.279	15	0.085
2	00	7	00	11	0.235	16	0.127
3	0.264	8	0.199	12	0.357	17	00
4	0.335	9	0.399	13	0.142	18	00
5	0.292	10	0.394	14	00	19	00
6	0.120	11	00	15	0.356	20	00
7	0.199	12	00	16	0.414	21	00
8	0.107	13	00	17	0.379	22	00
9	00	14	0.040	18	00	23	0.047
10	00	15	0.379	19	00	24	0.207
11	0.286	16	0.205	20	00	25	0.335
12	0.328	17	0.445	21	0.356	26	0.378
13	0.195	18	00	22	0.296	27	0.378
14	00	19	..262	23	00	28	00
15	00	20	0.313	24	00	29	00
16	00	21	00	25	00	30	00
17	00	22	0.073	26	00	31	00
18	00	23	00	27	00		

Table A.7. Average daily water flow in the T_4/S_6K tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	0.406	19	00	24	0.571	28	0.285
16	0.280	20	00	25	0.421	29	0.307
17	0.224	21	0.231	26	0.449	30	0.247
18	0.357	22	0.464	27	0.238	July 1	0.157
19	0.289	23	0.499	28	00	2	0.114
20	00	24	0.203	29	00	3	0.099
21	0.056	25	00	30	00	4	0.257
22	0.137	26	0.026	31	00	5	0.357
23	0.719	27	0.231	June 1	00	6	0.414
24	0.549	28	0.331	2	00	7	0.428
25	0.371	29	0.280	3	0.230	8	0.342
26	0.357	30	00	4	0.281	9	0.228
27	0.342	May 1	00	5	0.246	10	0.066
28	0.428	2	0.082	6	0.135	11	0.126
29	0.399	3	0.378	7	0.446	12	0.249
30	0.428	4	0.133	8	0.464	13	0.307
31	00	5	00	9	0.096	14	0.278
Apr. 1	0.342	6	00	10	00	15	0.167
2	0.342	7	00	11	00	16	0.049
3	0.317	8	0.273	12	0.173	17	0.016
4	0.521	9	0.428	13	0.317	18	00
5	0.471	10	0.410	14	0.342	19	00
6	0.464	11	0.016	15	00	20	00
7	0.464	12	00	16	00	21	00
8	0.466	13	00	17	00	22	00
9	0.064	14	00	18	0.065	23	00
10	00	15	0.294	19	0.421	24	0.028
11	0.142	16	0.428	20	0.481	25	0.317
12	0.464	17	0.317	21	0.499	26	0.328
13	0.464	18	0.392	22	0.499	27	0.357
14	0.346	19	0.414	23	0.399	28	00
15	0.257	20	0.328	24	0.070	29	00
16	0.070	21	0.371	25	00	30	00
17	00	22	0.428	26	0.089	31	00
18	00	23	0.464	27	0.317		

Table A.8. Average daily water flow in the T_8/S_6K tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
15	00	19	00	24	0.122	28	0.092
16	0.031	20	00	25	0.188	29	0.026
17	0.081	21	00	26	0.259	30	00
18	0.117	22	0.032	27	0.112	July 1	00
19	0.167	23	0.035	28	0.018	2	00
20	0.109	24	0.008	29	00	3	00
21	0.041	25	0.002	30	00	4	00
22	0.114	26	0.010	31	00	5	0.071
23	0.159	27	00	June 1	00	6	0.039
24	0.092	28	00	2	00	7	0.071
25	0.022	29	00	3	0.002	8	00
26	00	30	00	4	00	9	0.028
27	00	May 1	00	5	0.005	10	0.107
28	00	2	00	6	00	11	0.114
29	0.002	3	0.033	7	0.121	12	0.094
30	0.045	4	00	8	0.095	13	0.091
31	0.037	5	00	9	0.137	14	0.141
Apr. 1	00	6	00	10	0.251	15	0.078
2	0.052	7	00	11	0.159	16	0.067
3	0.067	8	00	12	0.061	17	0.074
4	0.039	9	00	13	0.098	18	0.015
5	0.036	10	00	14	0.105	19	00
6	0.013	11	00	15	0.124	20	00
7	0.091	12	00	16	0.145	21	00
8	0.054	13	00	17	0.145	22	00
9	0.001	14	00	18	0.165	23	00
10	00	15	00	19	0.237	24	00
11	00	16	0.013	20	0.157	25	00
12	0.018	17	0.037	21	0.137	26	00
13	0.037	18	0.037	22	0.106	27	00
14	0.007	19	0.042	23	0.101	28	00
15	00	20	0.038	24	0.039	29	00
16	00	21	0.071	25	0.014	30	00
17	00	22	0.098	26	0.109	31	00
18	00	23	0.141	27	0.137		

Table A.9. Average daily water flow in the $S_{12}K$ secondary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	1.23	19	00	24	0.564	28	0.542
16	1.127	20	00	25	1.574	29	1.431
17	0.899	21	00	26	1.222	30	1.256
18	1.190	22	1.077	27	1.755	July 1	1.094
19	1.570	23	00	28	00	2	1.151
20	1.904	24	1.213	29	00	3	1.260
21	1.936	25	00	30	00	4	1.465
22	0.999	26	00	31	00	5	1.465
23	1.298	27	0.923	June 1	0.064	6	2.295
24	1.155	28	0.271	2	0.723	7	0.863
25	1.184	29	0.271	3	0.599	8	1.507
26	1.607	30	00	4	00	9	0.342
27	1.432	May 1	00	5	0.490	10	1.569
28	0.917	2	0.435	6	0.149	11	1.550
29	0.953	3	0.471	7	0.927	12	1.415
30	1.643	4	0.807	8	2.157	13	1.381
31	0.704	5	00	9	1.555	14	0.899
Apr. 1	1.258	6	00	10	1.878	15	1.395
2	0.092	7	00	11	1.867	16	0.435
3	1.795	8	0.221	12	2.036	17	1.870
4	1.239	9	0.830	13	1.541	18	1.644
5	0.842	10	0.923	14	1.170	19	1.201
6	1.813	11	0.492	15	1.739	20	1.833
7	1.092	12	00	16	1.250	21	1.696
8	0.871	13	00	17	1.234	22	1.745
9	0.428	14	00	18	1.139	23	1.466
10	1.442	15	0.656	19	2.448	24	2.096
11	1.460	16	0.873	20	1.775	25	1.112
12	1.103	17	0.399	21	1.207	26	0.541
13	1.617	18	0.873	22	1.667	27	0.002
14	0.873	19	0.721	23	1.576	28	0.094
15	0.873	20	0.406	24	0.656	29	0.167
16	00	21	0.371	25	00		
17	00	22	0.997	26	0.171		
18	00	23	0.644	27	0.924		

Table A.10. Average daily water flow in the $T_1/S_{12}K$ tertiary canal; G-K Project, Bangladesh; Karif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	0.202	19	00	24	00	28	00
16	0.142	20	00	25	0.507	29	0.103
17	0.028	21	00	26	0.037	30	0.114
18	0.110	22	0.092	27	0.128	July 1	0.009
19	0.188	23	00	28	00	2	0.009
20	0.518	24	0.164	29	00	3	0.189
21	0.376	25	00	30	00	4	0.237
22	0.014	26	00	31	00	5	0.237
23	0.156	27	0.187	June 1	00	6	0.539
24	0.170	28	00	2	0.002	7	0.064
25	0.128	29	00	3	00	8	0.265
26	0.179	30	00	4	00	9	00
27	0.052	May 1	00	5	0.010	10	0.427
28	0.011	2	00	6	00	11	0.188
29	0.011	3	00	7	0.071	12	0.153
30	0.224	4	0.005	8	0.251	13	0.196
31	0.019	5	00	9	0.256	14	0.057
Apr. 1	0.116	6	00	10	0.279	15	0.153
2	00	7	00	11	0.268	16	00
3	0.376	8	00	12	0.316	17	0.307
4	0.040	9	0.002	13	0.199	18	0.259
5	00	10	0.087	14	0.128	19	0.116
6	0.350	11	00	15	0.397	20	0.270
7	0.007	12	00	16	0.108	21	0.254
8	00	13	00	17	0.149	22	0.260
9	00	14	00	18	0.111	23	0.167
10	0.260	15	0.181	19	0.606	24	0.427
11	0.261	16	0.002	20	0.276	25	0.127
12	0.007	17	00	21	0.065	26	0.035
13	0.249	18	0.002	22	0.225	27	0.002
14	0.002	19	00	23	0.234	28	0.094
15	0.002	20	00	24	00	29	0.167
16	00	21	00	25	00		
17	00	22	0.248	26	0.171		
18	00	23	0.002	27	0.025		

Table A.11. Average daily water flow in the $T_6/S_{12}K$ tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	0.173	19	0.089	24	0.192	28	00
16	0.127	20	00	25	0.192	29	00
17	0.047	21	00	26	0.237	30	0.244
18	0.192	22	00	27	0.259	July 1	00
19	0.048	23	00	28	0.119	2	00
20	0.119	24	00	29	0.089	3	00
21	0.052	25	0.106	30	0.061	4	0.171
22	0.244	26	00	31	0.088	5	0.067
23	00	27	00	June 1	0.089	6	00
24	0.229	28	0.112	2	0.128	7	0.193
25	00	29	00	3	0.132	8	0.080
26	0.037	30	00	4	0.096	9	00
27	00	May 1	00	5	0.109	10	00
28	0.149	2	0.104	6	0.149	11	0.176
29	0.151	3	00	7	0.128	12	0.070
30	00	4	00	8	0.109	13	00
31	0.199	5	0.106	9	0.237	14	0.183
Apr. 1	00	6	0.089	10	0.111	15	0.065
2	00	7	0.055	11	00	16	00
3	00	8	00	12	00	17	00
4	0.178	9	0.192	13	0.257	18	0.219
5	00	10	00	14	00	19	0.070
6	00	11	0.111	15	00	20	00
7	0.192	12	0.098	16	0.207	21	0.238
8	00	13	0.077	17	00	22	0.067
9	00	14	00	18	00	23	00
10	00	15	00	19	00	24	00
11	0.171	16	0.189	20	0.222	25	0.106
12	00	17	00	21	00	26	00
13	00	18	00	22	00	27	00
14	0.178	19	0.178	23	0.250	28	00
15	00	20	00	24	0.112	29	0.085
16	00	21	0.115	25	00		
17	00	22	00	26	00		
18	0.067	23	0.139	27	0.244		

Table A.12. Average daily water flow in the $T_8/S_{12}K$ tertiary canal; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)	Month/ Date	Flow (CMS)
Mar. 15	0.273	19	00	24	0.238	29	00
16	0.102	20	00	25	0.102	30	00
17	00	21	00	26	0.102	July 1	0.057
18	0.324	22	0.057	27	0.042	2	00
19	00	23	00	28	00	3	00
20	0.121	24	00	29	00	4	00
21	0.214	25	00	30	00	5	0.153
22	0.239	26	00	June 1	00	6	00
23	00	27	00	2	00	7	00
24	00	28	00	3	0.139	8	0.125
25	0.164	29	0.017	4	00	9	00
26	00	30	00	5	00	10	00
27	0.088	May 1	00	6	00	11	00
28	0.151	2	00	7	0.073	12	0.147
29	0.051	3	0.047	8	00	13	00
30	0.094	4	00	9	00	14	00
31	0.064	5	00	10	0.150	15	0.308
Apr. 1	0.374	6	0.047	11	00	16	00
2	00	7	00	12	00	17	00
3	00	8	00	13	00	18	00
4	00	9	00	14	0.143	19	00
5	0.343	10	0.080	15	00	20	0.161
6	00	11	00	16	0.163	21	00
7	00	12	00	17	0.087	22	00
8	0.078	13	00	18	00	23	0.080
9	00	14	00	19	00	24	00
10	00	15	00	20	0.094	25	00
11	00	16	00	21	0.064	26	0.089
12	00	17	0.074	22	00	27	00
13	00	18	00	23	00	28	00
14	00	19	00	24	0.086	29	00
15	0.063	20	0.074	25	00	30	0.085
16	00	21	0.062	26	00	31	00
17	00	22	00	27	00		
18	00	23	0.084	28	0.099		

Table A.13. Average weekly discharge rate of the selected canals at the first section. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year 1/	Discharge rate in (CMS)			
	S_1K	T_1/S_1K	T_2/S_1K	T_3A/S_1K
11	0.222	0.017	0.013	0.072
12	0.269	0.056	0.034	0.057
13	0.378	0.072	0.047	0.016
14	0.533	0.081	0.092	0.147
15	0.198	0.057	0.040	0.051
16	0.221	0.018	0.036	0.070
17	0.155	0.035	0.025	0.063
18	0.228	0.135	0.037	0.056
19	0.268	0.128	0.037	0.032
20	0.747	0.312	0.114	0.068
21	0.965	0.280	0.148	0.092
22	0.492	0.132	0.071	0.067
23	1.057	0.272	0.183	0.102
24	1.366	0.262	0.195	0.131
25	0.601	0.244	0.097	0.071
26	0.396	0.126	0.051	0.073
27	1.335	0.515	0.172	0.132
28	1.260	0.589	0.158	0.135
29	0.208	0.117	0.048	0.050
30	0.499	0.148	0.085	0.173

1/ Week No. 11 is the 11th week of the year.

Table A.14 Average weekly discharge rate of the selected canals at the middle section; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year1/	Discharge rate in (CMS)			
	S_6K	T_1B/S_6K	T_4/S_6K	T_8/S_6K
11	1.923	0.436	0.316	0.057
12	1.299	0.270	0.303	0.100
13	0.927	0.212	0.328	0.012
14	1.229	0.188	0.432	0.050
15	0.791	0.115	0.248	0.009
16	0.481	0.092	0.109	0.004
17	1.027	0.207	0.224	0.012
18	0.668	0.129	0.084	0.004
19	0.975	0.141	0.161	00
20	1.579	0.205	0.310	0.023
21	1.154	0.010	0.420	0.141
22	0.234	00	0.032	0.002
23	1.561	0.108	0.238	0.087
24	1.855	0.306	0.118	0.098
25	1.588	0.073	0.347	0.134
26	0.823	0.038	0.200	0.054
27	1.469	0.423	0.287	0.025
28	1.347	0.274	0.203	0.093
29	0.147	0.018	0.009	0.022
30	1.412	0.192	0.147	00

1/ Week No. 11 is the 11th week of the year.

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Table A.15 Average weekly discharge rate of the selected canals at the last section; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year[1/]	Discharge rate in (CMS)			
	$S_{12}K$	$T_1/S_{12}K$	$T_6/S_{12}K$	$T_8/S_{12}K$
11	1.110	0.120	0.134	0.174
12	1.423	0.213	0.165	0.105
13	1.204	0.086	0.076	0.117
14	0.105	0.110	0.052	0.060
15	1.099	0.110	0.049	0.009
16	0.153	0.013	0.022	0.008
17	0.382	0.050	0.031	0.002
18	0.257	0.013	0.042	0.013
19	0.257	0.012	0.076	0.011
20	0.352	0.026	0.052	0.021
21	0.560	0.130	0.162	0.090
22	1.061	[illegible]	0.100	0.019
23	0.197	0.123	0.134	0.031
24	0.021	0.223	0.066	0.056
25	0.547	0.216	0.083	0.034
26	1.494	0.060	0.069	0.022
27	0.773	0.219	0.073	0.039
28	1.428	0.167	0.070	0.065
29	1.488	0.209	0.084	0.023
30	0.782	0.145	0.015	0.024

1/ Week no. 11 is the 11th week of the year.

Table A.16 Daily rainfall observed at the first section[1/] of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)
Mar. 15	00	19	31.7	24	20.5	29	1.0
16	00	20	00	25	54.1	30	3.3
17	00	21	20.0	26	00	July 1	1.2
18	00	22	00	27	2.5	2	3.3
19	00	23	00	28	29.7	3	00
20	00	24	00	29	57.6	4	00
21	00	25	00	30	00	5	00
22	00	26	00	June 1	30.7	6	11.4
23	1.7	27	00	2	00	7	2.5
24	00	28	00	3	00	8	38.1
25	00	29	00	4	9.3	9	00
26	00	30	00	5	0.5	10	1.7
27	00	May 1	00	6	00	11	1.2
28	00	2	00	7	00	12	3.3
29	00	3	3.3	8	8.1	13	1.0
30	17.7	4	00	9	00	14	2.0
31	00	5	9.6	10	15.7	15	00
Apr. 1	00	6	00	11	1.5	16	33.5
2	00	7	00	12	8.1	17	33.0
3	00	8	4.0	13	00	18	22.8
4	00	9	5.3	14	10.1	19	00
5	00	10	00	15	7.6	20	00
6	00	11	00	16	00	21	73.6
7	00	12	8.8	17	00	22	00
8	00	13	00	18	9.3	23	00
9	00	14	00	19	0.5	24	2.7
10	00	15	47.2	20	00	25	2.5
11	00	16	00	21	7.1	26	1.2
12	00	17	00	22	1.7	27	4.3
13	00	18	00	23	17.0	28	00
14	00	19	00	24	29.2	29	28.4
15	00	20	14.4	25	43.4	30	3.8
16	19.8	21	00	26	25.4	31	00
17	00	22	9.3	27	1.7		
18	0.5	23	8.6	28	00		

1/ First section is the upstream one-third service area of the Project.

Table A.1·7. Daily rainfall observed at the middle section[2/] of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)
Mar. 15	00	19	38.1	24	59.6	28	00
16	00	20	00	25	39.3	29	3.3
17	00	21	44.1	26	3.0	30	1.5
18	00	22	00	27	14.7	July 1	00
19	00	23	00	28	35.5	2	11.1
20	00	24	00	29	30.4	3	00
21	00	25	00	30	19.3	4	7.8
22	1.5	26	4.0	31	00	5	00
23	8.1	27	00	June 1	27.9	6	9.9
24	00	28	00	2	00	7	6.3
25	00	29	00	3	15.2	8	27.9
26	00	30	1.0	4	00	9	8.8
27	00	May 1	00	5	00	10	00
28	00	2	00	6	00	11	33.5
29	00	3	00	7	14.7	12	00
30	29.2	4	00	8	00	13	2.7
31	0.7	5	6.0	9	20.8	14	6.3
Apr. 1	00	6	00	10	00	15	00
2	4.5	7	00	11	4.5	16	8.8
3	00	8	6.0	12	00	17	5.3
4	0.2	9	2.5	13	6.3	18	3.8
5	1.2	10	00	14	10.1	19	00
6	00	11	00	15	00	20	00
7	00	12	4.5	16	00	21	63.5
8	00	13	12.1	17	2.7	22	00
9	1.7	14	0.2	18	8.8	23	00
10	00	15	34.2	19	00	24	4.8
11	00	16	00	20	00	25	7.1
12	00	17	00	21	12.1	26	2.0
13	00	18	00	22	17.0	27	2.2
14	1.0	19	00	23	3.0	28	00
15	00	20	6.6	24	13.9	29	22.8
16	41.9	21	00	25	27.9	30	00
17	00	22	20.8	26	29.2	31	00
18	0.7	23	11.1	27	2.2		

2/ Middle section is the middle one-third service area of the Project.

Table A. 18 Daily rainfall observed at the last section[3/] of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)	Month/ Date	Rainfall (mm)
Mar. 15	00	19	18.0	24	33.0	28	3.3
16	00	20	00	25	72.3	29	0.7
17	00	21	29.2	26	4.0	30	00
18	00	22	00	27	35.0	July 1	00
19	00	23	00	28	29.7	2	00
20	00	24	00	29	7.6	3	00
21	00	25	00	30	13.2	4	00
22	00	26	00	31	00	5	00
23	11.1	27	00	June 1	38.8	6	00
24	00	28	00	2	00	7	18.2
25	00	29	00	3	24.3	8	1.5
26	00	30	00	4	35.0	9	00
27	00	May 1	00	5	9.1	10	00
28	00	2	00	6	00	11	1.7
29	00	3	00	7	24.3	12	00
30	25.2	4	6.3	8	00	13	6.8
31	1.2	5	4.0	9	00	14	16.2
Apr. 1	00	6	00	10	16.2	15	00
2	1.7	7	00	11	00	16	152.4
3	00	8	1.2	12	00	17	10.4
4	00	9	29.2	13	13.2	18	00
5	00	10	3.3	14	00	19	00
6	00	11	00	15	00	20	00
7	00	12	00	16	00	21	60.9
8	00	13	7.1	17	1.2	22	00
9	00	14	00	18	00	23	00
10	00	15	00	19	20.3	24	00
11	00	16	00	20	3.0	25	00
12	00	17	00	21	19.0	26	2.0
13	00	18	00	22	53.3	27	1.2
14	3.5	19	00	23	3.0	28	00
15	00	20	14.2	24	1.5	29	12.7
16	13.9	21	33.0	25	12.7	30	00
17	00	22	00	26	9.1	31	7.8
18	00	23	44.4	27	00		

3/ Last section is the tailend one-third service area of the Project.

Table A.19. Daily evaporation observed at the first section of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)
Mar 15	4.2	19	4.4	24	3.3	28	2.4
16	3.3	20	3.2	25	3.3	29	2.8
17	3.3	21	4.0	26	2.8	30	4.8
18	3.9	22	2.4	27	2.2	July 1	3.3
19	2.8	23	4.6	28	3.5	2	2.6
20	3.5	24	4.9	29	6.2	3	3.9
21	4.6	25	4.9	30	3.2	4	3.2
22	4.2	26	3.9	31	3.2	5	4.9
23	4.4	27	4.9	June 1	4.6	6	4.4
24	5.3	28	5.6	2	2.8	7	4.0
25	4.6	29	6.0	3	2.8	8	3.5
26	4.2	30	3.5	4	4.3	9	3.0
27	6.0	May 1	3.5	5	3.5	10	3.7
28	6.0	2	6.7	6	2.4	11	3.3
29	5.6	3	4.0	7	2.8	12	4.8
30	5.3	4	5.6	8	2.8	13	2.4
31	3.5	5	3.5	9	1.7	14	3.5
Apr. 1	4.9	6	4.2	10	2.4	15	3.5
2	4.9	7	5.3	11	2.4	16	2.1
3	4.1	8	4.6	12	4.2	17	3.2
4	6.0	9	2.4	13	3.2	18	2.1
5	3.5	10	3.9	14	2.4	19	5.3
6	5.6	11	3.9	15	3.2	20	4.2
7	6.0	12	3.7	16	5.3	21	3.2
8	6.4	13	1.7	17	4.2	22	3.2
9	3.9	14	2.8	18	2.6	23	2.8
10	3.2	15	7.1	19	2.4	24	2.8
11	4.2	16	2.8	20	4.2	25	2.4
12	4.9	17	4.2	21	3.2	26	1.9
13	3.0	18	4.2	22	3.0	27	2.4
14	4.9	19	4.2	23	3.0	28	3.5
15	5.3	20	6.2	24	2.6	29	2.5
16	3.9	21	6.1	25	3.3	30	2.2
17	4.2	22	5.1	26	0.7	31	2.5
18	3.2	23	4.2	27	0.8		

Table A.20. Daily evaporation observed at the middle section of the G-K Project, Phase-I, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)
Mar. 15	4.5	19	1.1	24	5.6	28	4.1
16	6.5	20	5.0	25	4.3	29	2.5
17	4.0	21	4.1	26	4.0	30	2.9
18	4.0	22	8.0	27	1.7	July 1	5.6
19	6.7	23	8.0	28	0.5	2	3.7
20	3.0	24	6.0	29	0.6	3	7.9
21	5.0	25	6.0	30	3.3	4	4.3
22	4.5	26	7.0	31	1.0	5	5.6
23	4.1	27	5.0	June 1	2.9	6	3.0
24	6.0	28	8.0	2	4.0	7	4.0
25	4.0	29	8.0	3	2.7	8	2.5
26	3.0	30	4.0	4	3.5	9	3.8
27	7.0	May 1	6.0	5	6.5	10	6.7
28	7.0	2	5.0	6	5.5	11	2.6
29	6.0	3	7.0	7	2.2	12	6.4
30	2.2	4	9.0	8	4.0	13	4.2
31	3.0	5	6.0	9	4.3	14	2.8
Apr. 1	6.0	6	6.0	10	7.5	15	6.0
2	5.5	7	6.0	11	3.8	16	2.9
3	3.0	8	8.0	12	4.7	17	2.6
4	7.2	9	5.5	13	4.4	18	2.1
5	2.2	10	5.5	14	2.8	19	5.8
6	2.3	11	5.5	15	3.1	20	6.5
7	7.0	12	6.5	16	3.9	21	2.0
8	7.0	13	4.1	17	2.0	22	6.5
9	5.7	14	5.2	18	2.1	23	5.2
10	5.0	15	7.2	19	4.4	24	3.8
11	7.0	16	3.0	20	3.9	25	3.5
12	7.0	17	5.0	21	2.8	26	2.2
13	6.0	18	8.0	22	2.9	27	3.7
14	4.0	19	3.0	23	2.8	28	4.0
15	6.0	20	8.0	24	2.7	29	2.8
16	6.9	21	8.0	25	3.4	30	3.5
17	6.0	22	6.8	26	3.3	31	4.5
18	2.7	23	5.1	27	1.0		

Table A.21'. Daily evaporation observed at the last section of the Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)	Month/ Date	Evaporation (mm)
Mar. 15	6.0	19	6.0	24	3.0	28	2.8
16	5.0	20	6.0	25	2.4	29	3.6
17	3.0	21	7.0	26	4.0	30	4.0
18	7.0	22	6.0	27	2.0	July 1	2.0
19	5.0	23	3.0	28	5.0	2	5.0
20	5.0	24	4.0	29	2.0	3	5.0
21	7.0	25	5.0	30	2.0	4	6.0
22	4.0	26	6.0	21	3.0	5	5.0
23	6.1	27	6.0	June 1	3.8	6	4.5
24	7.0	28	8.0	2	5.0	7	3.2
25	7.0	29	8.0	3	4.0	8	4.0
26	5.0	30	6.0	4	5.0	9	5.0
27	7.0	May 1	7.0	5	3.0	10	4.0
28	6.0	2	6.0	6	4.0	11	4.7
29	7.0	3	5.0	7	4.3	12	6.0
30	8.2	4	5.3	8	4.0	13	2.8
31	1.2	5	7.0	9	5.0	14	3.2
Apr. 1	7.0	6	7.0	10	2.0	15	6.0
2	3.7	7	8.0	11	2.5	16	3.7
3	5.0	8	7.0	12	5.5	17	3.5
4	6.0	9	7.0	13	2.2	18	5.9
5	5.0	10	8.3	14	6.0	19	3.5
6	7.0	11	5.0	15	5.0	20	4.5
7	4.0	12	6.0	16	3.0	21	3.2
8	4.0	13	3.1	17	5.2	22	4.3
9	7.0	14	5.0	18	4.0	23	3.0
10	5.5	15	6.0	19	1.0	24	2.7
11	5.0	16	6.0	20	2.0	25	5.0
12	8.0	17	7.0	21	1.5	26	4.2
13	4.0	18	4.0	22	3.0	27	4.1
14	6.5	19	8.0	23	3.0	28	3.6
15	6.0	20	4.2	24	1.5	29	3.2
16	5.0	21	3.0	25	2.7	30	5.0
17	6.0	22	4.0	26	3.5	31	3.3
18	4.0	23	5.0	27	4.0		

Table A.22. Weekly total evaporation and rainfall in the different sections of the G-K Project, Bangladesh, Kharif-I (dry) season, 1978.

Week of the year	First section		Middle section		Last section	
	Rainfall (mm)	Evaporation (mm)	Rainfall (mm)	Evaporation (mm)	Rainfall (mm)	Evaporation (mm)
11	00	25.70	00	33.25	00	36.75
12	1.70	29.40	9.60	33.30	11.10	41.10
13	17.70	25.50	29.90	34.20	26.40	41.40
14	00	36.50	5.90	34.20	1.70	34.70
15	00	29.40	2.70	40.70	3.50	42.00
16	72.00	25.30	124.80	33.80	61.10	40.00
17	00	34.80	4.00	48.00	00	40.00
18	12.90	31.00	7.00	43.00	10.30	43.30
19	18.10	25.50	25.10	41.10	40.80	44.40
20	61.60	31.50	41.00	39.40	14.20	40.20
21	95.00	27.00	148.50	35.50	221.70	23.40
22	118.00	24.30	128.30	14.80	113.60	24.80
23	33.60	19.90	35.50	33.50	84.60	27.30
24	27.30	24.90	23.60	24.70	14.40	29.40
25	64.80	21.00	54.80	19.50	100.10	16.00
26	76.00	18.10	64.10	22.80	25.80	22.60
27	55.30	26.50	63.00	31.00	19.70	32.70
28	9.20	24.20	51.30	32.50	24.70	31.70
29	162.90	19.10	81.40	28.40	223.70	28.60
30	39.10	18.30	38.90	33.20	16.20	25.80

Table A.23 Transplantation progress in selected tertiary canal T_2/S_1K service area; G-K Project; Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11					
12	101.21	0.017	.00	..00	
13		0.056	0.12	0.11	
14		0.072	0.26	0.25	
15		0.081	1.47	1.45	
16		0.057	4.45	4.39	
17		0.018	9.71	9.59	
18		0.035	18.01	17.79	
19		0.135	36.03	35.59	81.19
20		0.128	52.63	52.00	
21		0.312	56.68	56.00	
22		0.280	67.20	66.39	
23		0.132	72.06	71.19	
24		0.272	80.16	79.20	
		0.262	82.18	81.19	

Table A.24 Transplantation progress in selected tertiary canal T_1/S_1K service area; G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11					
12	76.92	0.013	00	.00	
13		0.034	00	.00	
14		0.167	0.20	0.26	
15		0.092	0.20	0.26	
16		0.040	2.02	2.62	
17		0.036	6.07	7.89	
18		0.025	22.06	28.67	
19		0.037	22.06	28.67	
20		0.037	31.05	40.36	65.28
21		0.114	38.34	49.84	
22		0.148	44.55	57.91	
23		0.071	49.41	64.23	
24		0.183	49.41	64.23	
		0.195	50.22	65.28	

Table 25 Transplantation progress in selected tertiary canal T_3A/S_1K service area; G-K project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area trans-planted (ha)	Cumulative % of the programmed area transplanted: Weekly	Total
11		0.072	00	00	
12	66.39	0.057	0.22	0.33	
13		0.106	0.51	2.27	
14		0.147	1.72	2.59	
15		0.051	2.02	3.04	
16		0.070	5.55	8.35	
17		0.063	5.55	8.35	49.40
18		0.056	9.17	13.81	
19		0.032	12.52	18.85	
20		0.068	16.06	24.19	
21		0.092	20.82	31.36	
22		0.067	32.80	49.40	

Table 26 Transplantation progress in selected tertiary canal T_1B/S_6K service area; G-K project, Bangladesh; Kharif-I(dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area trans-planted (ha)	Cumulative % of the programmed area transplanted: Weekly	Total
11		0.436	0	0	
12	114.97	0.270	0.08	0.06	
13		0.212	0.60	0.52	
14		0.188	0.60	0.52	
15		0.115	6.15	5.34	
16		0.072	15.38	13.37	
17		0.207	52.42	45.59	
18		0.127	68.86	59.89	93.84
19		0.141	78.13	67.95	
20		0.205	87.04	75.70	
21		0.010	94.31	82.03	
22		00	96.35	83.80	
23		0.108	107.89	93.84	

Table A.27 Transplantation progress in selected tertiary canal T_4/S_6K service area; G-K project, Bangladesh; Kharif-1 (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11		0.316	.00	.00	
12	106.85	0.303	0.31	0.29	
13		0.328	0.31	0.29	
14		0.432	0.31	0.29	
15		0.268	2.02	1.92	
16		0.109	8.09	7.71	
17		0.224	33.40	31.85	
18		0.084	79.35	75.67	89.96
19		0.161	89.67	85.52	
20		0.310	90.68	86.48	
21		0.420	94.33	89.96	

Table A. 28 Transplantation progress in selected tertiary canal T_8/S_6K service area; G-K project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11		0.067	.00	.00	
12	157.66	0.100	.00	.00	
13		0.012	0.08	0.05	
14		0.050	0.14	0.08	
15		0.009	0.47	0.29	
16		0.004	0.55	0.34	
17		0.006	2.44	1.54	9.74
18		0.012	2.74	1.74	
19		0.006	2.74	1.74	
20			2.74	1.76	
21		0.023	6.66	4.23	
22		0.161	12.63	8.02	
23		0.002	15.35	9.74	

Table A.29 Transplantation progress in selected tertiary canal $T_1/S_{12}K$ service area; G-K project, Bangladesh; Kharif-I (dry) season, 1978

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11		0.120	00	00	
12	85.02	0.213	0.56	0.65	
13		0.086	0.93	1.09	
14		0.110	5.38	6.32	
15		0.110	20.28	23.85	
16		0.013	31.01	36.47	74.27
17		0.050	37.48	44.08	
18		0.013	42.34	49.80	
19		0.012	53.44	62.85	
20		0.026	63.15	74.27	

Table A.30 Transplantation progress in selected tertiary canal $T_6/S_{12}K$ service area; G-K project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11		0.134	1.00	1.00	
12	101.21	0.165	2.42	2.39	
13		0.076	5.06	4.99	
14		0.052	5.06	4.99	
15		0.049	14.97	14.97	
16		0.022	26.72	26.40	
17		0.031	40.48	39.99	
18		0.042	40.48	39.99	69.22
19		0.076	40.48	39.99	
20		0.052	40.48	39.99	
21		0.162	64.77	63.99	
22		0.100	68.82	67.99	
23		0.134	70.06	69.22	

Table A.31 Transplantation progress in selected tertiary canal $T_8/S_{12}K$ service area; G-K project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Area programmed for irrigation (ha)	Average flow rate (CMS)	Cumulative area transplanted (ha)	Cumulative % of the programmed area transplanted	
				Weekly	Total
11					
12	66.72	0.174	0.10	0.14	
13		0.105	0.36	0.[illegible]9	
14		0.117	1.39	2.28	
15		0.060	1.39	2.28	
16		0.009	3.82	6.29	
17		0.008	8.48	13.96	
18		0.002	13.34	21.96	38.01
19		0.013	13.34	21.[illegible]	
20		0.011	13.34	21.96	
21		0.021	13.34	21.96	
22		0.090	22.59	37.20	
		0.019	23.08	38.01	

Table A.32 Average weekly water use, pan evaporation and daily seepage and percolation rate in T_1, T_2 and T_3A service areas of S_1K. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Weekly values of (ET+S&P) in mm			Pan Evaporation (mm)	Average daily S&P in mm/day		
	T_1/S_1K	T_2/S_1K	T_3A/S_1K		T_1/S_1K	T_2/S_1K	T_3A/S_1K
20	62.50	69.50	65.50	31.50	4.42	5.42	4.85
21	68.00	70.00	69.00	27.00	5.85	6.14	6.00
22	70.50	64.50	70.50	24.30	6.31	5.74	6.60
23	61.00	65.00	62.00	19.90	5.87	6.44	6.01
24	65.00	68.00	63.50	24.90	5.72	5.51	5.61
25	67.00	63.50	64.20	21.00	6.57	6.71	6.57
26	60.00	68.00	67.00	18.10	5.98	7.12	6.94
27	68.50	67.50	68.50	26.50	6.00	5.85	6.00
28	63.00	65.00	66.00	24.20	5.54	5.82	5.97
Ave. for all weeks	65.05	66.77	66.24	24.15	5.82	6.08	6.06
Ave. for three service areas		66.02		24.15		5.95	

Table A.33 Average weekly water use, pan evaporation and daily seepage and percolation rate in T_1B, T_4 and T_8 service areas of S_6K. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Weekly values of (ET+S&P) in mm			Pan evaporation (mm)	Average daily S&P in mm/day		
	T_1B/S_6K	T_4/S_6K	T_8/S_6K		T_1B/S_6K	T_4/S_6K	T_8/S_6K
20	56.00	66.75	69.50	39.40	2.37	3.90	4.30
21	60.25	66.11	64.20	35.50	3.53	4.37	4.10
22	62.50	62.60	68.00	14.80	6.81	6.82	7.60
23	60.20	54.44	59.00	33.50	3.81	2.99	3.64
24	58.80	61.25	61.00	24.70	4.87	5.22	5.18
25	60.00	60.04	63.00	19.50	5.78	5.79	6.21
26	61.00	61.83	68.00	22.80	5.45	5.57	6.45
27	65.98	64.05	65.50	31.00	4.99	4.72	4.92
28	59.00	58.66	69.00	32.50	3.78	3.73	5.21
Ave. for all weeks	60.41	61.74	65.24	28.18	4.59	4.45	5.29
Ave. for three service areas		62.46		28.18		4.77	

Table A.34 Average weekly water use, pan evaporation and daily seepage and percolation rate in T_1, T_6 and T_8 service areas of $S_{12}K$. G-K Project, Bangladesh; Kharif-I (dry) season, 1978.

Week of the year	Weekly values of (ET+S&P) in mm			Pan Evaporation (mm)	Average daily S&P in mm/day		
	$T_1/S_{12}K$	$T_6/S_{12}K$	$T_8/S_{12}K$		$T_1/S_{12}K$	$T_6/S_{12}K$	$T_8/S_{12}K$
20	55.00	52.00	70.00	40.20	2.11	1.68	4.25
21	52.50	60.00	87.50	23.40	4.15	5.22	9.15
22	60.00	59.00	78.00	24.80	5.02	4.88	7.60
23	58.50	50.55	77.50	27.30	4.45	3.32	7.17
24	53.00	58.50	80.50	29.40	3.37	4.15	7.30
25	59.00	58.00	75.00	16.00	6.14	6.00	8.42
26	55.00	52.50	76.00	22.60	4.62	4.27	7.62
27	58.00	52.50	72.50	32.70	3.61	2.82	5.68
28	61.00	50.00	70.00	31.70	4.18	2.61	5.47
Ave. for all weeks	56.88	54.78	76.33	27.55	4.18	3.88	6.96
Ave. for three service areas		62.66		27.55		5.00	

Table A.35 Weekly water use efficiency (WUE) for the selected tertiary canal T_1/S_1K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied 1/ (mm) (3)	Rainfall (mm) (4)	Potential Water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE 2/ % (7)	Ave. WUE % (8)
20	0	272	61.6	62.5	4.42	18.73	
21	0	240	95.0	68.0	5.85	20.29	
22	0	104	118.0	70.5	6.31	31.75	
23	0	205	33.6	61.0	5.87	25.56	
24	0.66	192	27.3	65.0	5.72	27.91	23.56
25	0	179	64.8	67.0	6.57	27.48	
26	0	92	76.0	60.0	5.98	35.71	
27	0	419	55.3	68.5	6.00	14.44	
28	1	554	9.2	63.0	5.54	10.20	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A.36 Weekly water use efficiency (WUE) for the selected tertiary canal T_2/S_1K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied 1/ (3)	Rainfall (mm) (4)	Potential water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE 2/ % (7)	Ave. WUE % (8)
20	1.66	121	61.6	69.5	5.42	33.13	
21	0.33	179	95.0	70.0	6.14	24.80	
22	5.0	85	118.0	64.5	5.76	13.34	
23	4.0	220	33.6	65.0	6.44	15.47	24.46
24	0	234	27.3	68.0	6.15	26.02	
25	2.10	116	64.8	63.5	6.07	28.40	
26	3.33	63	76.0	68.0	7.12	31.86	
27	0.66	231	55.3	67.5	5.85	22.22	
28	1.33	220	9.2	65.0	5.82	24.97	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $WUE = \frac{\text{Col } 5 - \text{Col } 6 \times \text{Col } 2}{\text{Col } 3 + \text{Col } 4} \times 100$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A.37 Weekly water use efficiency WUE) for the selected tertiary canal T_3A/S_1K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied[1/] (3)	Rainfall (mm) (4)	Potential water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE[2/] % (7)	Ave. WUE % (8)
20	1.66	125	61.60	65.5	4.65	30.78	
21	0	169	95.00	69.0	6.[illegible]	26.13	
22	0.66	123	118.0	70.5	6.31	27.53	
23	2.0	188	33.60	62.0	6.[illegible]	22.55	
24	0	241	27.30	63.5	5.51	27.97	25.41
25	0	130	64.8	64.2	6.[illegible]	23.66	
26	0	136	76.0	67.0	6.98	32.95	
27	0.66	239	55.30	68.5	6.03	21.93	
28	3.33	293	9.20	66.0	5.97	15.25	
29	0						
30							

1/ Depth of water supplied was calculated by dividng the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5 - Col 6 x Col 2}}{\text{Col 3 + Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A.38 Weekly water use efficiency (WUE) for the selected tertiary canal T_1B/S_6K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied1/ (3)	Rainfall (mm) (4)	Potential water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE2/ % (7)	Ave. WUE % (8)
20	0.66	124	41.0	56.0	2.37	32.98	
21	0	5	148.50	60.25	3.53	39.37	
22	0	0	128.30	62.50	6.81	48.82	
23	0	60	35.50	60.20	3.81	63.03	
24	0	172	23.60	58.80	4.87	30.06	43.31
25	0	52	54.80	60.00	5.78	56.17	
26	0	21	64.10	61.0	5.45	71.68	
27	0	250	63.00	65.98	4.99	21.07	
28	0	170	51.30	59.0	3.78	26.66	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$WUE = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A. 39 Weekly water use efficiency(WUE) for the selected tertiary canal T_4/S_6K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied[1/] (3)	Rainfall (mm) (4)	Potential water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE[2/] % (7)	Ave. WUE % (8)
20	1.33	179	41.0	66.75	3.90	27.98	
21	0	269	148.50	66.11	4.37	15.85	
22	0	20	128.30	62.60	6.82	42.21	
23	0	152	35.50	54.44	2.99	29.03	27.99
24	0	79	23.60	61.25	5.22	59.69	
25	0	276	54.80	60.04	5.79	18.14	
26	0	235	64.10	61.83	5.57	20.67	
27	0	288	63.00	64.05	4.72	18.24	
28	0	240	51.30	58.66	3.73	20.13	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A. 40 Weekly water use efficiency (WUE) for the selected tertiary canal T_8/S_6K service area, G-K Project, Bangladesh. Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied 1/ (mm) (3)	Rainfall (mm) (4)	Potential water use (ET + S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE 2/ % (7)	Ave. WUE % (8)
20	5.0	145	41.0	69.5	4.3	25.80	
21	0	629	148.50	64.2	4.1	8.25	
22	0	8	128.30	60.0	6.45	44.02	
23	4.66	342	35.50	59.0	3.64	11.13	
24	1.33	386	23.60	61.0	5.18	13.21	15.81
25	0.33	543	54.80	63.0	6.21	10.19	
26	0.33	484	64.10	68.0	6.45	12.01	
27	7	269	63.00	65.5	4.92	9.33	
28	3.33	561	51.30	69.0	5.21	8.43	

1/ Depth of water supplied was calculated by dividing the weekly total flow in with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss throughthe tertiary canal has been neglected in calculating the WUE.

Table A. 41 Weekly water use efficiency (WUE) for the selected tertiary canal $T_1/S_{12}K$ service area, G-K Project, Bangladesh, Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied 1/ (mm) (3)	Rainfall (mm) (4)	Potential water use (ET + (S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE 2/ % (7)	Ave. WUE % (8)
20	0	16	14.20	55.0	2.11	18.20	
21	0	84	221.70	52.5	4.15	17.17	
22	0	00	113.60	60.0	5.02	52.81	47.84
23	0	117	84.60	58.5	4.45	29.01	
24	0	213	14.40	53.0	3.37	23.30	
25	2.33	208	100.10	59.0	6.14	14.50	
26	0	62	25.80	55.0	4.62	62.64	
27	0.33	244	19.70	58.0	3.61	21.53	
28	0	196	24.70	61.0	4.18	27.63	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5 - Col 6 x Col 2}}{\text{Col 3 + Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A. 42 Weekly water use efficiency (WUE) for the selected tertiary canal $T_6/S_{12}K$ service area, G-K Project, Bangladesh, Kharif-I (dry) season, 1978.

Week of the year	Average weighted stress days	Average depth of water supplied 1/ (mm)	Rainfall (mm)	Potential water use (ET + S&P) (mm)	Daily rate of S&P (mm)	WUE 2/ %	Ave. WUE %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	2.33	51	14.20	52.0	1.68	73.74	
21	2.33	137	221.70	60.0	5.22	13.33	
22	1.33	84	113.60	59.0	4.88	26.56	
23	0	113	84.60	50.55	3.32	25.58	
24	0	54	14.40	58.50	4.15	85.67	46.32
25	1.0	68	100.10	58.0	6.00	30.93	
26	0	56	25.80	52.5	4.27	64.18	
27	4.66	66	19.70	52.5	2.82	45.91	
28	2.00	63	24.70	50.0	2.61	51.06	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

Table A. 43 Weekly water use efficiency (WUE) for the selected tertiary canal $T_8/S_{12}K$ service area, G-K Project, Bangladesh, Kharif-I (dry) season, 1978.

Week of the year (1)	Average weighted stress days (2)	Average depth of water supplied 1/ (mm) (3)	Rainfall (mm) (4)	Potential water use (ET + S&P) (mm) (5)	Daily rate of S&P (mm) (6)	WUE 2/ % (7)	Ave. WUE % (8)
20	6.33	76	14.20	70.0	4.25	47.77	
21	1.66	235	221.70	87.5	9.15	15.83	
22	1.33	49	113.60	78.0	7.60	41.75	
23	2.33	81	84.60	77.5	7.17	36.70	
24	1.33	146	14.40	80.5	7.30	44.13	34.77
25	4.0	89	100.10	75.0	8.42	21.85	
26	1.0	73	25.80	76.0	7.62	69.21	
27	2.33	190	19.70	72.5	5.68	28.25	
28	3.66	639	24.70	70.0	5.47	7.52	

1/ Depth of water supplied was calculated by dividing the weekly total flow in m^3 with the area under farming activities in that week in m^2.

2/ $$\text{WUE} = \frac{\text{Col 5} - \text{Col 6} \times \text{Col 2}}{\text{Col 3} + \text{Col 4}} \times 100$$

Conveyance loss through the tertiary canal has been neglected in calculating the WUE.

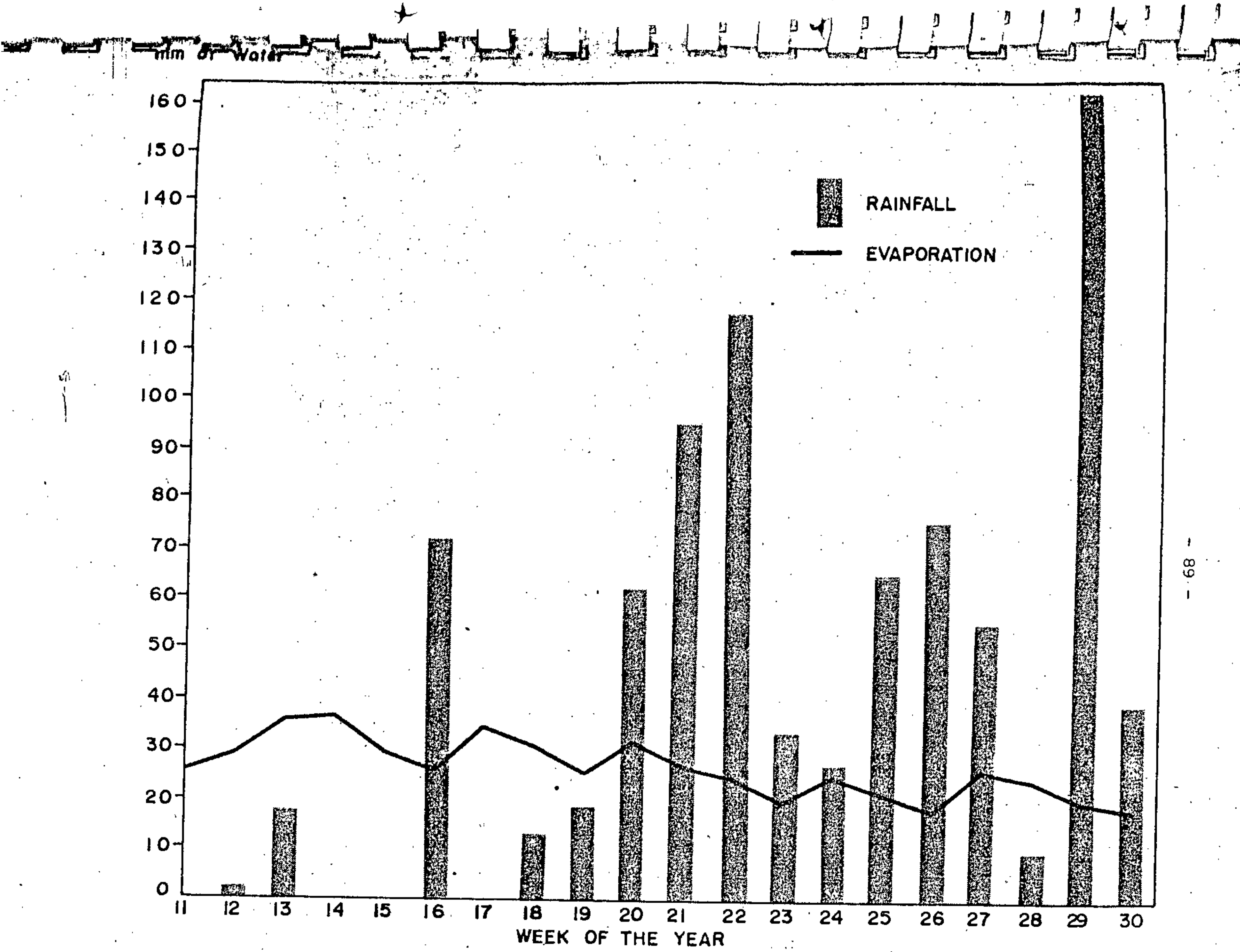

Fig. A.1 Weekly evaporation and rainfall distribution in the first section of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

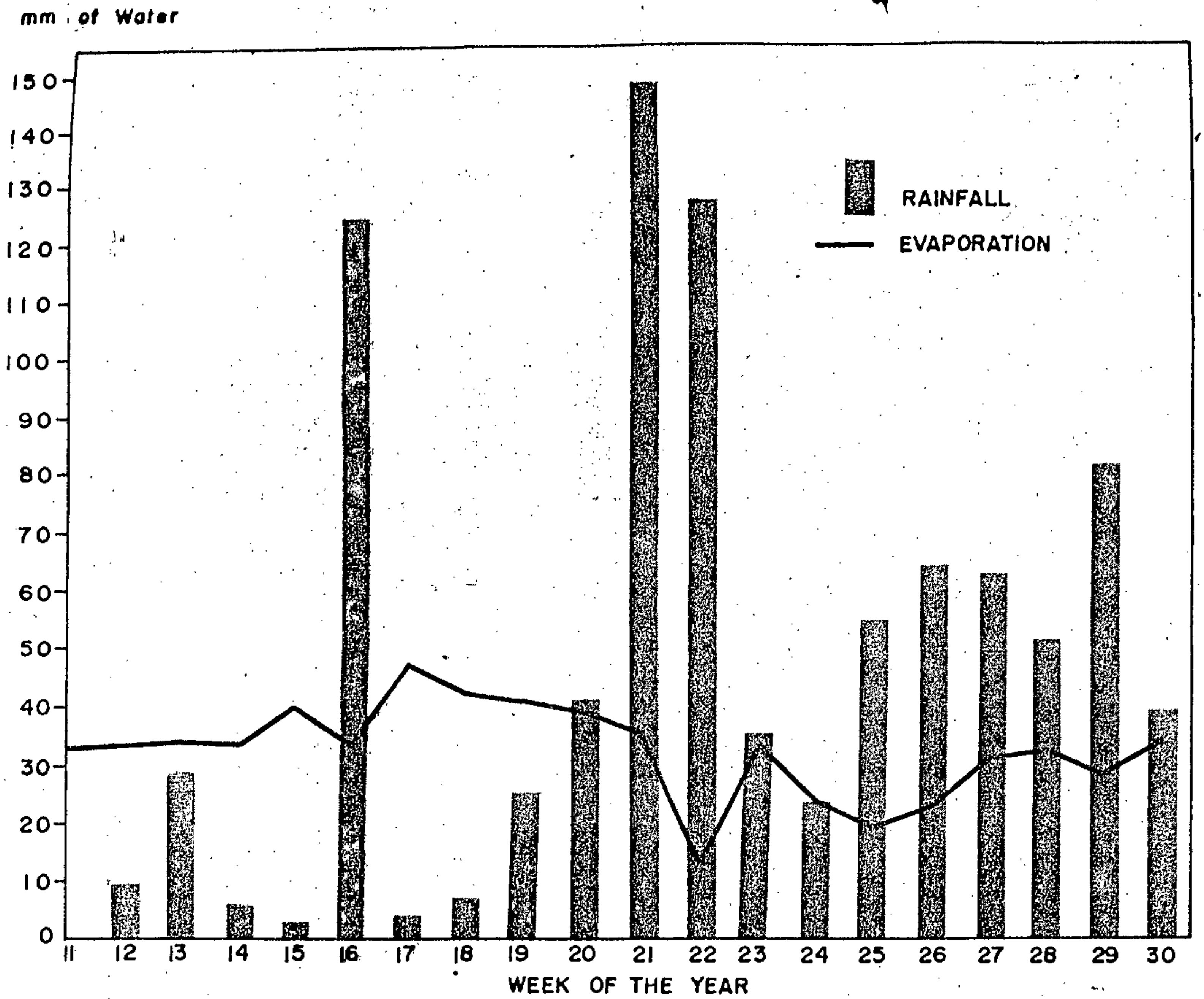

Fig. A.2 Weekly evaporation and rainfall distribution in the middle section of the G-K Project, Phase-1, Bangladesh. Kharif-I (dry) season, 1978.

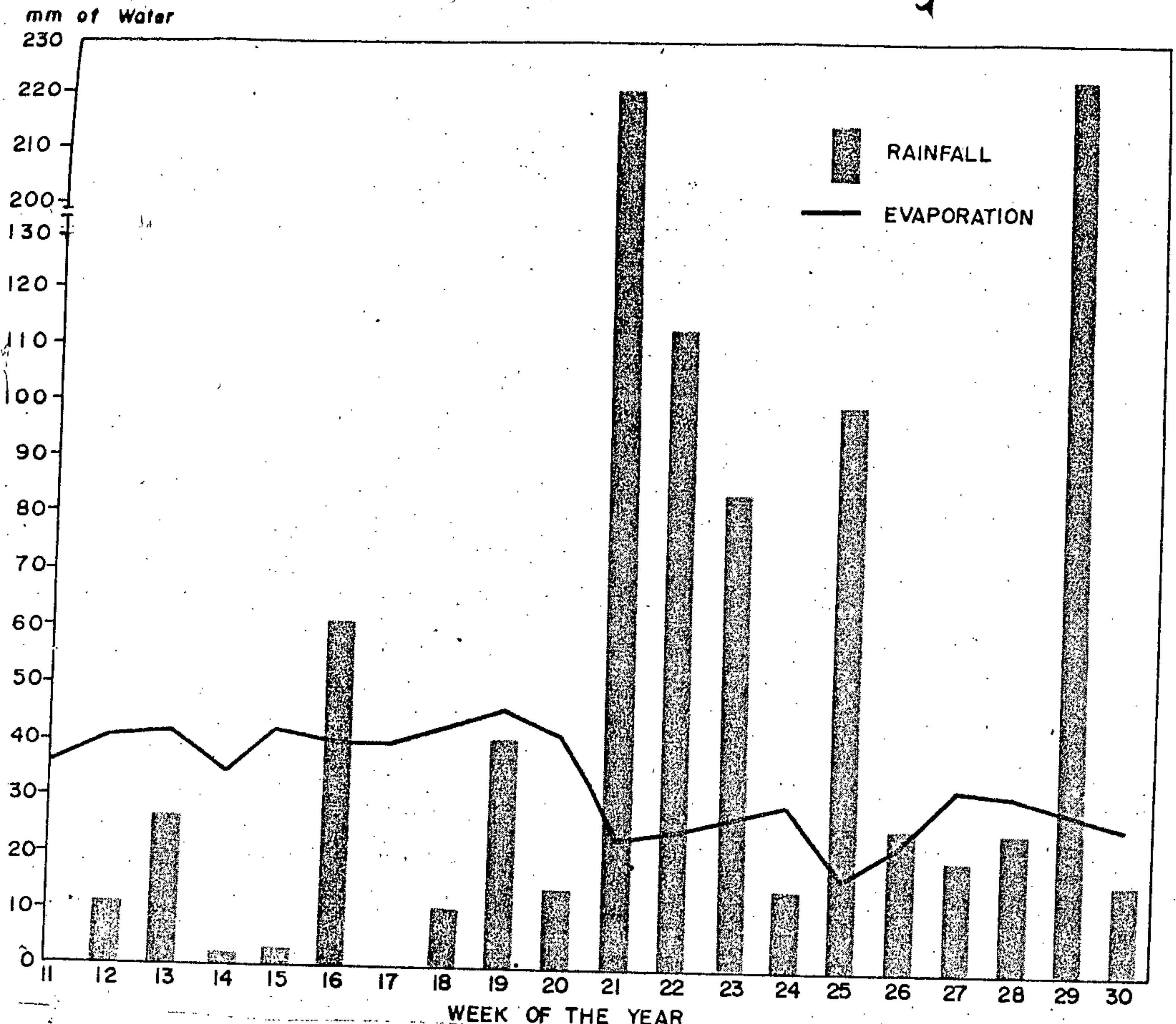

Fig. A.3 Weekly evaporation and rainfall distribution in the last section of G-K Project, Phase-1. Bangladesh.