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WATER CONSERVATION MEASURES IN THE ARID AND SEMI-ARID AREA OF HARD ROCK REGION

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PREFACE

In India 224 million lakh hectares of area out of 329 million lakh hectares of geographical areas is mainly dependant on rainfall. Since 68% land depends on rainfall, it is inevitable that the country has to concentrate much on the development of rainfed areas. Normally, rainfall in dry areas is uneven, erratic and uncertain and scanty. Due to this land has become unfertile and unproductive. Also the growing population pressure, higher demand for food and fodder coupled with impact of rapidly changing socio-economic conditions have influenced the developmental activities of watershed management. In the rural areas, especially the poor farmers are adopting traditional and indigenous soil water conservation measures. The existing soil and water conservation structures are owing to the inadequacies and ineffectiveness in fulfilling the objectives, therefore it is necessary to focus on the technical skills required to construct traditional soil and water conservation structures. But structures in the fields can not be sustained unless they are appropriate and go beyond well built technical assistance.

Karnataka state is characterised by excessive dependence on monsoon and nearly 78% of agricultural land is rainfed. In the present study, Somadevarahatti watershed of Bijapur taluk and Herehalla watershed of Hangund taluk in Bijapur district were considered. The study was carried out with an objective to assess the overall situation of existing soil and water conservation structures and the water resources potential available for the development and management of watersheds, by analysing the annual and monthly rainfall and its distribution over the study area, the status of groundwater occurrence, and the water yield of watersheds. This report entitled 'Water Conservation Measures in the Arid and Semi-Arid Area of Hard Rock Region is prepared by Mr. A. V. Shetty, Scientist 'C', Mr. Dilip G. Durbude, Scientist 'B' and Mr. S. Chandrakumar R. A. of Hard Rock Regional Centre, Belgaum.

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Soil and water, the most valuable natural resources for farming, are not preserved in-situ and conserved for future use owing to the inadequacies and ineffectiveness of the existing structures and measures. With this regard, to assess the overall situation of water resources for the development and management of watersheds, the annual and monthly rainfall and its distribution over the study area, and the status of groundwater occurrence has been analysed. The water yield of watersheds were estimated using SCS method with different initial abstraction conditions and peak discharges were estimated for peak annual rainfall series. Probable maximum one day precipitation and corresponding runoff were also estimated for the design of conservation structures. A survey was carried out in order to find the effectiveness, merits and demerits of the soil and water conservation structures. Recommendations for the improvement of the existing structures were also made.

1.0 Introduction

Water is essential for life on the planet. Water resources have been a decisive factor in the growth and development of human civilisation. With an ever increasing human and animal population, demand on soils for food production has been increasing. The water resources are pre-requisite for any developmental activity and agricultural production. Dynamic nature of the hydrological cycle provides an opportunity to widen the effective resources through appropriate techniques. Among these, most important factors to be considered are soil and water conservation measures which would preserve the land and its fertility on a sustained basis and at the same time promote better agriculture, increase yields and achieve maximum benefits from such lands. Most of the precipitation is lost by way of surface runoff. The uncontrolled runoff causes gully formation and stream bank erosion. Unmanaged lands yield high sedimentation rate resulting in silting up of the riverbeds as well as reservoir beds and hence causing floods in the lower reaches.

In India 224 million lakh hectares of area out of 329 million lakh hectares of geographical areas (KWDP, 1999) mainly depend on rainfall for agricultural purposes. Since 68% land depends on rainfall, it is inevitable that the country has to concentrate much on the development of rainfed areas. Normally, rainfall in dry areas is uneven, erratic, uncertain and scanty. Due to this, land have become unfertile and unproductive. Also the growing population pressure, higher demand for food and fodder coupled with impact of rapidly changing socio-economic conditions have influenced the developmental activities of watershed management. The World Water Council has classified all the water related problems into five groups (G. C. Mishra). These are water scarcity problems, water pollution problems, over exploitation of groundwater, flood disasters and inadequate water resources planning and management. Water and sediments are the end-products of a watershed. Therefore many of these problems can be solved through appropriate watershed development practices. The piecemeal approaches such as contour bunding or terracing on individual holdings or group of farms benefit only marginally because they ignore other areas which are being influenced in their hydrologic characteristics. Such sporadic actions generally fail to attract farmers as they do not yield benefits commensurating effort with efforts and investment made. Thus for maximising the advantages, all developmental activities should be undertaken in a comprehensive way on watershed basis with following principles of watershed management.

1. Utilising the land according to its capacity.
2. Putting adequate vegetal cover on the soil during rainy season.
3. Conserving as much rainwater as possible at the place where it falls.
4. Drain out excess water with a safe velocity, diverting to storage ponds and store it for future use.
5. Avoiding gully formation and putting checks at suitable intervals to control soil erosion and recharge ground water.
6. Maximising productivity of land per unit area, per unit time and per unit of water.
7. Increasing cropping intensity, and land equivalent ratio through inter-cropping and sequence cropping.
8. Safe utilisation of marginal lands through alternate land use systems.
9. Ensuring sustainability of the eco-systems befitting the man-animal-plant-land- water-complex in the watershed.
10. Maximising the combined income from the inter-related and dynamic crop -livestock-tree-labour complex over years.
11. Stabilising total income and cut down risk during adverse weather conditions.

1.1 Watershed Approach

Planning and design of soil and water conservation structures such as bunds and terraces, waterways, grade stabilisation and gully control structures, water harvesting structures etc. are carried out considering peak runoff to be handled by these structures and/or the runoff volume expected; which in turn are determined on the basis of contributing area or the watershed size. It is, therefore, essential to consider watershed as a basis for planning and implementation of the various soil and water conservation programmes. Obviously, planning for water disposal systems for fields, carried out in isolation, is likely to result in repetition of efforts involving sometimes extra expenditure. Based on these considerations, the watershed has been rightly recognised as a convenient unit in planning for overall development of an area. Thus, the concept of watershed management - a holistic approach has emerged (Singh,1990) aiming at optimising the use of land, water and vegetation in an area, so as to provide an answer to alleviate drought, moderate floods, prevent soil erosion, improve water availability, and increase fuel, fodder and agricultural production on a sustained basis. In this programme, the development is not confined just to agricultural lands alone but covers the entire watershed area starting from the highest point (ridge line) to the outlet of the nallah or natural stream. It involves implementation of ameliorative measures on barren hill slopes, marginal lands, privately owned agricultural lands and badly cut nallahs and river courses.

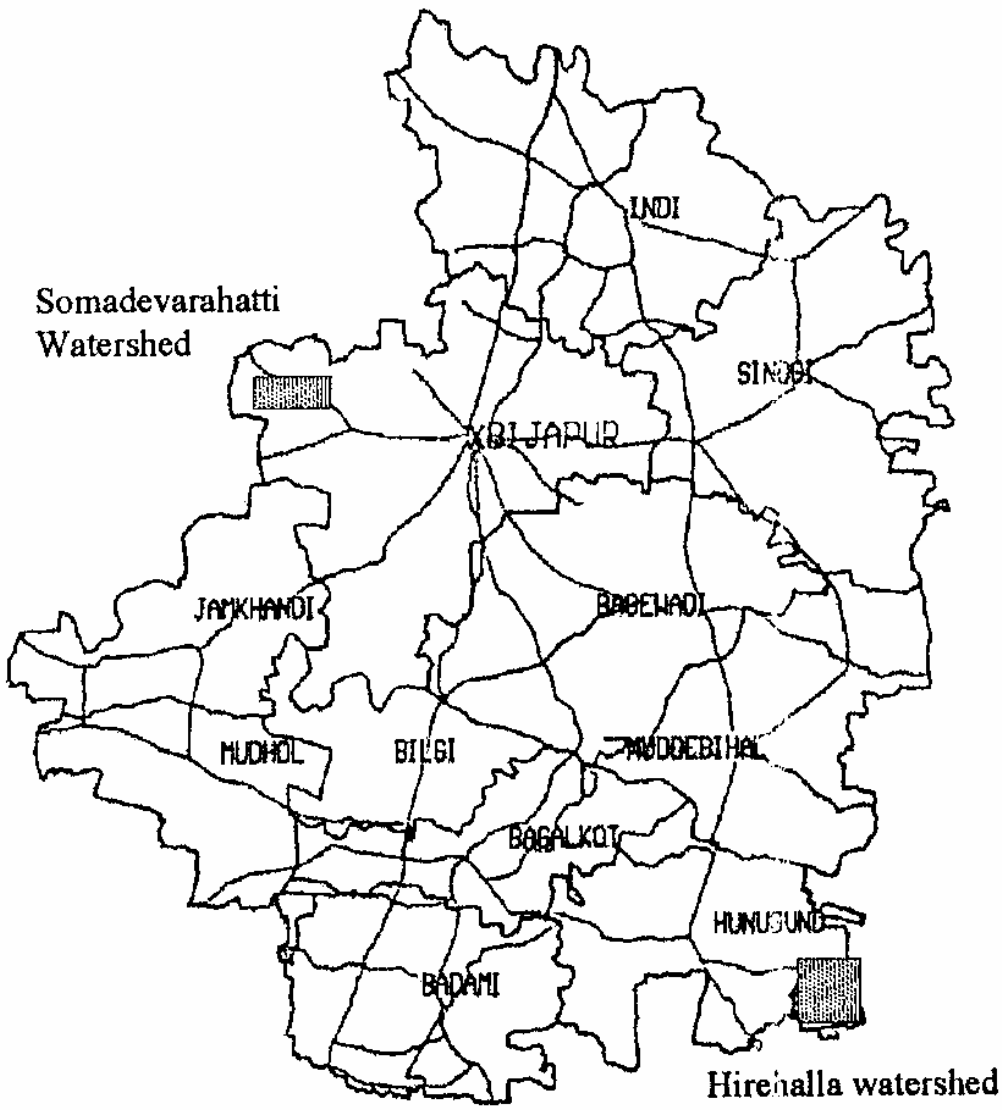
Soil and water conservation practices receive top priority for planning watershed management as they form the foundation for sustainable agriculture. Water resource development stimulates all further developments in the watershed. All attempts to store effectively the rainfall in the soil profile, between the bunds and check dams, and in water storage reservoirs are made so that the rainfall is effectively utilised in the watershed. Subsequently, crop improvement measures such as contour farming, timely implementation of all agricultural operations, adoption of improved varieties etc. are components of the integrated package of watershed management technology. Also alternate land use systems involving forestry, pasture and agro-forestry, are essential as they are good means of stabilising both productivity of drylands and income of dryland farmers. All these measures together will naturally mitigate the severity of drought effects in the catchment and floods in the command areas besides reducing soil erosion and increasing ground water recharge. Watershed management, thus, not only improves the productivity of lands but also acts as an investment in the nation's future. Above all, it also controls erosion of highly degraded lands and leads to the stabilisation of the ecological balance of our environment.

The basic aim of this study is to protect the soils from further deterioration and to conserve the maximum rainwater in the soil profile.

2. 0 Study Area

In the present study, two watersheds have been selected and location of watersheds are presented in figure 1. The Herehalla watershed has a geographical area 2638ha. and the watershed is spread over two villages namely Kandgal and Gonal of Hangund taluk in Bijapur district. The Somadevarahatti watershed is having an area of 2868ha. of Somadevarahatti village in Bijapur taluk. The watersheds are surrounded by hillock with highly sloped sidelines. Slope on the top of the upper reach is less while that the top to the bottom of the hillocks is very steep causing high velocity of the runoff water and severe soil erosion. The soil in this reach is generally very shallow, gravelly and black in colour and in Kandgal watershed where red soils are also found.. Soil in the middle

FIGURE 1. LOCATION MAP



reach is light in texture, medium in depth and black or grey in colour while the lower reach has a relatively deep soil though the texture is light. However, the slope in the lower reach is mild for obvious reasons. In general soils in the watersheds are relatively shallow, highly eroded, light, light textured and poor fertility. The present condition of soils is the consequences of continuous runoff of rainwater, which went uncontrolled for ages.
The undulated topography presents serious problems of water management in crop raising even in the lower reach.

3.0 Methodology

The study was carried out with an objective to assess the overall situation of existing soil and water conservation structures and the water resources potential available for the development and management of watersheds. Keeping the objective of the study in view, the following methodology were adopted for the planning and management, and improvement of soil water conservation structure.

3.1 Rainfall Distribution

Rainfall forms the input in all hydrological studies for a catchment area for which the distribution of rainfall assumes considerable importance. Among the several meteorological factors, rainfall is considered as of utmost importance especially for agricultural activity and water balance components. Besides providing water to the growing crops, rain brings out a favourable change in the climate surrounding the plants thereby promoting active vegetative growth. Apart from the quantum of rainfall, its time distribution also plays a decisive role in the cropping pattern of a particular region and also for the planning and management of watersheds.

The analysis of rainfall trend over the study area is carried out by departure analysis of annual rainfall. The annual rainfall departure analysis is a good indicator of the deviation of the rainfall from the normal rainfall over a period of time. The probability analysis of annual rainfall is useful to predict the relative frequency of occurrence in different group of intervals of annual rainfall.

Probability is a constant characterising a given set of objects or incidents in a particular period. The probability analysis of annual rainfall is useful to predict with reasonable accuracy the relative frequency of occurrence in different group intervals of annual rainfall. It is also possible to work out the percentage probability of occurrence of 75% of annual rainfall or more for identification of drought proneness of the study area. Sarma and Narayana swamy (1982) have computed the coefficients of variation in order to study the distribution of rainfall.

The daily, monthly, seasonal and annual rainfall using different distributions are useful to predict expected rainfall amount in a particular day, month, season and year for desired recurrence interval and per cent of chances to estimate corresponding runoff yield. The Hershfield technique(Dhar and Kamte 1971) normally used to study the extreme value rainfall.

Hershfield used the following equation to find out the PMP value,

$$X_m = \bar{X} + K_m\sigma$$

Where

$\bar{X}$ = Mean of the one day annual maximum series.

σ = Standard Deviation of one day annual maximum series.

X_m = Estimate of one day PMP value for a station

$K_m = (X_L - \bar{X}_{n-1}) / \sigma_{n-1}$

Where,

X_L = Largest value of one day annual maximum series omitting the largest value from the series.

$\bar{X}_{n-1}$ = Mean of the one day annual maximum series omitting the largest value from the series.

σ_{n-1} = Standard deviation of the one day annual maximum series omitting the largest value from the series.

3.2 Groundwater Table Analysis

The change in storage of groundwater in an aquifer is reflected by change in groundwater levels. Groundwater levels are influenced by precipitation, evapotranspiration and discharge from the groundwater reservoir. Usually change in groundwater storage is a seasonal phenomenon and shows a seasonal pattern of fluctuation.

The seasonal water level fluctuations are tested by the statistical analyses to find the trend of groundwater over the several years. The rainfall recharge and discharge condition of the study area is also reflected by the relationships between the water level fluctuation and monthly rainfall. The recharge and discharge of groundwater table is influenced by soil cover and its characteristics, weathered rocks at the surface, open joints etc. The future development of watershed is mainly dependant on the recharge and exploitation condition and the overall trend of the groundwater table in the watershed either for surface water conservation or conservation for recharging groundwater resources.

3.3 Surface Water Potential

The assessment of the surface water potential is essential for the watershed development planning and management. The assessment quantities such as total water yield from the watershed, and peak discharges are required to design tanks, bunds, waste weirs and other conservation structures. In order to design a water conservation structure, the peak rate of surface runoff due to a rainstorm of a specified frequency can be determined by the rational methods when the watershed area is less than 800 hectares (Shukla M. K.). The Soil Conservation Service (SCS) procedure of soil and cover conditions is perhaps more appropriate for the design of water conservation structures.

3.3.1 SCS Method

The SCS method is widely used because it is a reliable procedure that has been used for many years in different parts of the world. It is computationally efficient, the required inputs are generally available, and it relates runoff to soil type, land use and management practices.

The soil moisture accounting and volume of runoff depend on both meteorologic and watershed characteristics. The precipitation volume is probably the single most important meteorological characteristic in estimating the soil moisture storage. The soil type, land use and hydrologic condition of the cover are the watershed factors that will have the most significant effect on soil moisture storage.

The SCS has developed an index, which is called the runoff curve number (CN) to represent the combined hydrologic effects of soil, land use, agricultural land treatment class, hydrologic condition, and antecedent soil moisture. The SCS has defined soil classification system that consists of four hydrologic groups according to their minimum infiltration rate obtained for a bare soil after prolonged wetting. The groups are identified with the letters A, B, C, and D and the soil characteristics associated with the each group have been determined. The hydrologic soil groups (SCS, 1972) are:

Group A: Soils having high infiltration rates (low runoff potential)

Group B: Soils having moderate infiltration rate

Group C: Soils having slow infiltration rate, and

Group D: Soils having very slow infiltration rate (high runoff potential)

Apart from the soil, infiltration rate is also governed by the type of vegetation cover. Dense vegetation cover induces high infiltration rates. Furthermore, infiltration rate will continue to vary till soil moisture reaches saturation point. In other words, dry soil has higher infiltration than wet soil even though soil type and the vegetation cover remain the same. The antecedent moisture condition(AMC) is divided into three classes, namely AMC class I, AMC class II and AMC class III which represents dry, damp and wet soil moisture conditions respectively. The quantitative definition of AMC classes for a particular day is based on the total rainfall for the previous five days. The quantitative definition of these classes for a particular day given in the table 1.

Table: 1. Antecedent moisture condition classes

Sl. No.	AMC Class	5 days total antecedent rainfall (mm)	
		Dormant Season	Growing Season
1	I	< 13	<36
2	II	13 to 28	36 to 53
3	III	>28	>53

For practical use, curve numbers (CN) are converted into potential maximum retention(S) by the relation

$CN = (25400)/(S + 254)$ or $S = (25400)/(CN) - 254$

Where, S is in millimetres.

The storm runoff is estimated by the following equation;

$Q = (P - 0.2S)^2 / (P + 0.8S)$ Where as $Ia = 0.2S$

The initial abstraction (Ia) is related to S by the following equations (Ministry of Agriculture, 1972) which are modified from the original equations of the USDA, SCS method for the following soils.

$Ia = 0.1S$ for black soil (AMC II and AMC III)

$Ia = 0.3S$ for black soil (AMC I)

Ia = 0.3S for all other soils.

$Q = (P - 0.1S)^2 / (P + 0.9S)$ for black soil (AMC II and AMC III) and $P > 0.1S$

$Q = (P - 0.3S)^2 / (P + 0.7S)$ for black soil (AMC I) and for all other soils(AMC I, AMC II and AMC III) and $P > 0.3S$.

The daily rainfall series may be used obtain daily runoff series which can be integrated to arrive annual yield of the watershed. Also different probability levels of runoff can be estimated based upon the daily rainfall using SCS method in order to find out the dependability of runoff for the total capacity of storage and design of soil water conservation structures. The SCS method can also be used to estimate the probable maximum runoff (PMR) from daily and annual probable maximum precipitation (PMP) series. The return period of PMR annual series may be used in fixing the capacity of storage and daily series in design of SWC structures and its outlets.

3.4 Field Survey

Field survey is aimed to get specific information for indigenous soil water conservation structures, rainfall pattern, groundwater level status and flood situation from the land holders. The sample of questionnaire is given at annexure-I. It comprises detailed collection of information about the watersheds for further analysis and recommendations. The feedback from farmers on rainfall pattern, flow pattern of nala, flooding situation is used to analyse the status of surface water in the watershed and to ascertain whether direct runoff is draining out of the watershed without utilising the available surface water resources. The information on groundwater table of the area gives an idea on the groundwater status and recharging pattern in various years. In case sufficient groundwater recharging is not taking place, and a considerable amount of surface runoff taking place out of the watershed, there is a need of harnessing water within the watershed by soil and water conservation structures. The main aim of the survey is to assess the effectiveness of existing indigenous SWC structures and to draw some recommendations for the further improvement and efficient use of the structures.

4.0 Analysis and Results

Soil and water, the most valuable natural resources for farming, are not preserved in-situ and conserved for future use owing to the inadequacies and ineffectiveness of the existing structures and measures. With this regard, to assess the overall situation of water resources two watersheds were selected, one in Hangund taluk of Kandgal village namely Hirehalla watershed and another in Bijapur taluk of Somadevarahatti watershed of same village under Bijapur district. The rainfall and its distribution over the study area, the status of groundwater occurrence/potential and surface runoff have been estimated and analysed. The survey has been carried out on soil and water conservation structures to find the effectiveness of the structures. Recommendations for the improvement of the existing structures have been suggested.

4.1 Rainfall Analysis

Annual rainfall in Somadevarahatti watershed ranges from 174.0mm to 910.0mm. Normal rainfall is estimated for 22 years. The statistical analysis is presented in the table 2, for Somadevarahatti watershed. The overall situation of rainfall distribution over the years were reasonably dependable.

Table: 2. Annual Rainfall Distribution Somadevarahatti Watershed

Watershed: Somadevarahatti Village: Somadevarahatti			Taluk: Bijapur R. G. Station: Tikota		
Mean/Normal (mm)	S.D (mm)	C. V	Coef. of Asymmetry	Prob. Of Occurrence of 75% normal	Prob. of Occurrence of 50% normal
399.0	192.0	0.483	0.966	65	89

Rainfall is distributed from May to October and maximum is during the months of June, July and September. The range of rainfall in Somadevarahatti watershed for rainy months is presented in the table 3.

Monthly distribution of rainfall in Somadevarahatti watershed from 1972-1994 are plotted as shown in the figures from 2 to 9. There was no distinct trend found for the monthly rainfall over the years. The monthly rainfall were also used for the statistical distribution and presented in the table 3.

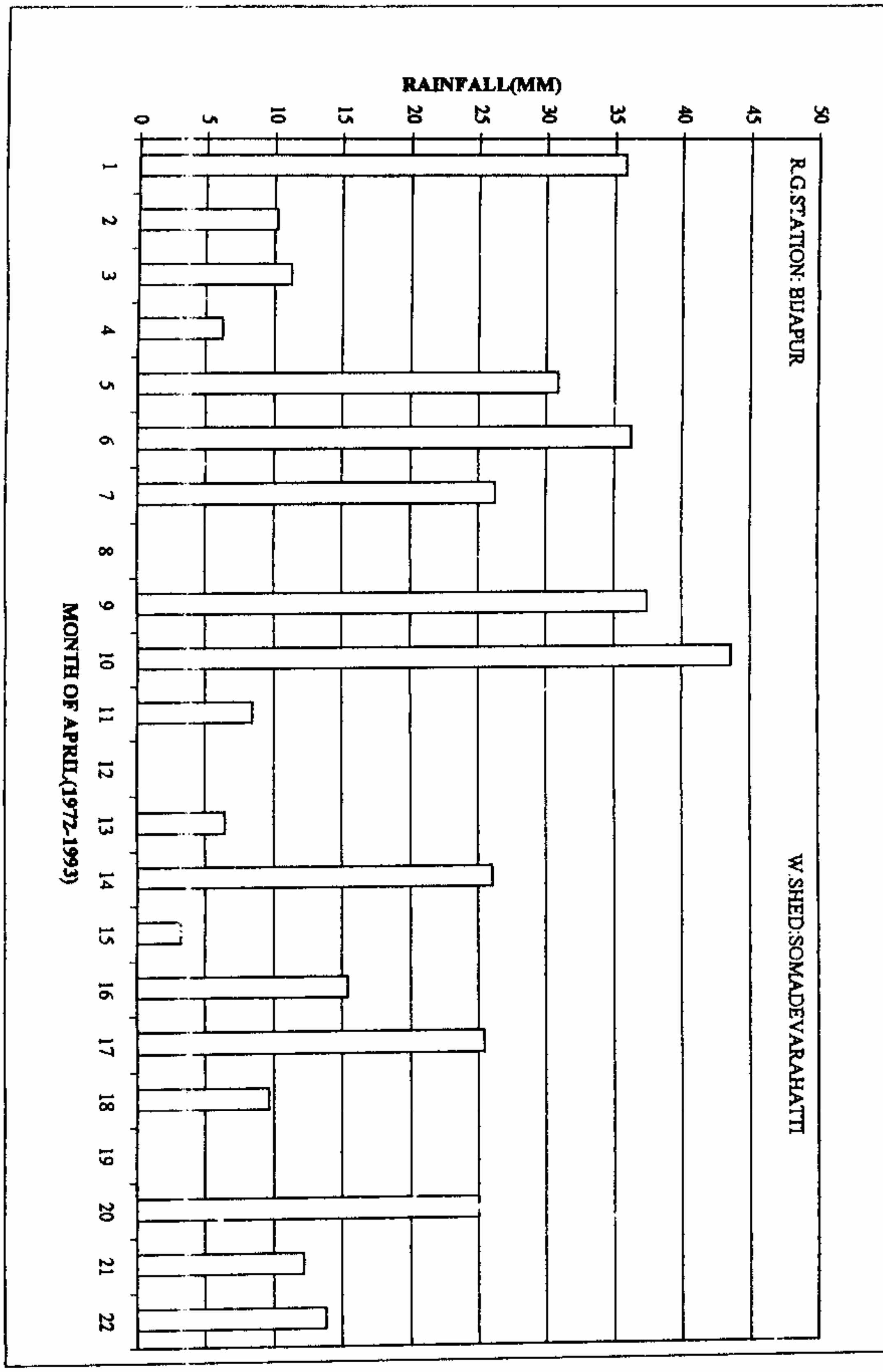


FIGURE: 2. DISTRIBUTION OF MONTHLY RAINFALL

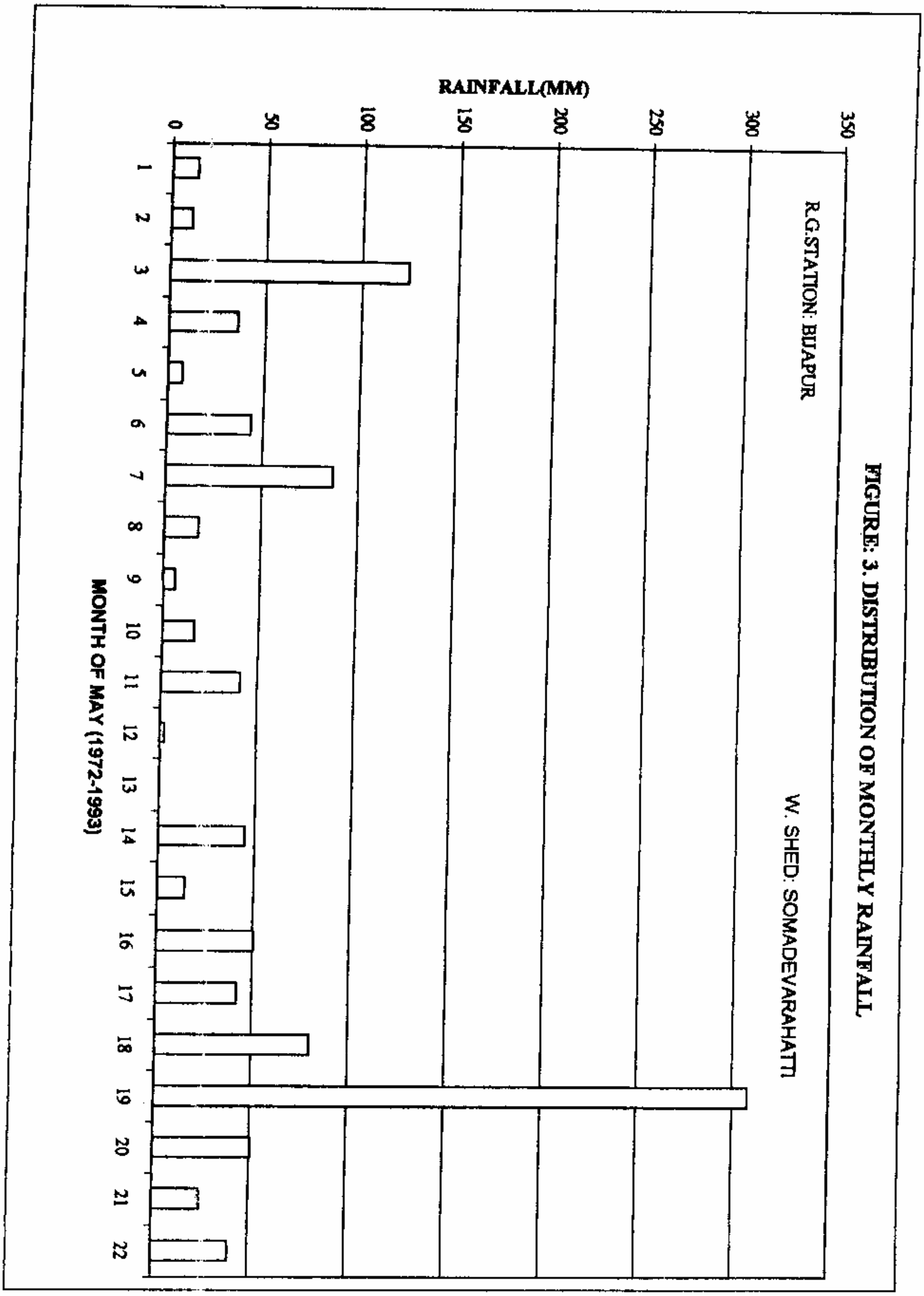


FIGURE: 3. DISTRIBUTION OF MONTHLY RAINFALL
R.G.STATION: BIJAPUR
W. SHED: SOMADEVARAHATTI
RAINFALL(MM)
0
50
100
150
200
250
300
350
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
MONTH OF MAY (1972-1993)

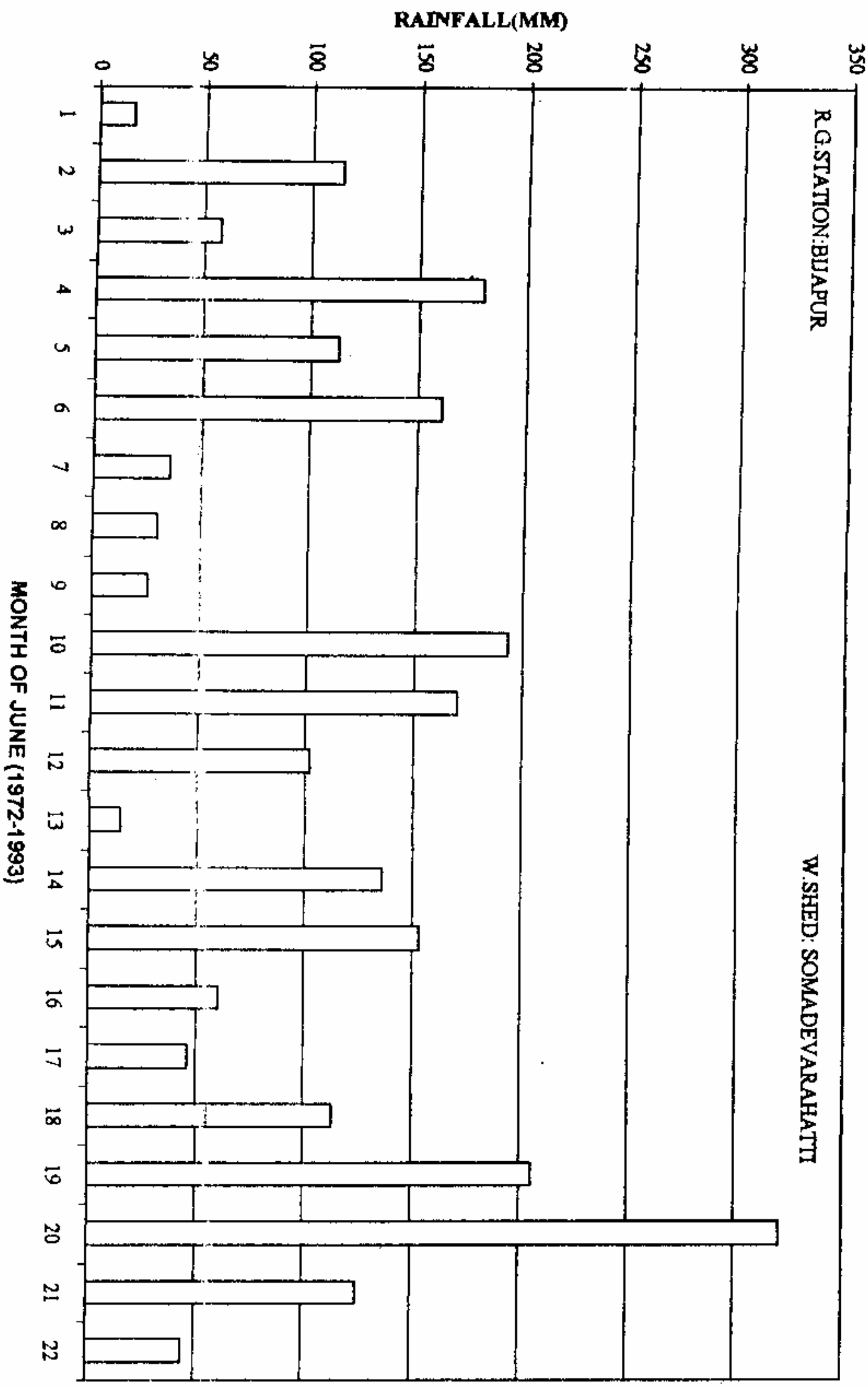


FIGURE: 4. DISTRIBUTION OF MONTHLY RAINFALL

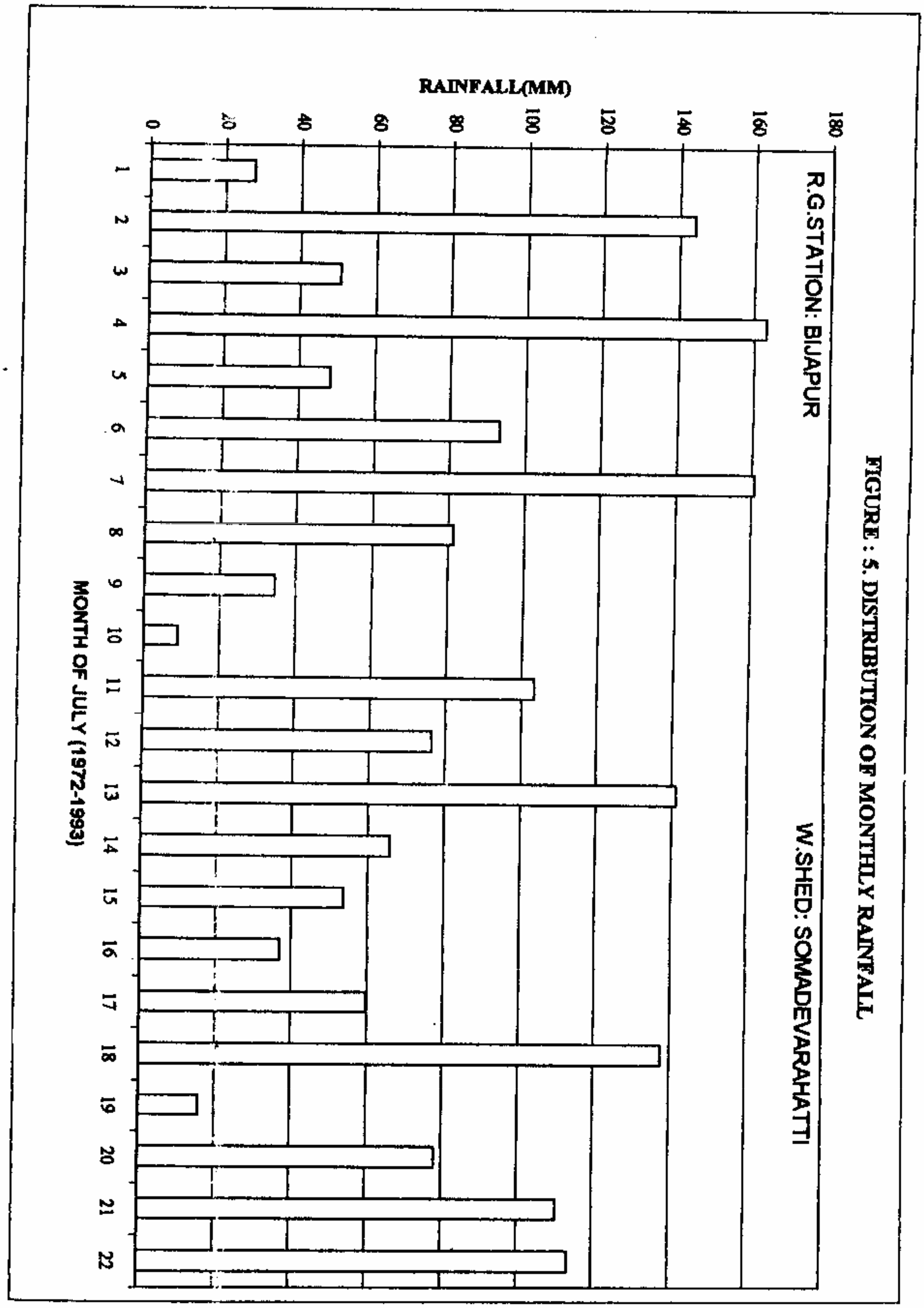
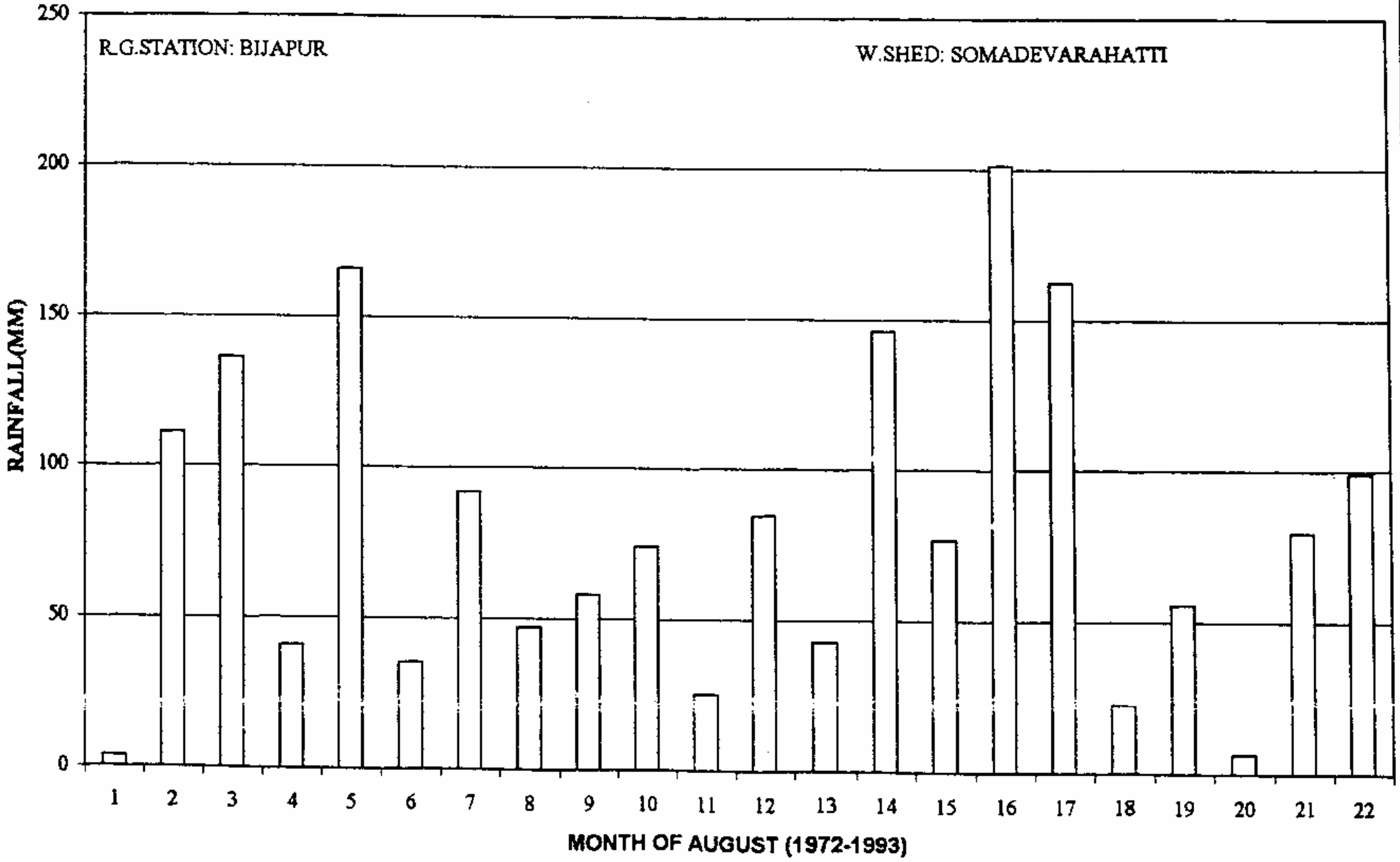


FIGURE : 5. DISTRIBUTION OF MONTHLY RAINFALL

FIGURE : 6. DISTRIBUTION OF MONTHLY RAINFALL



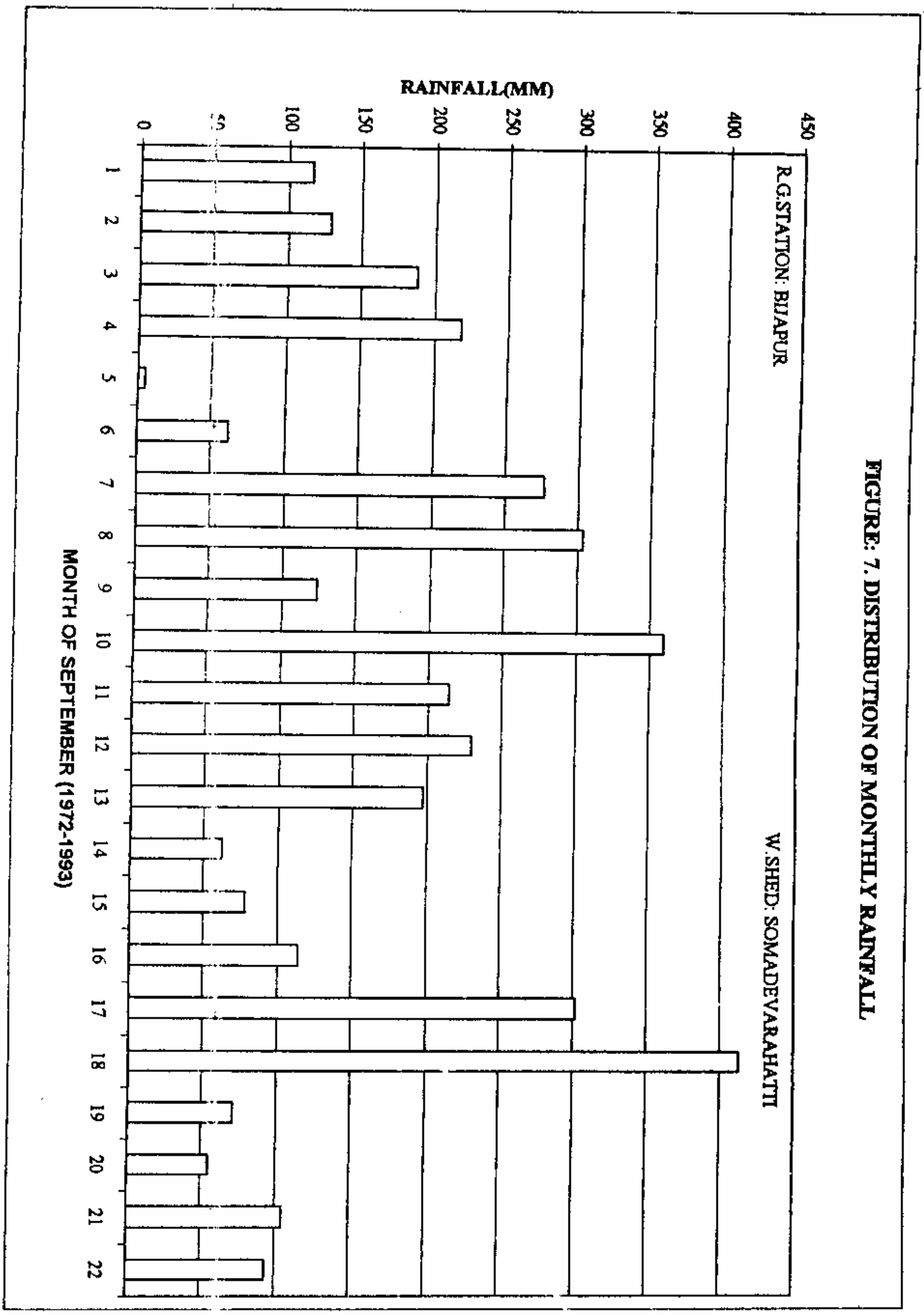


FIGURE: 7. DISTRIBUTION OF MONTHLY RAINFALL

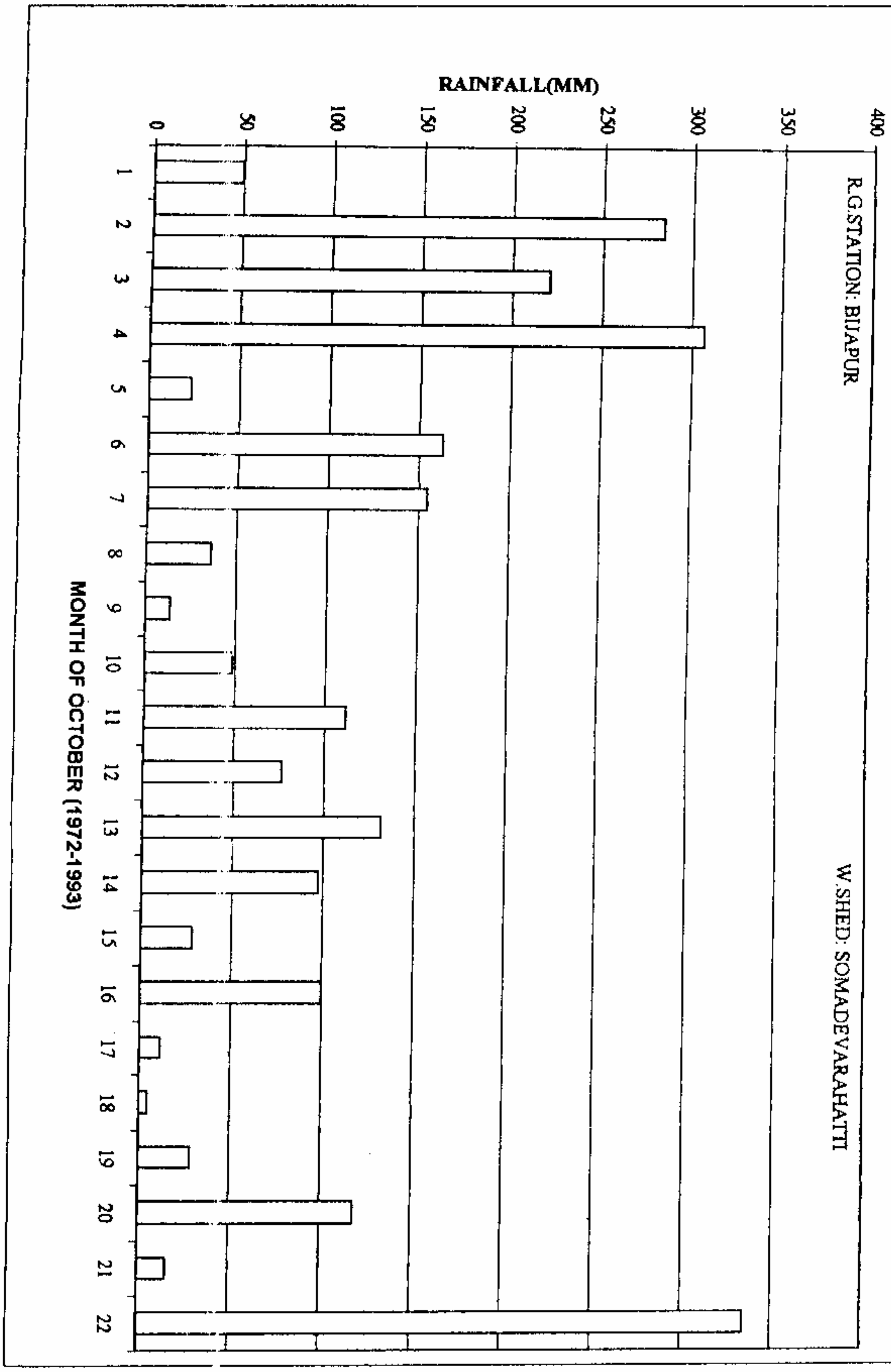


FIGURE: 8. DISTRIBUTION OF MONTHLY RAINFALL

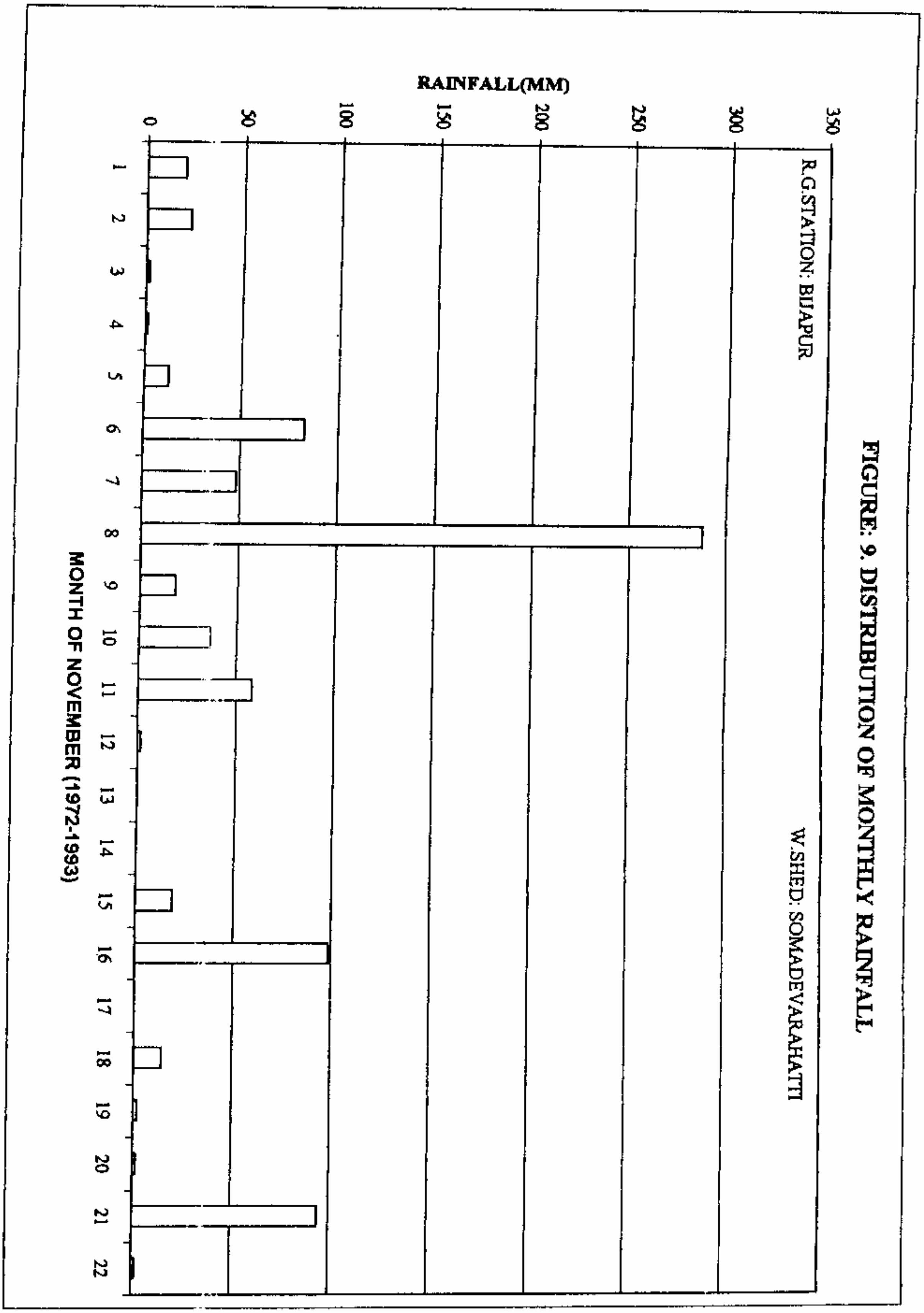


FIGURE: 9. DISTRIBUTION OF MONTHLY RAINFALL

Table: 3. Statistical Value of Monthly Distribution of Rainfall in Somadevarahatti Watershed

Month	Rainfall Range (mm)	Mean (mm)	% of Normal R-Fall	S.D (mm)	C. V	Coef. of Asymtry.	Prob. of Occurrence of 75% normal	Prob. of Occurrence of 50% normal
May	0-307	15.0	4.00	22.3	1.48	2.96	43.0	56.0
June	15-327	81.0	20.0	86.0	1.06	2.13	48.0	65.0
July	9-163	57.0	14.0	44.0	0.76	1.53	52.0	76.0
August	4-201	45.0	11.0	47.0	1.06	2.13	48.0	65.0
September	5-413	123.0	31.0	97.0	0.79	1.58	51.0	68.0
October	4-335	51.0	13.0	66.0	1.29	2.58	45.0	60.0

It can be noticed from the Standard deviation, Coefficient of variation and Coefficient of asymmetry in all the rainfall months, that the distribution of rainfall is highly scattered and not dependable on monthly basis. Finally it is to say that monthly rainfall is erratic and not dependable in nature. The erratic nature of monthly rainfall distribution may not result in proper utilisation of the available surface water resources. Daily rainfall statistical analysis were also carried out and it is found to be highly erratic distribution in nature as the coefficient of variability varies from 1.50 to 4.50 and coefficient of asymmetry from 3.2 to 8.8. The present erratic nature of monthly and daily rainfall distribution owing to the need of water conservation structures.

Rainfall of Kandgal raingauge station was considered from 1973-1994 for

Hirehalla watershed. The rainfall over the years, ranges from 126.0mm to 1127.0mm. Normal rainfall estimated for 22 years is 422.0mm. . The statistical analysis for annual rainfall is presented in the table 4. The overall situation of rainfall distribution over the years are reasonably dependable.

Table: 4. Annual Rainfall Distribution Hirehalla Watershed

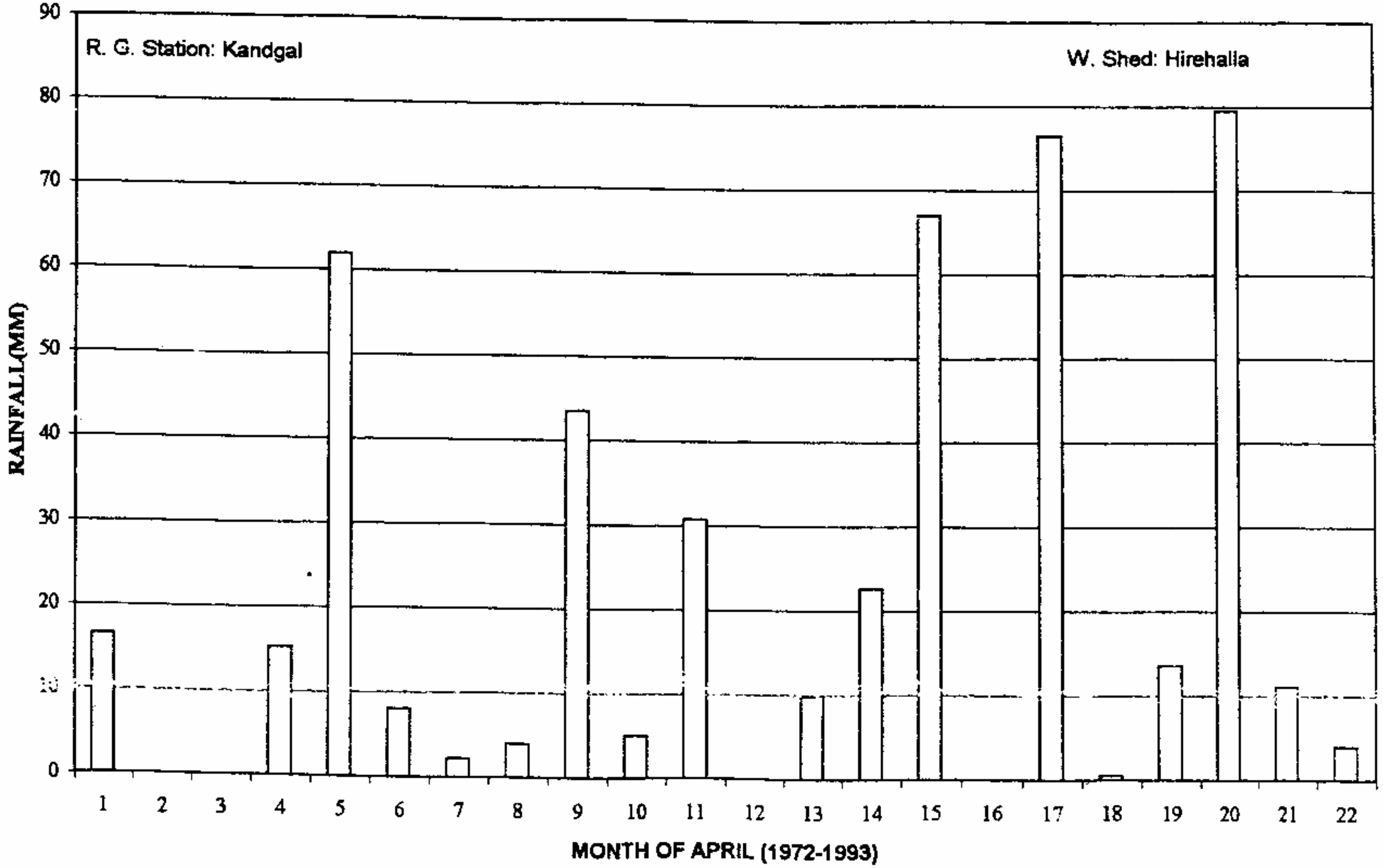
Watershed: Hirehalla			Taluk: Hangund		
Village: Kandgal			R. G. Station: Kandgal		
Mean/Normal (mm)	S.D (mm	C. V	Coef. of Asymmetry	Prob. of Occurrence of 75% normal	Prob. Of Occurrence of 50% normal
422.0	230.0	0.544	1.089	70	79

Rainfall is distributed from April to November and maximum is during months of June, July, August, September and October. Rainfall range of rainy months were presented in the table 5. Monthly distribution of rainfall from 1972-1994 were plotted as in the figures from 10 to 17. There is no clear monthly rainfall trend over the years found from the figures.

The monthly rainfall were also used for the statistical distribution and presented in the table 5.

It is noticed that from Standard deviation, Coefficient of variation and Coefficient of asymmetry in all the rainfall months, the distribution of rainfall is highly scattered and not dependable on monthly basis. Daily rainfall statistical analysis were also carried out and it is found to be highly erratic distribution in nature as the coefficient of variability varies from 1.70 to 4.50 and coefficient of asymmetry from 4.5 to 6.9. Finally it can be concluded that, annual distribution of rainfall is reasonably dependable, however monthly and daily distribution is erratic and not dependable

FIGURE: 10. DISTRIBUTION OF MONTHLY RAINFALL



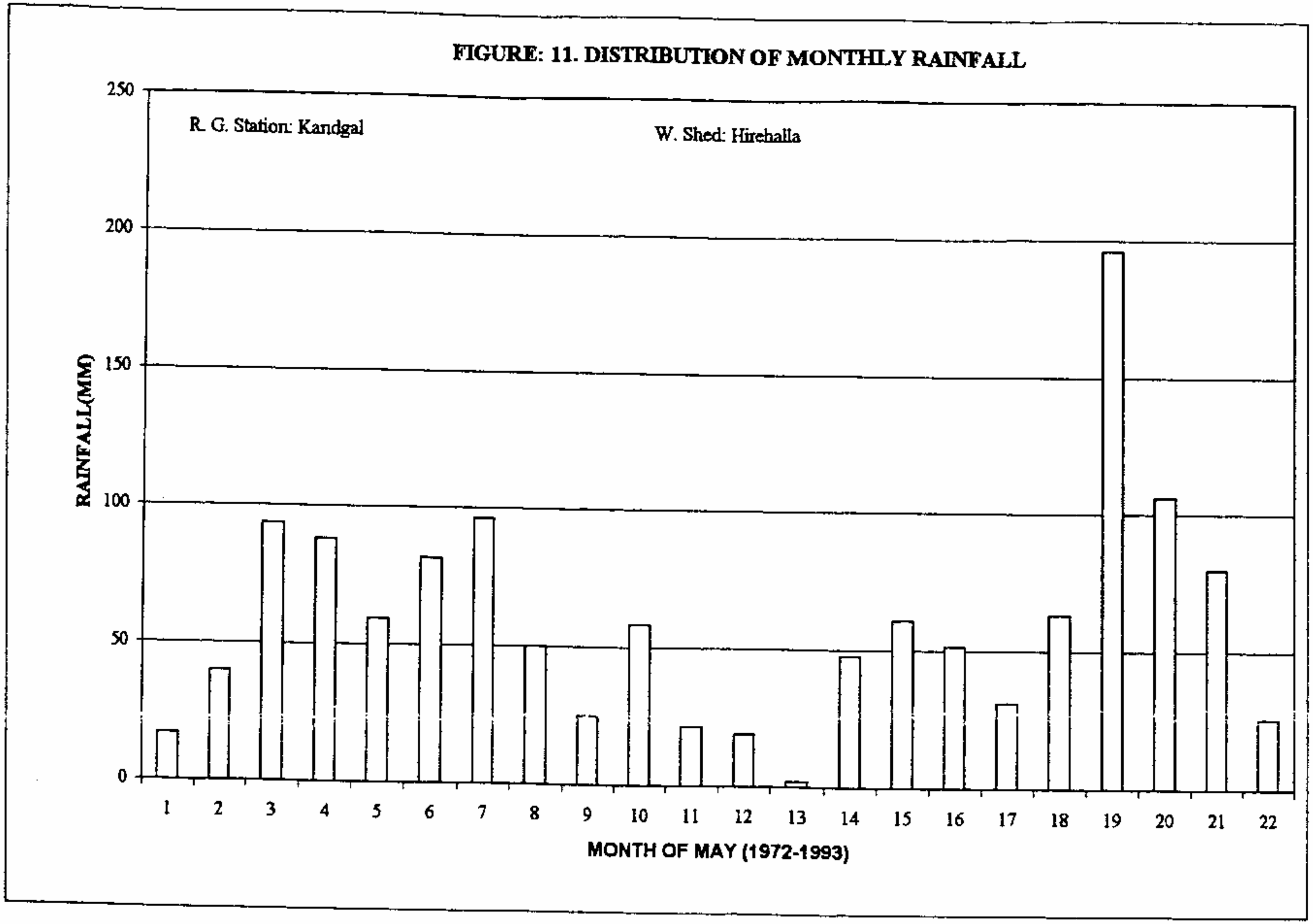
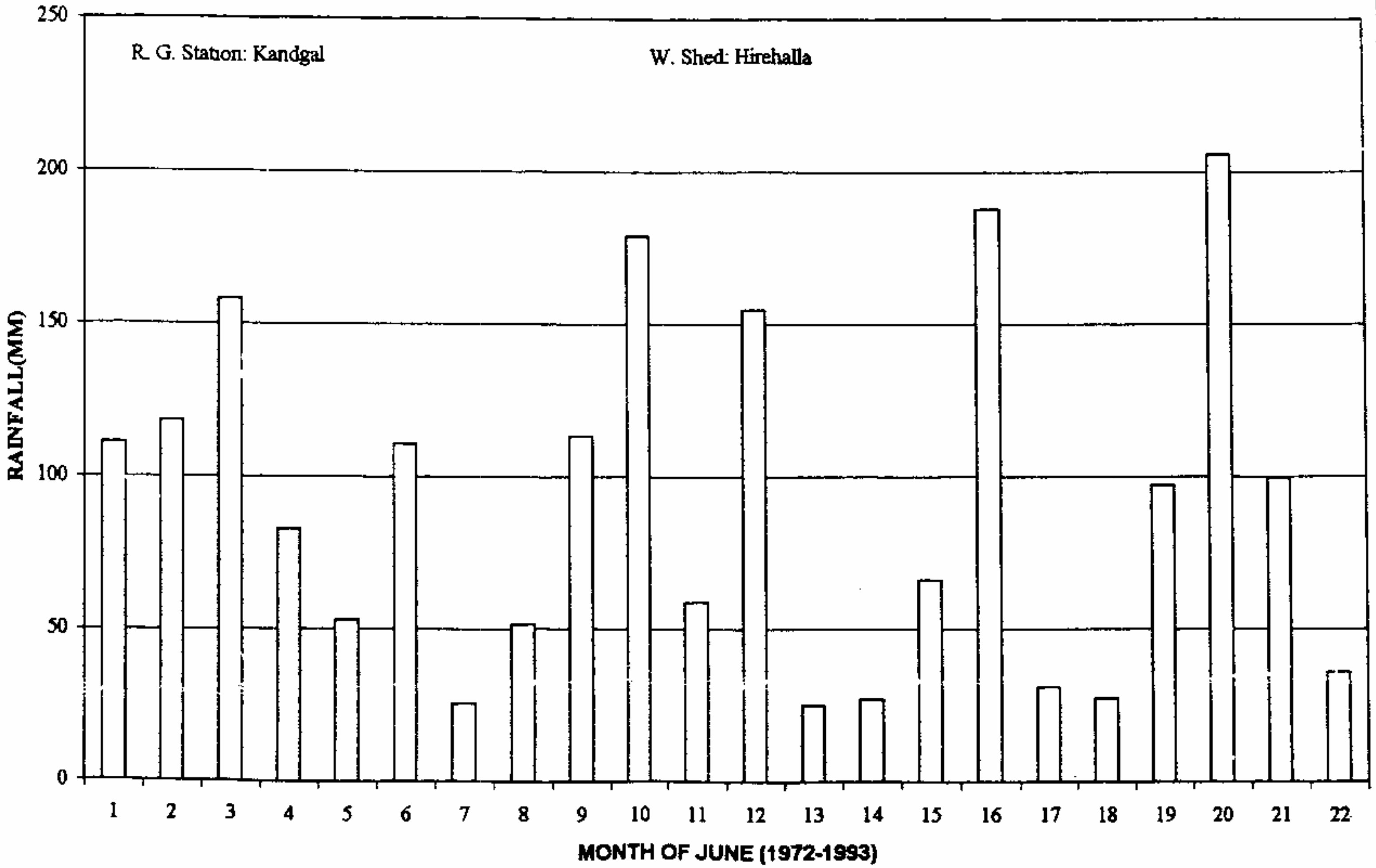


FIGURE: 11. DISTRIBUTION OF MONTHLY RAINFALL
R. G. Station: Kandgal
W. Shed: Hirehalla
RAINFALL(MM)
0
50
100
150
200
250
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
MONTH OF MAY (1972-1993)

FIGURE: 12. DISTRIBUTION OF MONTHLY RAINFALL



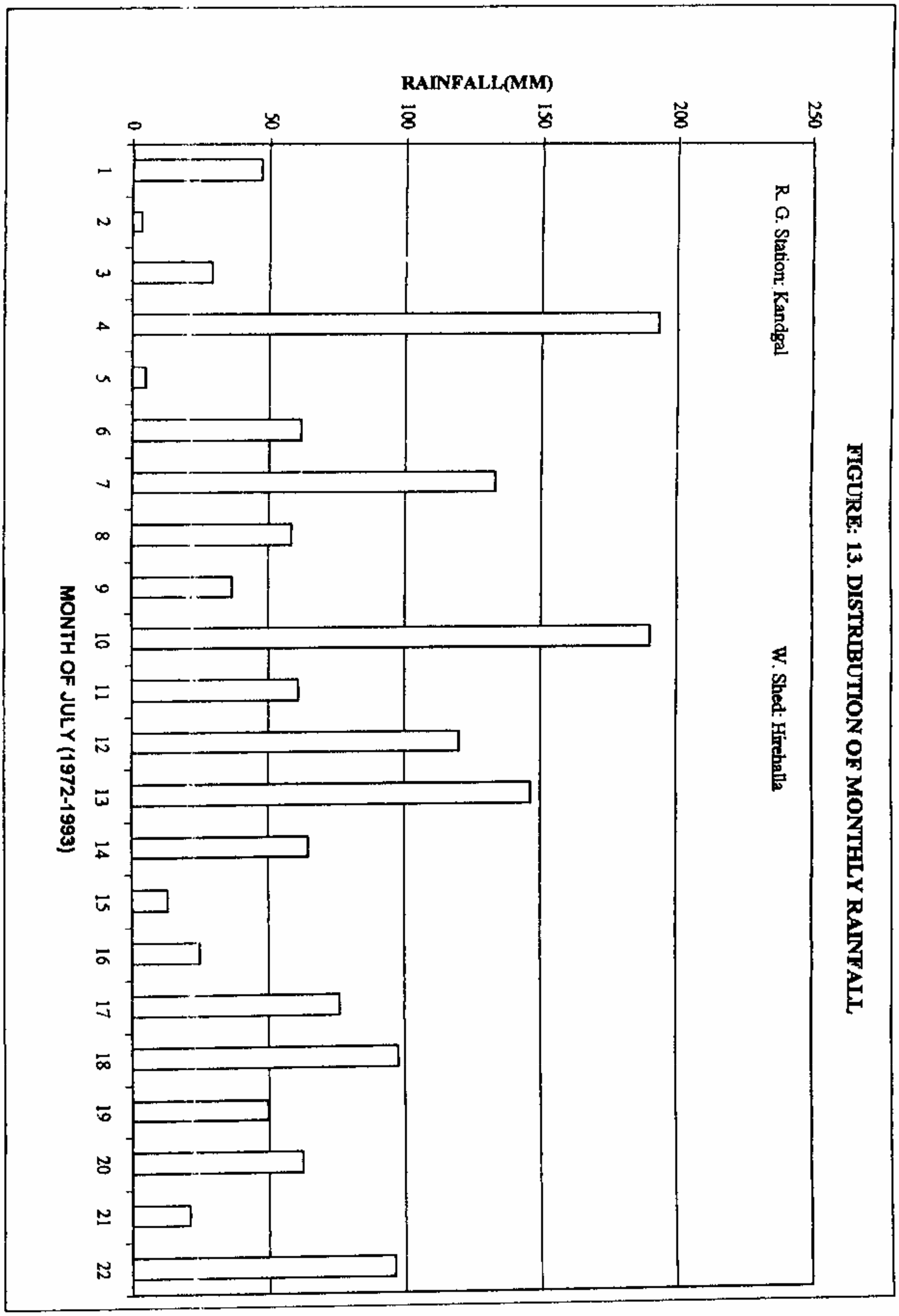


FIGURE: 13. DISTRIBUTION OF MONTHLY RAINFALL
R. G. Station: Kandgal
W. Shed: Hirehalla
RAINFALL(MM)
0
50
100
150
200
250
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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21
22
MONTH OF JULY (1972-1993)

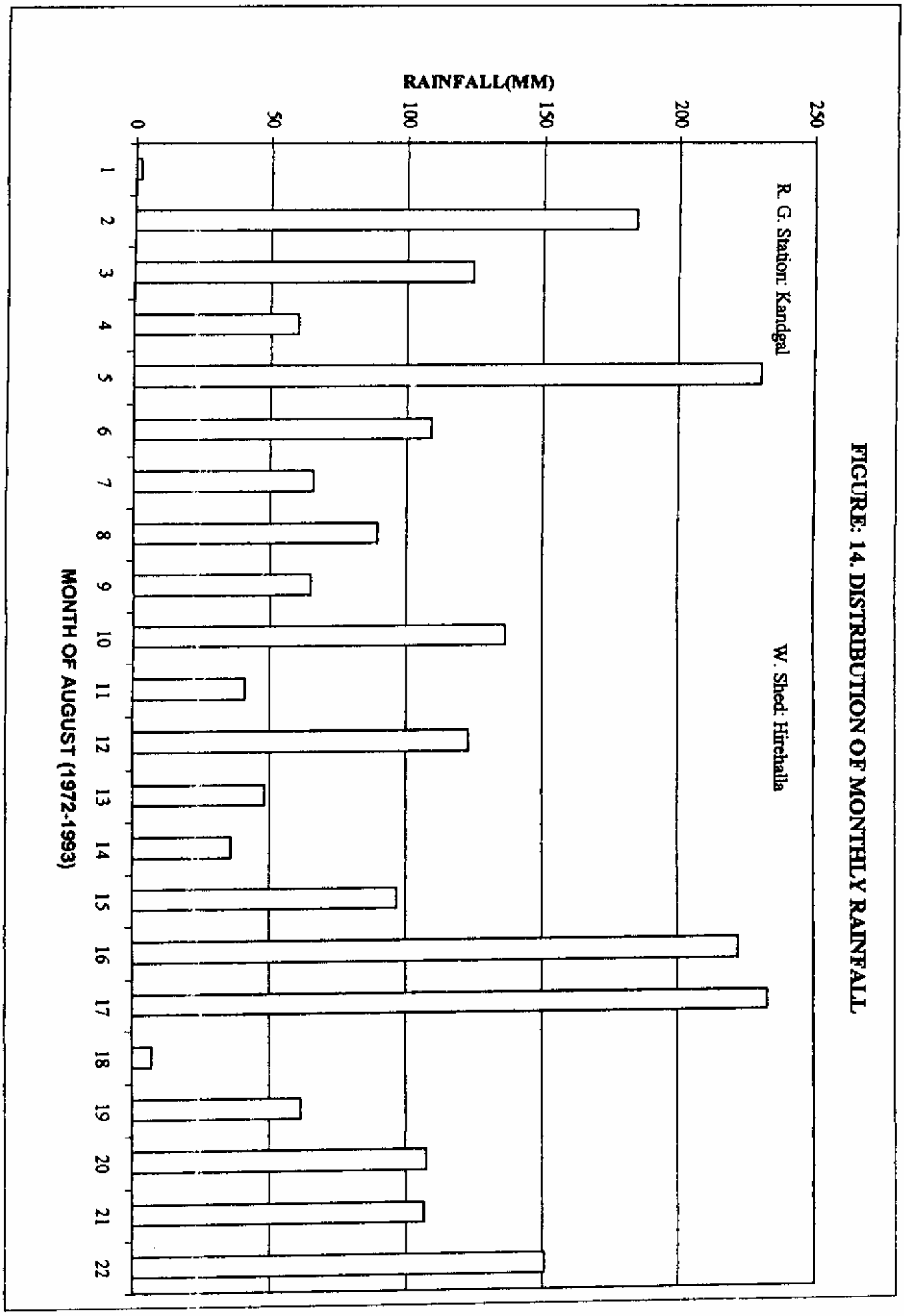


FIGURE: 14. DISTRIBUTION OF MONTHLY RAINFALL

FIGURE: 15. DISTRIBUTION OF MONTHLY RAINFALL

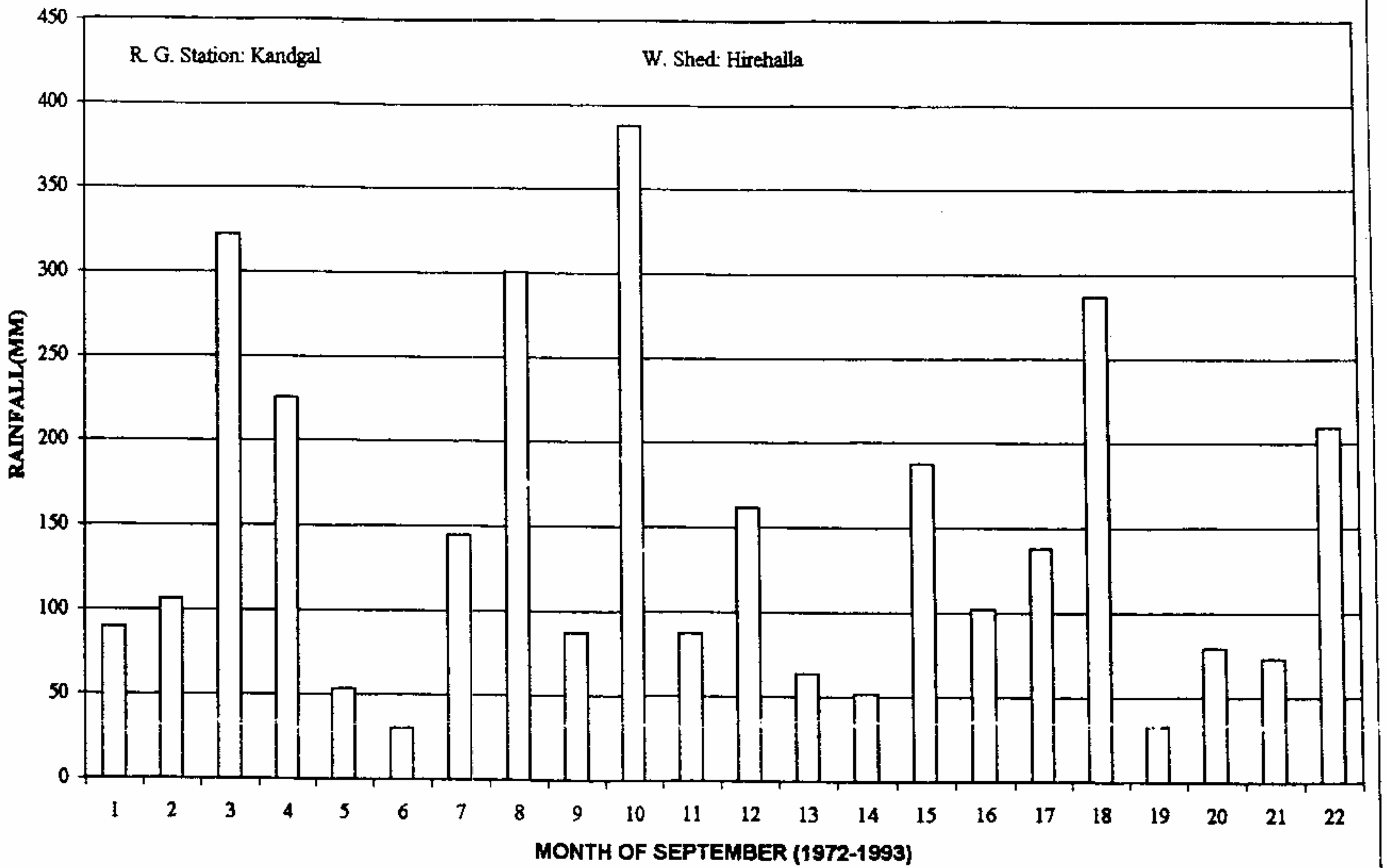


FIGURE: 16. DISTRIBUTION OF MONTHLY RAINFALL

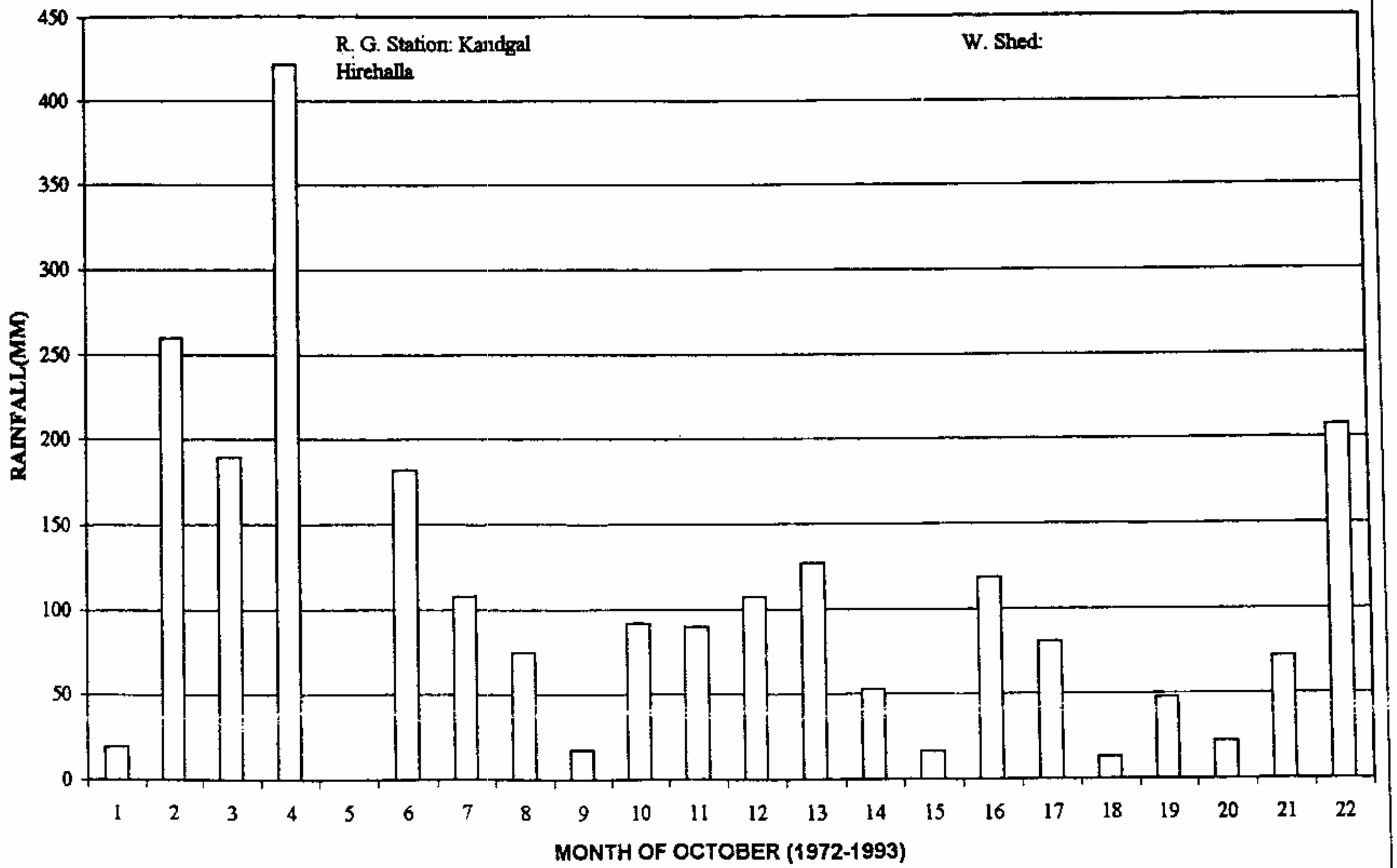
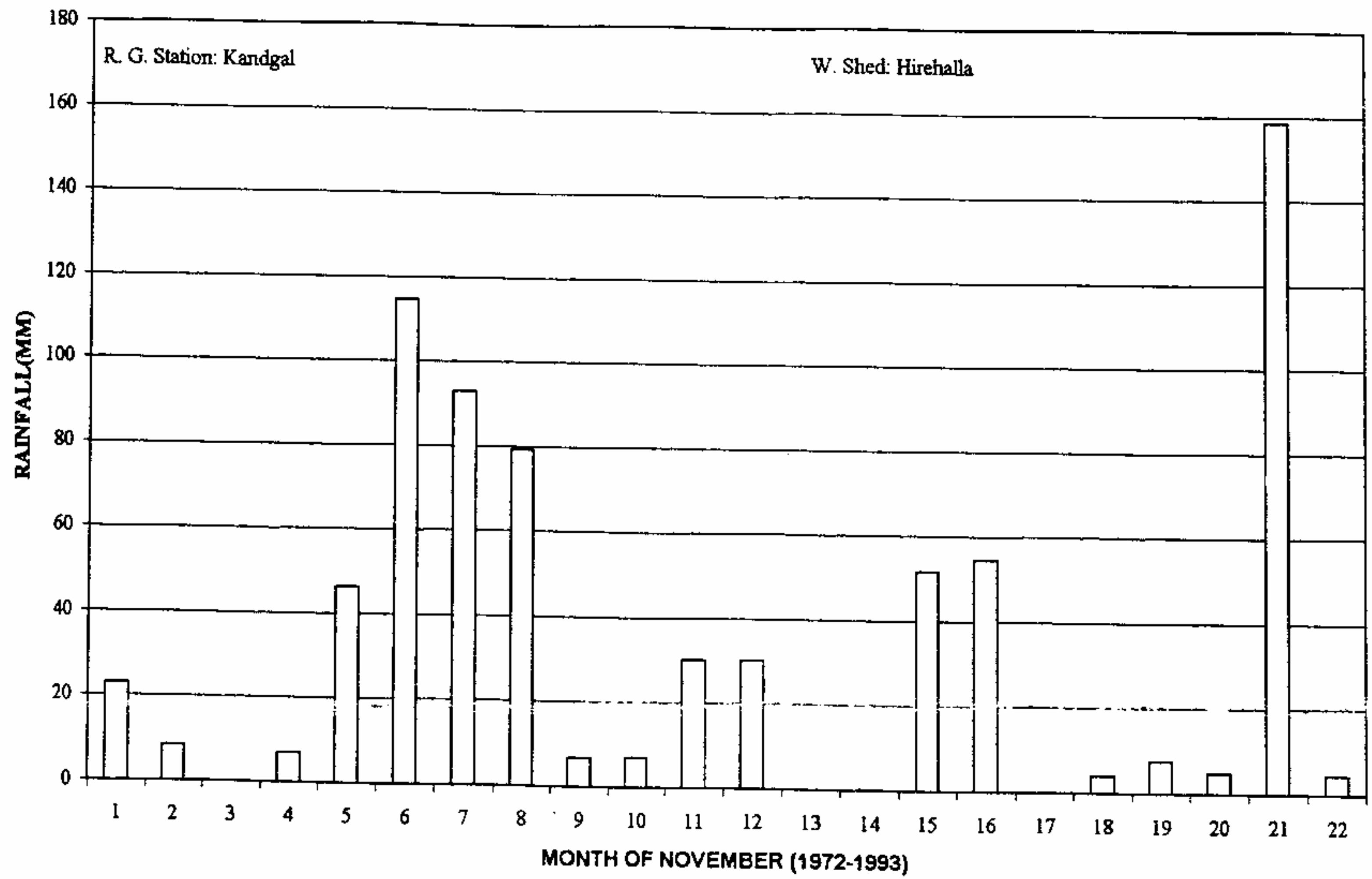


FIGURE: 17. DISTRIBUTION OF MONTHLY RAINFALL



Due to untimely monthly and daily rainfall, farmers may not be able to effectively utilise rainwater and hence there is a need of conservation of rainwater when it is surplus.

Table: 5. Statistical Value of Monthly Distribution of Rainfall Hirehalla Watershed

Month	Rainfall Range (mm)	Mean (mm)	% of Normal R-Fall	S.D (mm)	C. V	Coef. of Asymty.	Prob. Of Occurrence of 75% normal	Prob. of Occurrence of 50% normal
April	0-80	13.0	3.00	18.0	1.40	2.81	41.0	46.0
May	2-196	36.0	8.00	38.0	1.06	2.13	44.0	58.0
June	27-205	55.0	13.0	65.0	1.18	2.37	38.0	49.0
July	3-193	38.0	9.00	31.0	0.83	1.66	57.0	74.0
August	2-233	75.0	18.0	55.0	0.74	1.48	61.0	64.0
September	30-387	98.0	23.0	93.0	0.94	1.89	39.0	61.0
October	0-421	85.0	20.0	113.0	1.32	2.65	36.0	55.0
November	0-115	14.0	3.00	25.0	1.82	3.64	32.0	35.0

4.2 Groundwater Analysis

a. Somadevarahatti Watershed

The fractured zones are prominent in the area. There are number of bore wells drilled upto 300ft. depth. However, water table varies from 60 to 250ft.. Daily draft from the well is about 3-8 hrs a day with an energised motors of capacity from 3HP to 5HP. Only during the later part of the summer, piezometric level s go down. There are number of open wells in the weathered zone with total depth upto about 50ft., without lining. The normal size of the well diameter is 20 to 30 ft. or length 30-60ft. and width from 20-30ft.

The existing minor irrigation tank has an influence on the wells which are in the downstream of the tank. However, one month after the emptying of tank, wells also get dried. However, the tank has no influence on the bore well located near to the tank. Groundwater table has been improved after the construction of check dams/bhandaras. The statistics of number of wells, type of wells, and its features has been presented in table 6 for Somadevarahatti watershed.

Table: 6. Status of existing wells. **Village: Somadevarahatti**

Type of Well	Nos.	Size in ft.			Depth In Ft.	W.T Level in ft.	Pmg. Hours	Draft Power HP
		Dia	L	W				
Open Well	100	30	30-60	20-30	30-75	20-75	3-6	3-6
Bore Well	200	6"	-	-	250 -300	60 -300	4-6	3-7.5

Monthly data from 1973 to1994 is available for Tikota observation well which is only the observation well close to Somadevarahatti watershed. Minimum water levels are noticed generally in the month of May and maximum in the month of October. The fluctuation of water table varies from about 0 to 9m. The maximum and minimum water levels in a year were plotted over the years (1973-1994) as presented in the figure 18. The general trend of recharge and exploitation on water table level over the years were identified. It is also noticed from the figure that minimum and maximum water table follows same trend.

The monthly rainfall and water table levels have been plotted for few years (1974, 1979, 1982, 1990 and 1993) to understand the impact of monthly rainfall over recharge status of the groundwater from figure 19 to 23. From these figures, it shows that the recharge conditions of groundwater table were not having clear relationship with monthly rainfall in the later years. It may be attributed to the exploitation condition of groundwater.

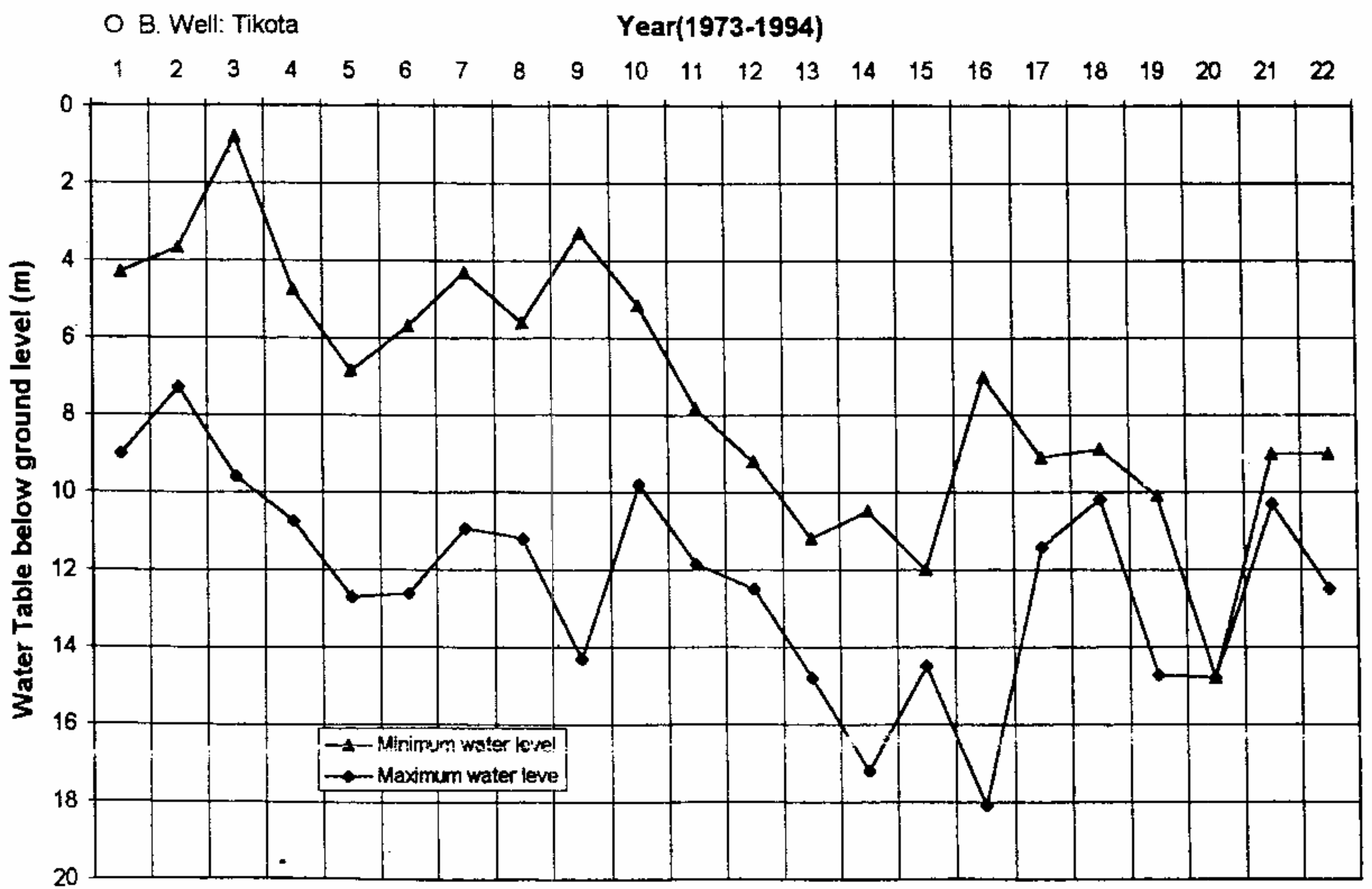


FIGURE: 18. Variation of Water Table

Figure: 19. Plot of Groundwater Table and Monthly Rainfall

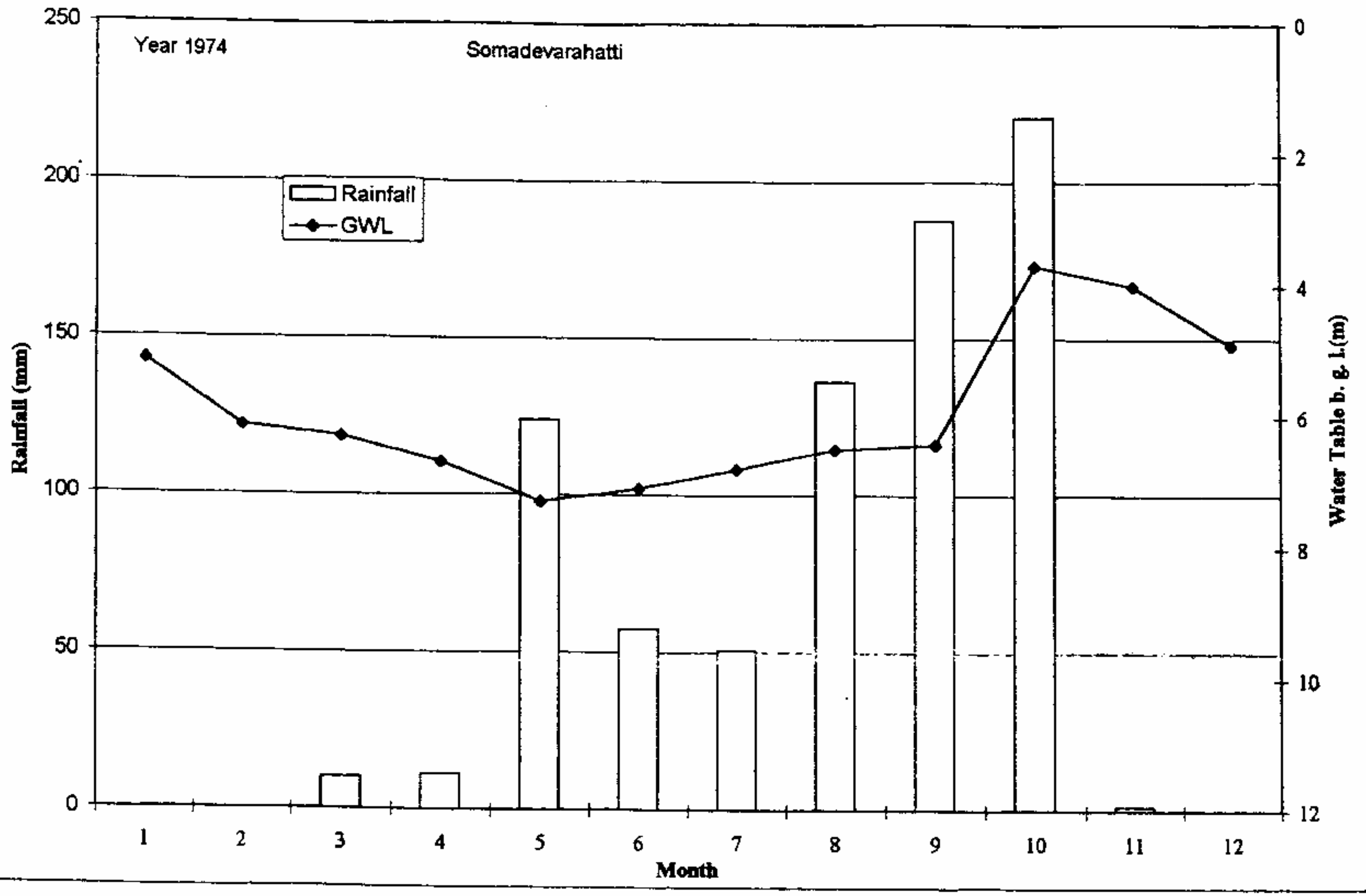


Figure: 20. Plot of Groundwater Table and Monthly Rainfall

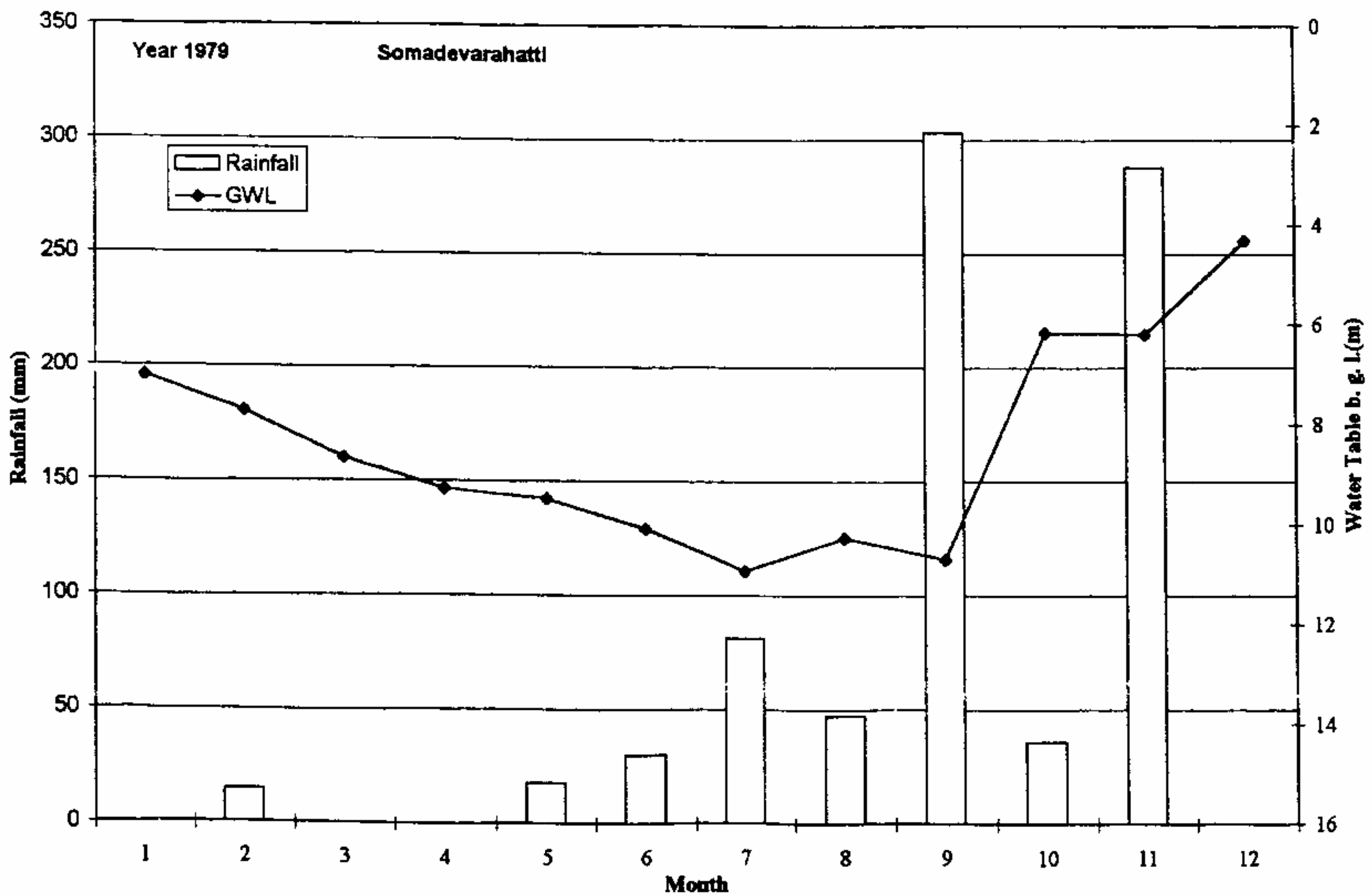


Figure: 21. Plot of Groundwater Table and Monthly Rainfall

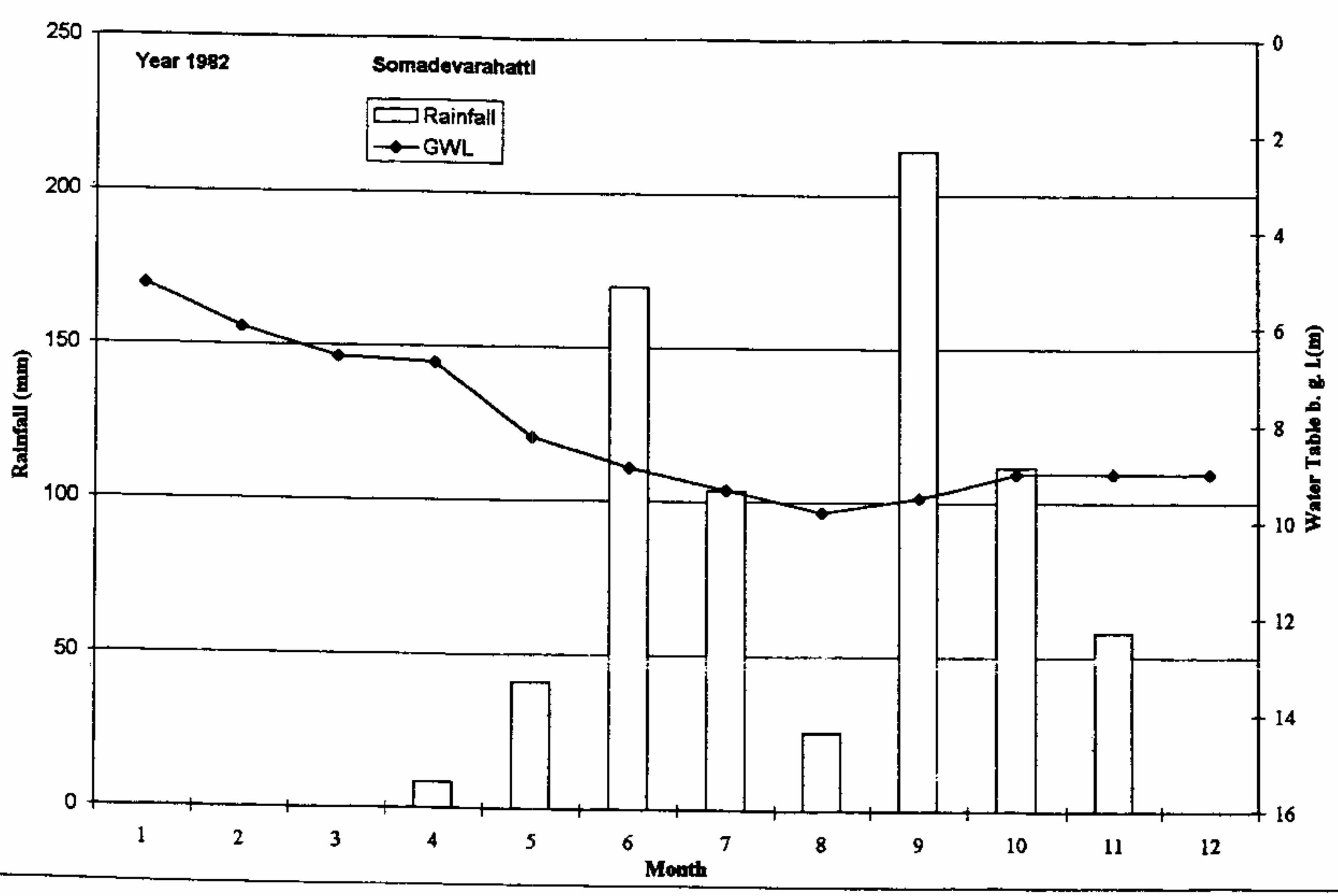


Figure: 22. Plot of Groundwater Table and Monthly Rainfall

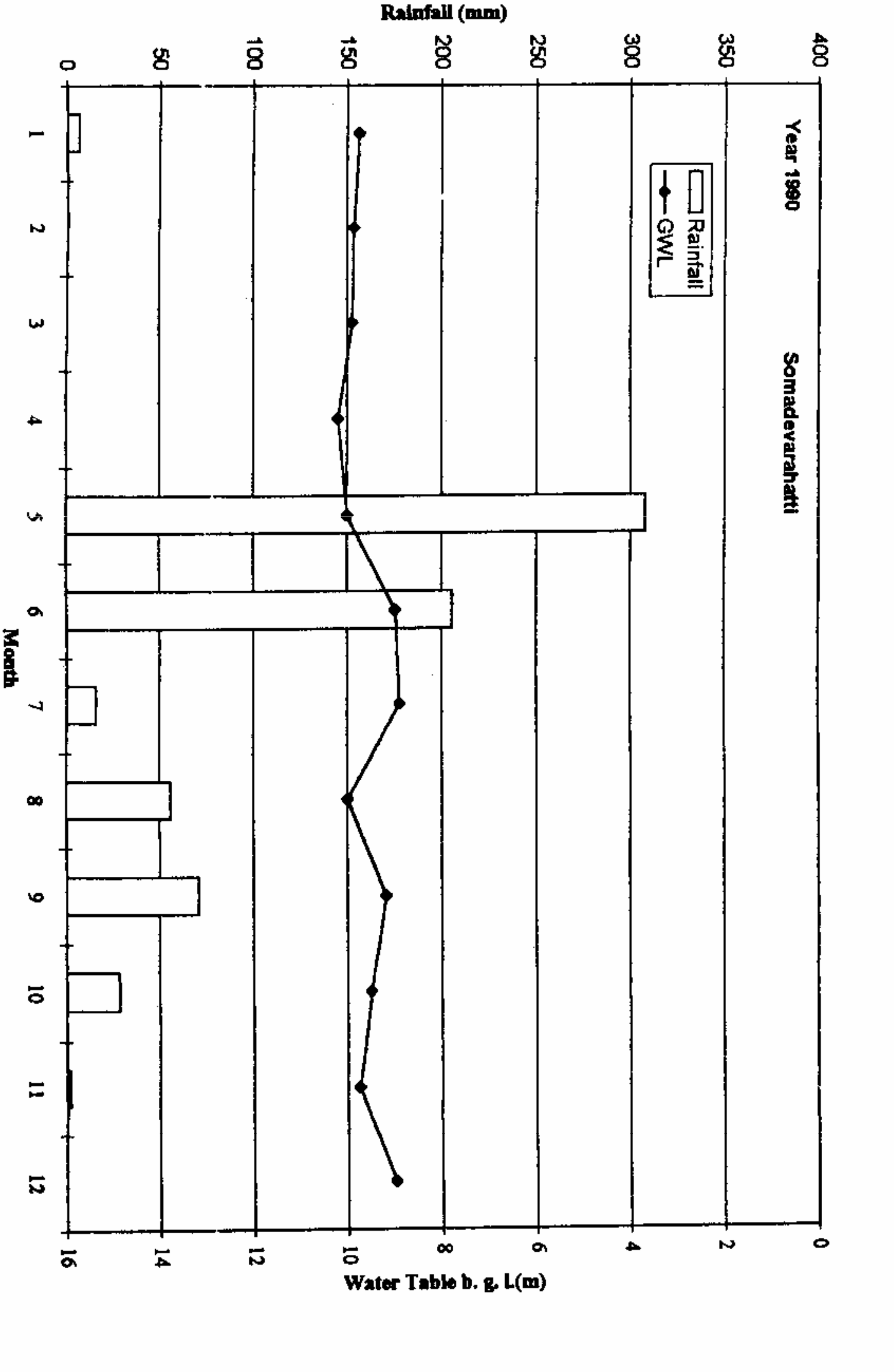
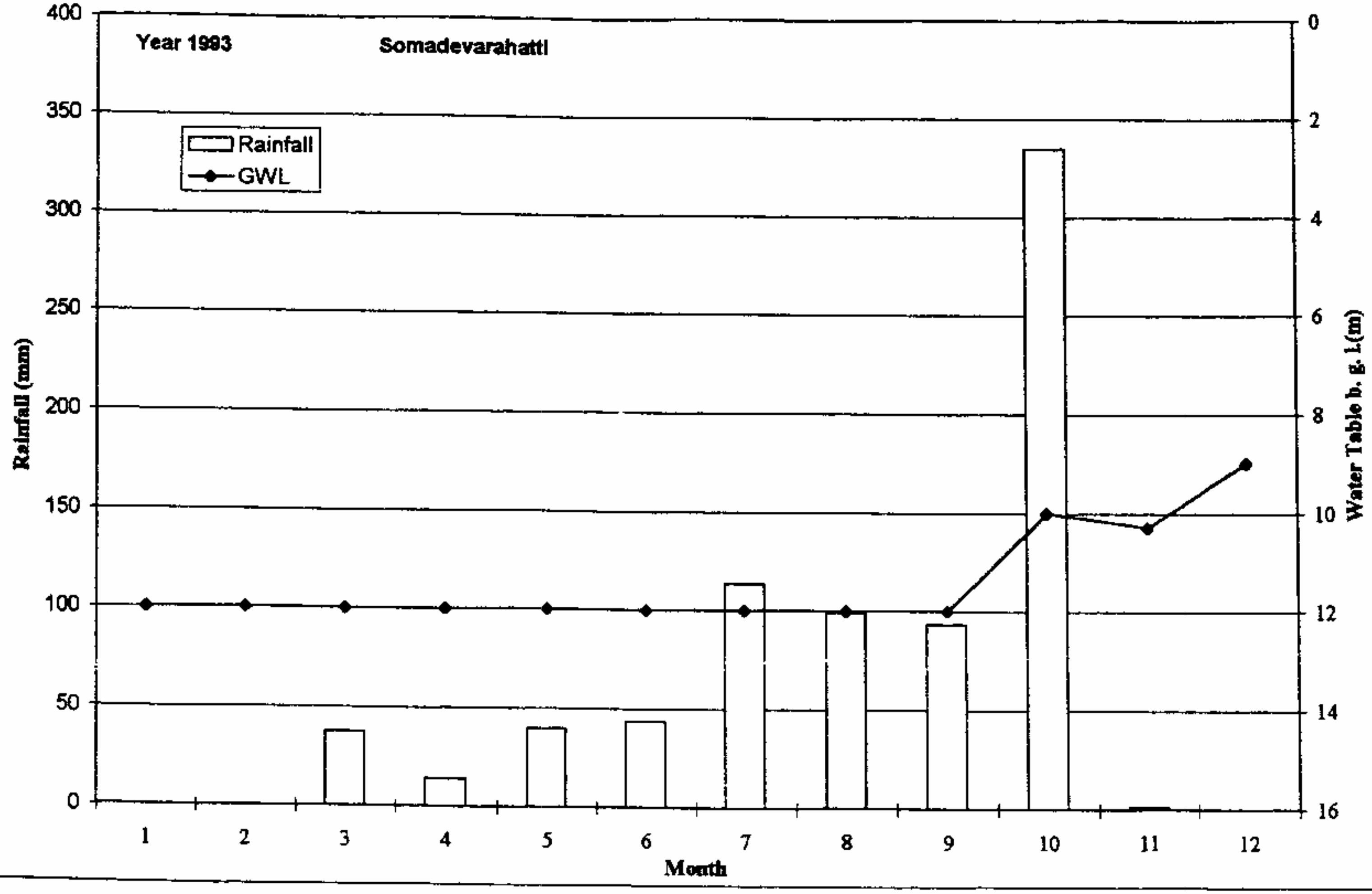


Figure: 23. Plot of Groundwater Table and Monthly Rainfall



b. Hirehalla Watershed

The fractured zones are prominent in the Kendgal watershed area. There are number of bore wells drilled upto 200ft. depth. However, water table varies from 70 to 200ft. . Daily draft from the well is about 3-8 hrs a day with an energised motors of capacity from 3HP to 5HP. There are number of open wells in the weathered zone with total depth upto about 50ft., without lining. The normal size of the well diameter is 20 to 30 ft., or length 30-40ft. and width 20-40ft.. The yield of the well is said to be very low. The status of wells has been presented in table 7.

Table: 7. Status of existing wells in Hirehalla Watershed

Type of Well	Nos.	Size in ft.			Depth In ft.	W.T Level in ft.	Pmg. Hours	Draft Power HP
		Dia	L	W				
Open Well	50	-	30-40	20-40	30-50	5-50	2-5	3-6
Bore Well	50	6"	-	-	160 - 200	70 -200	6-12	3-7.5

Monthly water table data from 1973 to1994 is available for Kendgal observation well which is only the observation well within the watershed. Minimum water levels are noticed generally in the month of May and June and maximum in the month of October and November. The fluctuation of water table varies from about 0.5 to 6m. The maximum and minimum water levels in a year were plotted over years (1973-1994) as presented in the figure 24. The general trend of recharge and exploitation on water table level over the years were identified. It is also noticed that from the figure minimum and maximum water table follows same trend. However, there were three different water table situations noticed over 22 years. In initial period (1973-1983), there is water table level at the higher level, middle of the period (1984 -1991) at the lower level and in the later period from 1992, water table at higher level.

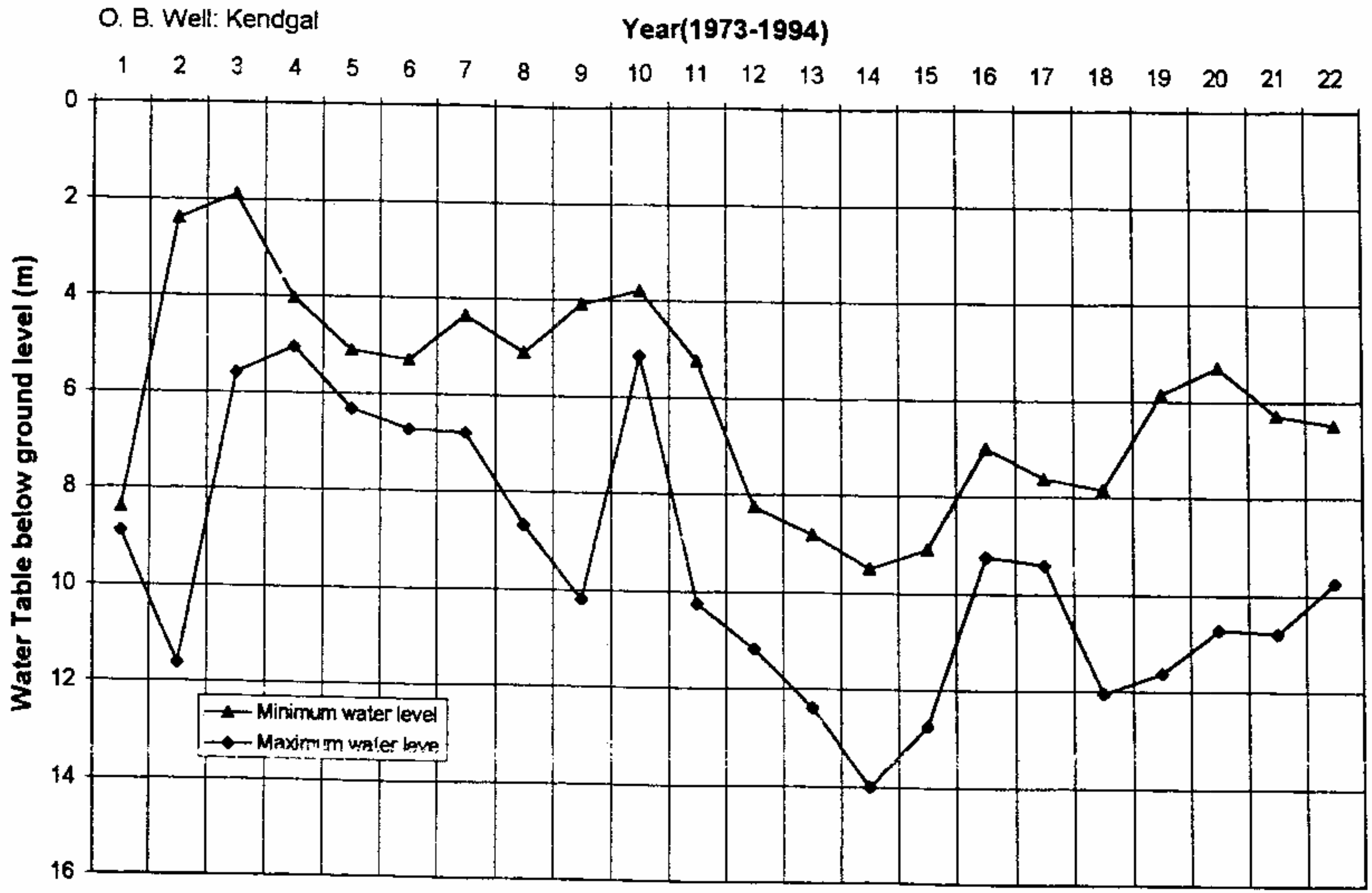


FIGURE: 24. Variation of Water Table

The monthly rainfall and water table levels have been plotted for few years (1974, 1979, 1982, 1990 and 1993) to understand the impact of monthly rainfall over recharge status of the groundwater from figures 25 to 29. From these figures, it shows that the recharge conditions of groundwater table were having clear relationship with a magnitude of monthly and annual rainfall. Therefore under the normal condition of rainfall over the watershed, normal recharge of groundwater is taking place.

4.3. Surface Water

Weighted curve numbers for Somadevarahatti and Hirehalla watershed were estimated based on the soil type, landuse, slope of the watersheds 76 and 83 respectively. The quantitative definition of these AMC classes for a particular day was based on the total rainfall for the past successive five days as given in the table 1. The initial abstraction conditions were also changed based on the AMC conditions. Initially, the effort has been made to work out the daily rainfall probabilities and corresponding water potential conditions. However, it is found that probability values were having high degree of variation. Therefore daily probability values were not used to estimate water yield from SCS method. The daily rainfall of Bijapur rain gauge station for 47 years in the case of Somadevarahatti watershed and 21 years for Kandgal was used to estimate the annual yield from watersheds the sample of estimation of daily runoff is given in annexure-II. The annual yield of watersheds were presented in the Tables 8 and 9. Annual rainfall is ranging from 240.8mm to 1161.9mm and yield from 0.86mm to 33.97mm. The average yield from Somadevarahatti watershed is 11.97 per cent of annual rainfall. In the case of Herehalla watershed, the annual rainfall is ranging from 51.22mm to 1120.1mm and yield from zero to 26.63mm. The average yield from the watershed is 11.62 per cent of annual rainfall. The relationship was established between annual rainfall series and yield series presented in the figures 30 and 31. Return periods of annual rainfall series were also developed and presented in the figures 32 and 33. The design yield of particular return period can be obtained by the relationship between return period, annual rainfall and annual yield. One day PMP values of annual series were used to estimate corresponding runoff series using SCS method and presented in the tables 10 and 11. The relationship between return period, one day PMP and corresponding runoff is established and presented in the figures 34-37. The one day probable maximum precipitation by Hershfield technique for both the watersheds were estimated and presented in table 12.

Figure: 25. Plot of Groundwater Table and Monthly Rainfall

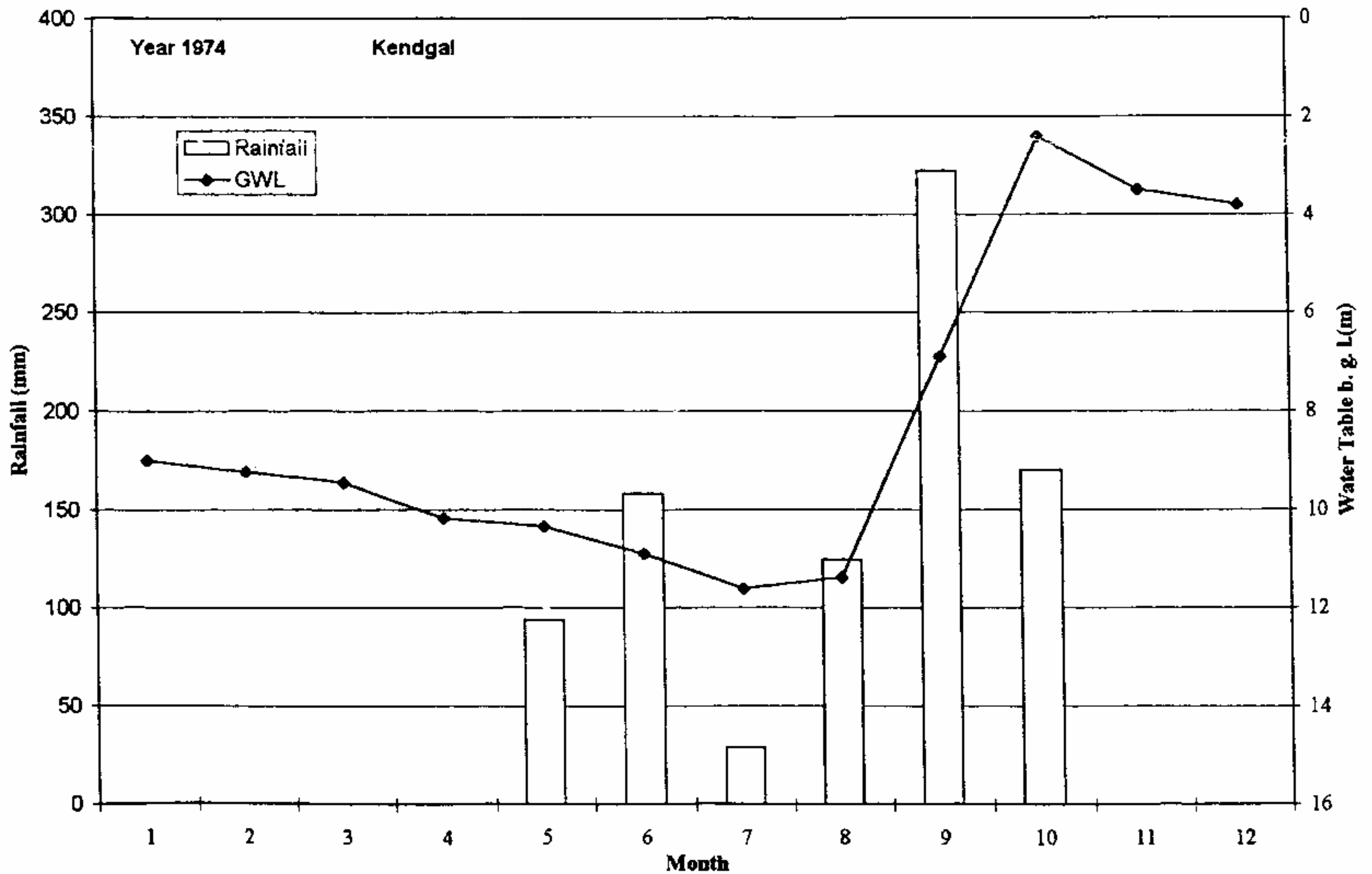


Figure: 26. Plot of Groundwater Table and Monthly Rainfall

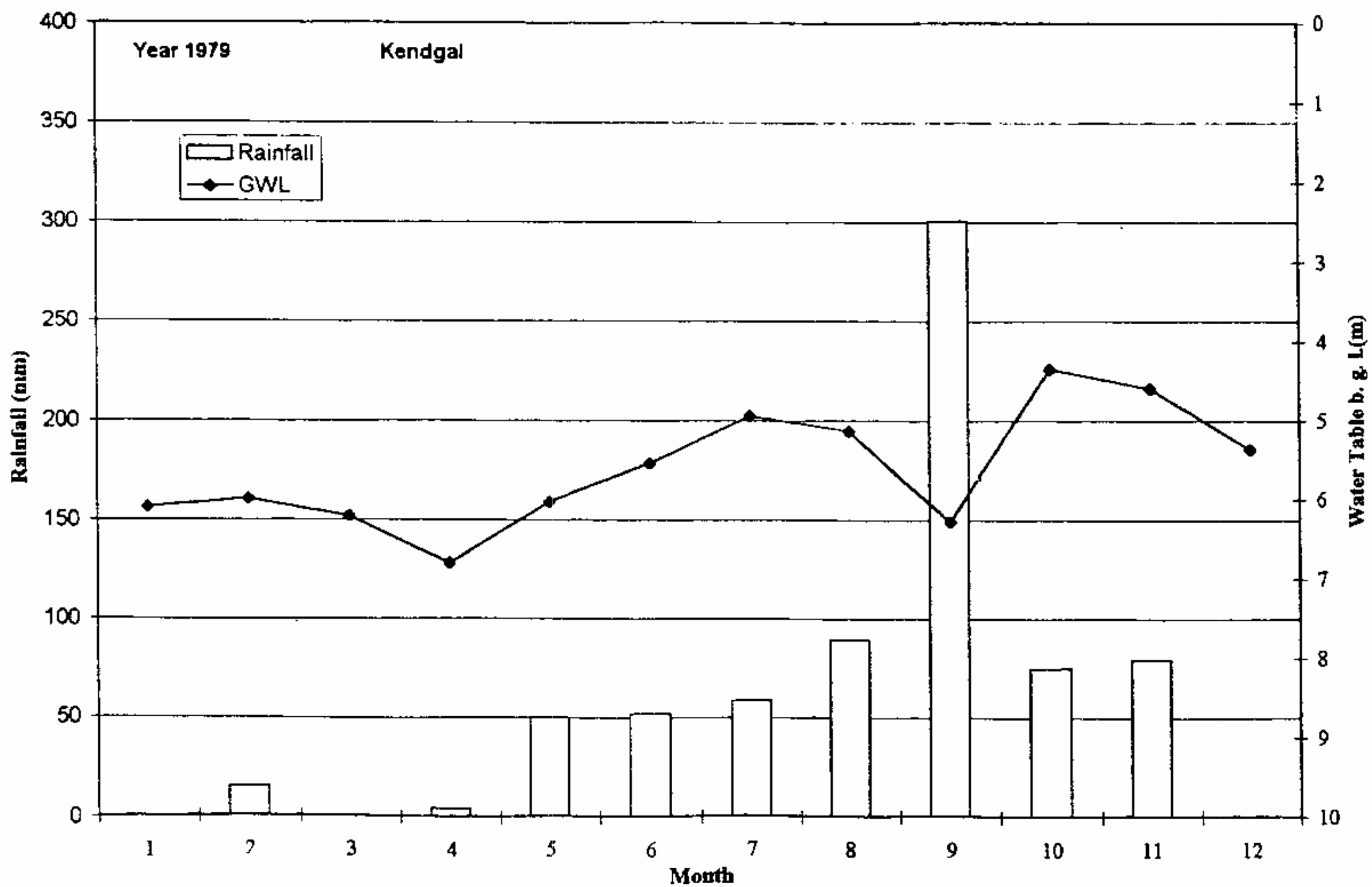
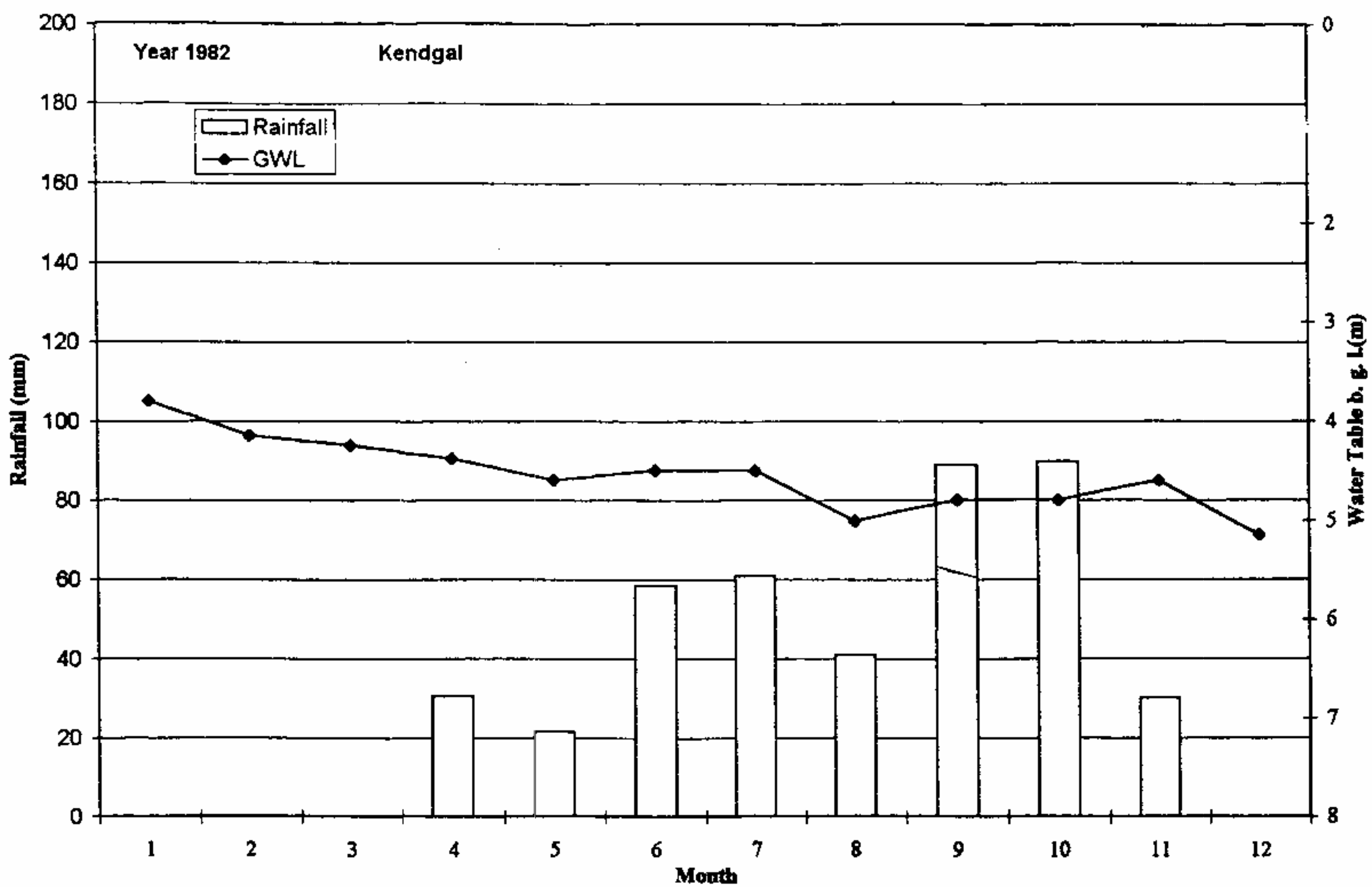


Figure: 27. Plot of Groundwater Table and Monthly Rainfall



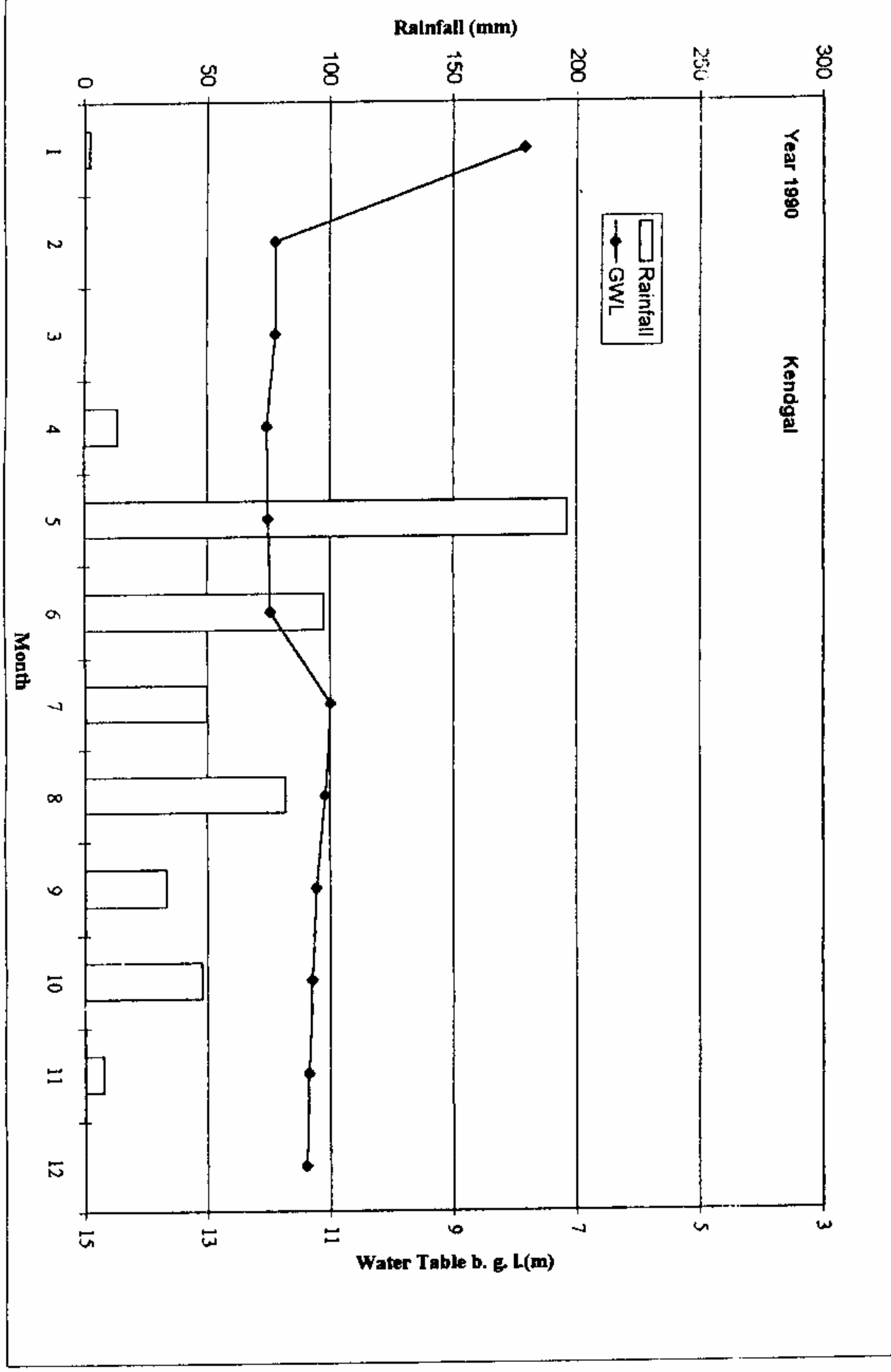


Figure: 28. Plot of Groundwater Table and Monthly Rainfall

Figure: 29. Plot of Groundwater Table and Monthly Rainfall

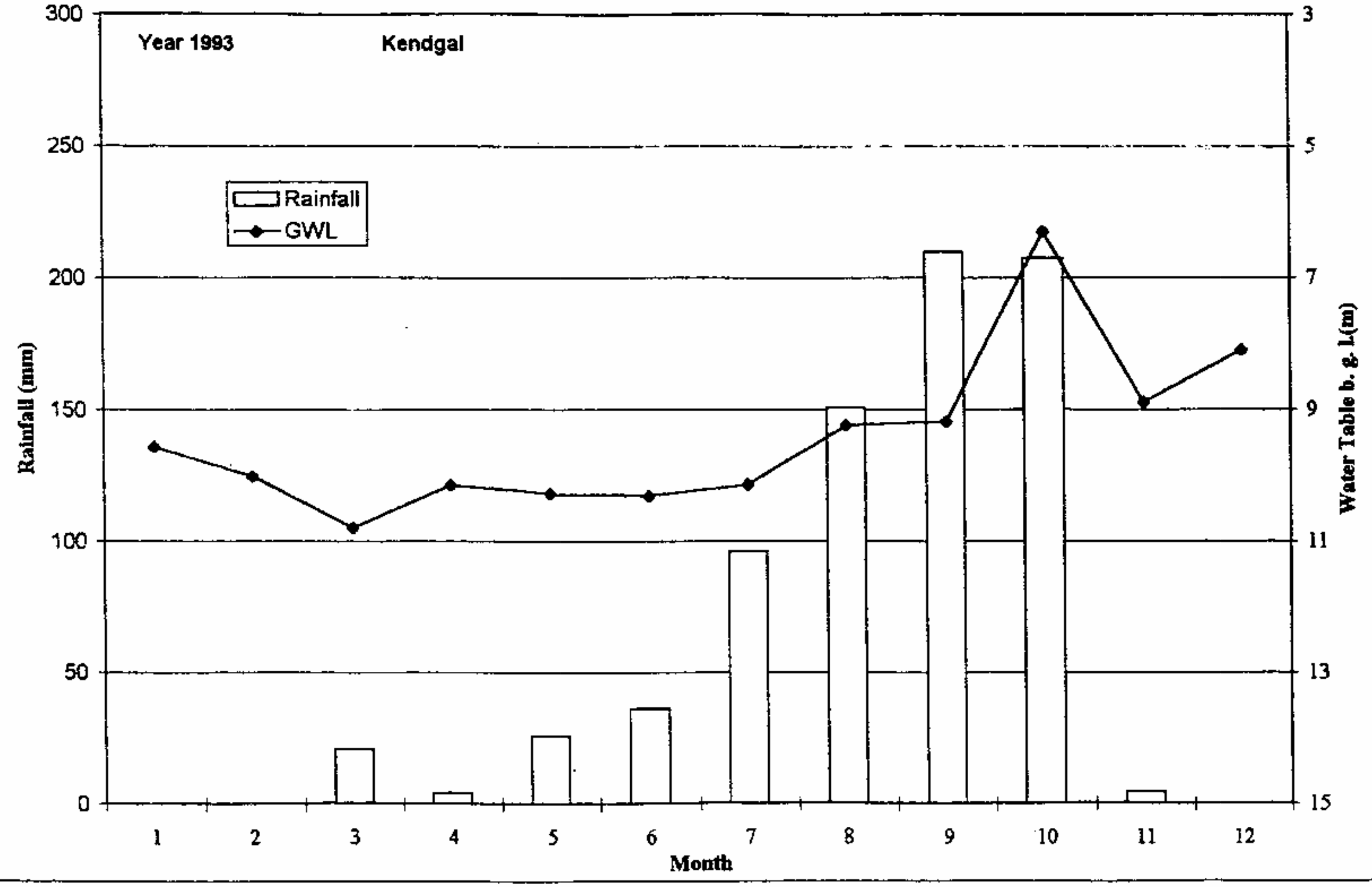


Table 8. Estimated Annual Yield by SCS method for Somadevarahatti Watershed

Sr. No.	Year	Annual Rainfall	Yield
1	43	805.20	84.02
2	44	520.50	40.88
3	45	346.20	10.98
4	46	519.80	38.34
5	47	459.20	3.95
6	48	494.80	57.36
7	49	638.30	147.49
8	50	541.90	43.71
9	51	536.70	41.96
10	52	539.00	15.60
11	57	773.00	106.38
12	58	857.90	161.82
13	59	610.80	69.75
14	60	842.50	161.53
15	61	574.50	23.07
16	62	791.30	58.58
17	63	740.10	100.08
18	64	1161.90	394.72
19	65	772.00	174.62
20	66	983.30	113.97
21	67	597.90	79.57
22	68	697.30	42.54
23	69	555.80	39.58
24	70	719.40	110.75
25	71	795.40	136.78
26	72	292.00	9.38
27	73	783.10	118.64
28	74	798.80	117.31
29	75	954.00	125.16
30	76	404.80	73.15
31	77	687.40	96.66
32	78	892.90	103.25
33	79	817.00	191.56
34	80	320.50	7.99
35	81	803.20	128.58
36	82	722.80	55.31
37	83	586.60	37.50
38	84	531.60	52.80
39	85	594.90	56.68
40	86	449.50	16.29
41	87	694.40	44.11
42	88	691.40	91.21
43	89	793.70	174.81
44	90	691.40	165.69
45	91	669.80	101.40
46	92	240.80	14.33
47	93	355.80	30.17

Table 9. Estimated Annual Yield by SCS method for Hirehalla Watershed

Sr. No.	Year	Annual Rainfall	Yield
1	72	51.20	0.19
2	73	502.00	124.52
3	74	667.00	166.54
4	75	1120.10	355.18
5	76	364.80	41.69
6	77	760.90	159.48
7	78	480.80	9.18
8	79	514.80	57.01
9	80	156.00	2.82
10	81	573.90	80.25
11	82	117.50	1.80
12	83	165.30	0.00
13	85	154.60	4.70
14	86	459.10	74.74
15	87	470.40	48.50
16	88	173.90	1.68
17	89	374.30	50.06
18	90	429.70	20.60
19	91	473.60	126.13
20	92	240.80	23.74
21	93	355.80	51.09

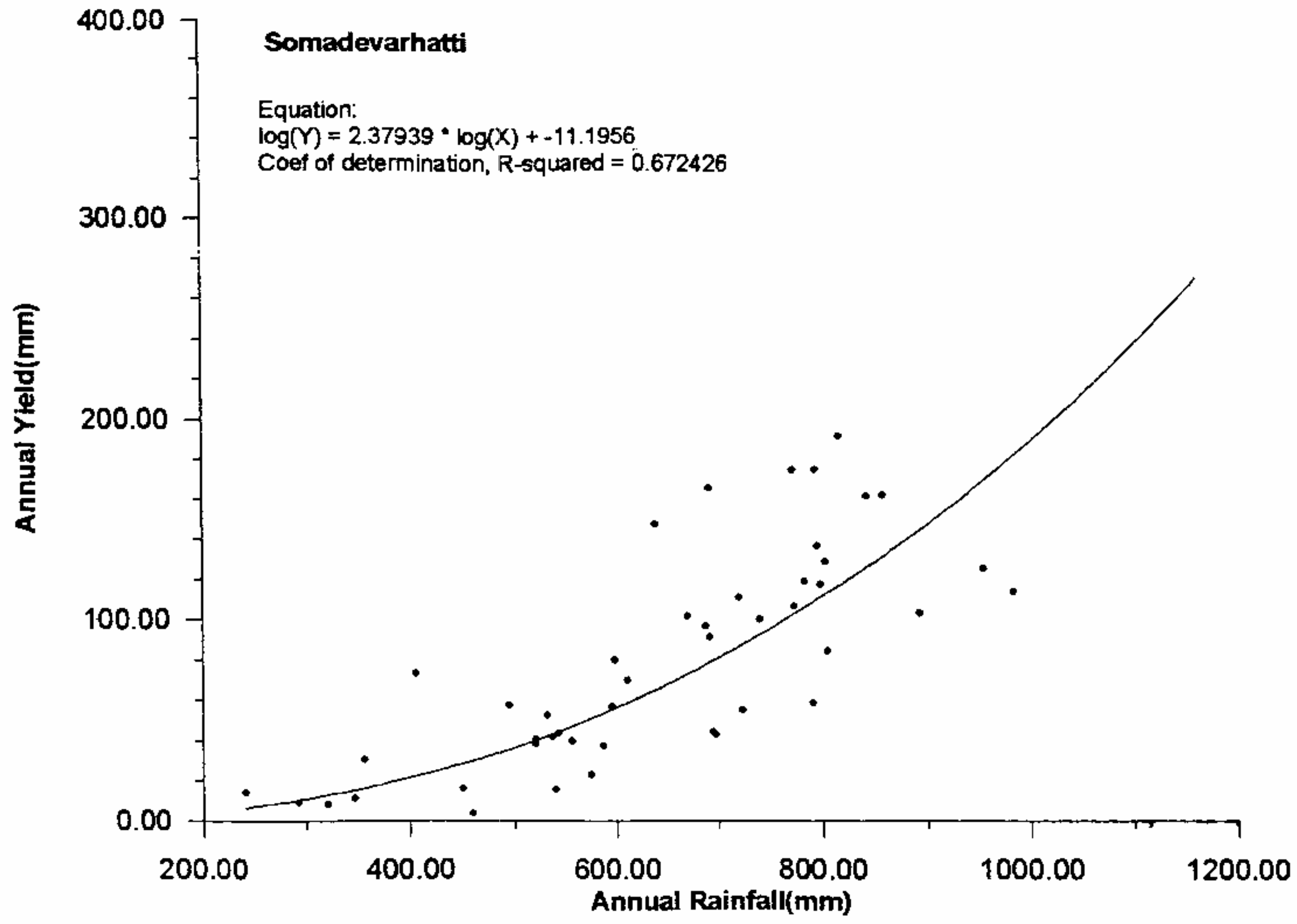


Figure 30. Relationship Between Annual Rainfall and Estimated Annual Yield

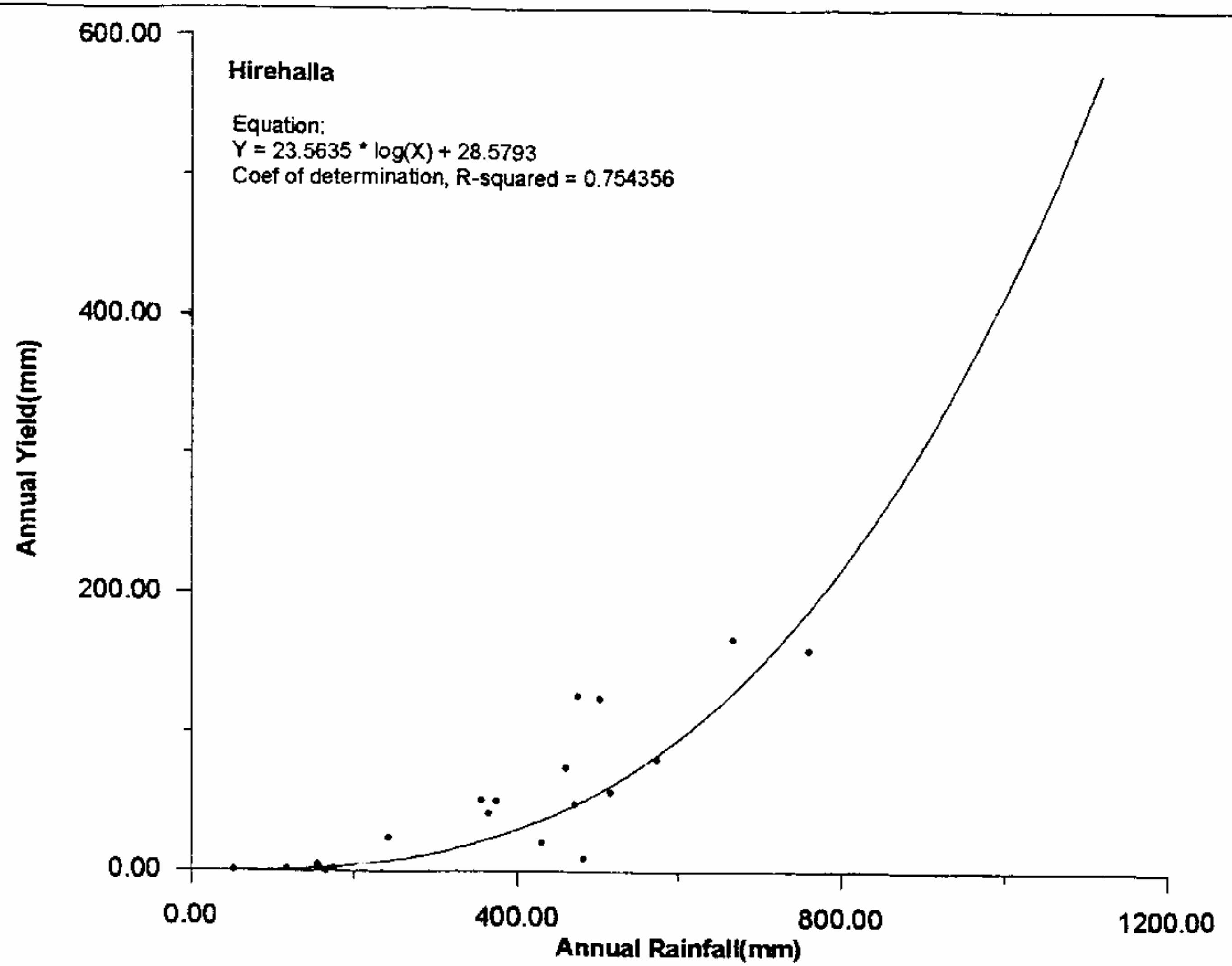


Figure 31.Relationship between Annual Rainfall and Estimated Annual Yield

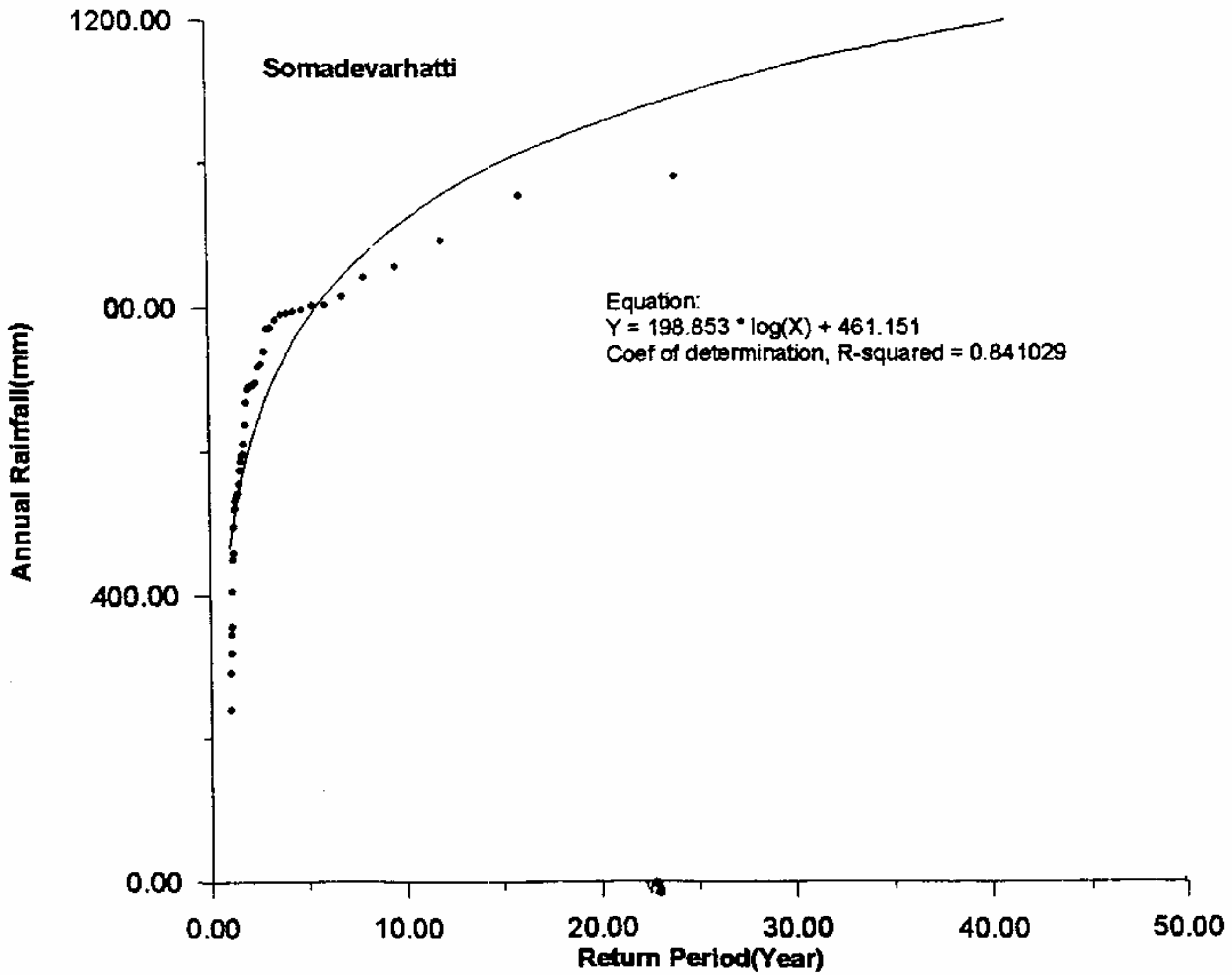


Figure 32. Relationship Between Return Period and Annual Rainfall

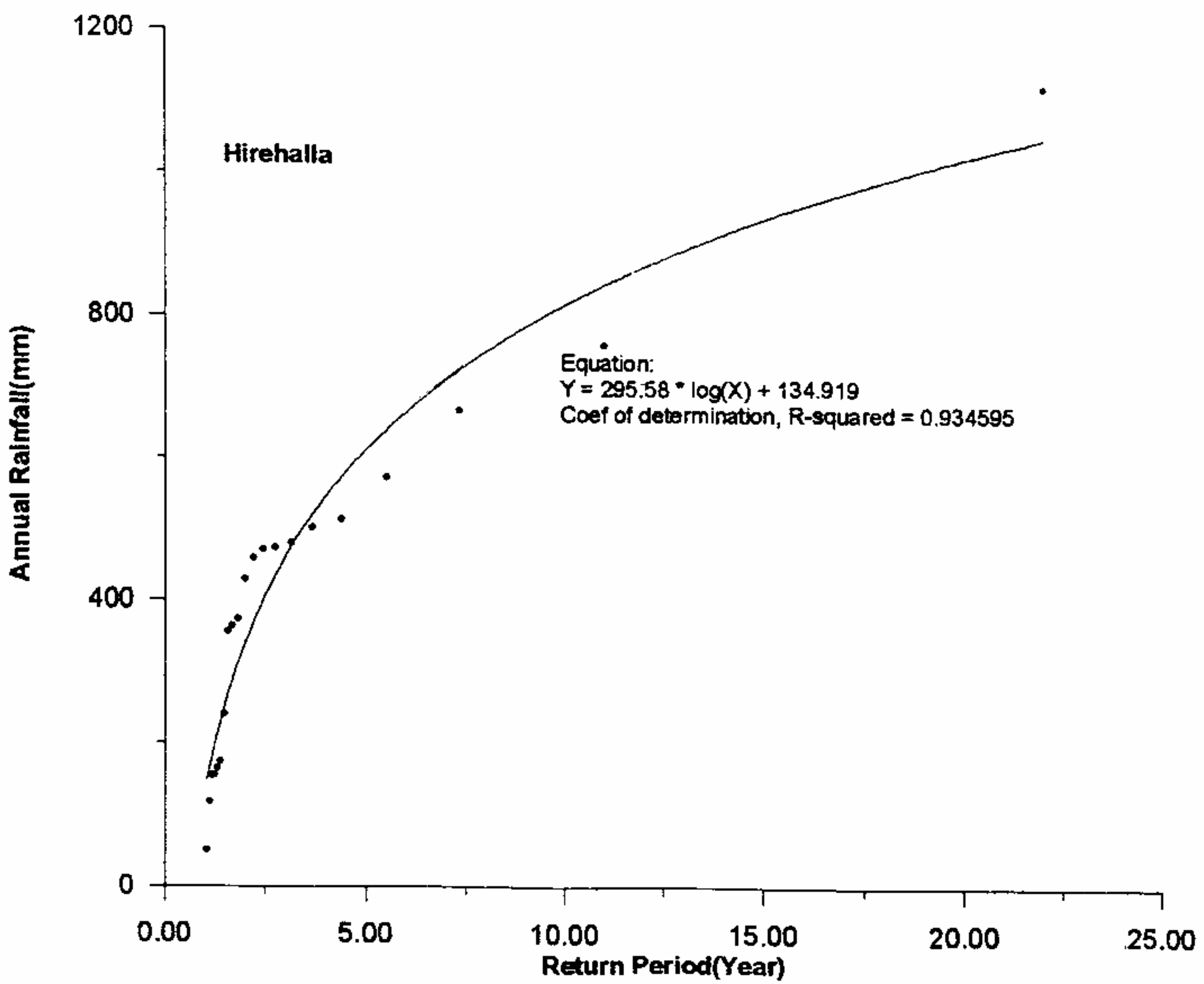


Figure 33. Relationship between Return Period and Annual Rainfall

Table 10. One Day Annual Maximum Precipitation and Corresponding Runoff for Somadevarahatti Watershed

Sr. No.	Year	One Day Annual Maximum Rainfall	Runoff
1	43	73.60	12.75
2	44	72.60	12.34
3	45	47.70	4.03
4	46	78.20	14.68
5	47	25.90	0.29
6	48	46.90	25.48
7	49	143.70	31.39
8	50	53.00	5.48
9	51	66.80	10.09
10	52	33.40	1.13
11	57	59.90	7.64
12	58	170.00	68.50
13	59	89.20	40.83
14	60	71.80	28.25
15	61	69.00	10.92
16	62	65.60	9.64
17	63	72.00	12.10
18	64	176.00	146.29
19	65	167.80	138.29
20	66	96.80	23.43
21	67	69.80	26.88
22	68	64.20	9.13
23	69	68.60	10.77
24	70	80.60	15.72
25	71	147.20	88.29
26	72	41.20	2.52
27	73	61.80	21.59
28	74	86.80	18.55
29	75	101.70	25.97
30	76	81.80	16.26
31	77	77.20	14.25
32	78	99.60	24.87
33	79	181.10	76.37
34	80	52.60	5.36
35	81	78.60	14.85
36	82	62.80	8.64
37	83	57.20	6.76
38	84	66.60	10.01
39	85	106.00	28.27
40	86	46.60	3.75
41	87	50.00	14.42
42	88	60.80	37.33
43	89	118.60	90.78
44	90	116.40	86.68
45	91	55.00	6.08
46	92	63.20	8.78
47	93	79.40	15.20

Table 11. One day Annual Maximum Precipitation and Corresponding Runoff for Hirehalla Watershed

Sr. No.	Year	One Day Annual Maximum Rainfall	Runoff
1	72	17.50	0.19
2	73	57.00	25.84
3	74	68.10	17.10
4	75	78.60	61.39
5	76	49.60	8.48
6	77	75.50	21.09
7	78	25.00	1.13
8	79	45.00	6.70
9	80	30.40	2.24
10	81	60.20	13.16
11	82	25.50	1.22
12	83	7.10	0.00
13	85	35.40	3.54
14	86	70.80	18.53
15	87	60.10	13.11
16	88	22.60	0.75
17	89	60.80	13.45
18	90	52.00	9.47
19	91	76.60	59.47
20	92	63.20	14.62
21	93	79.40	23.30

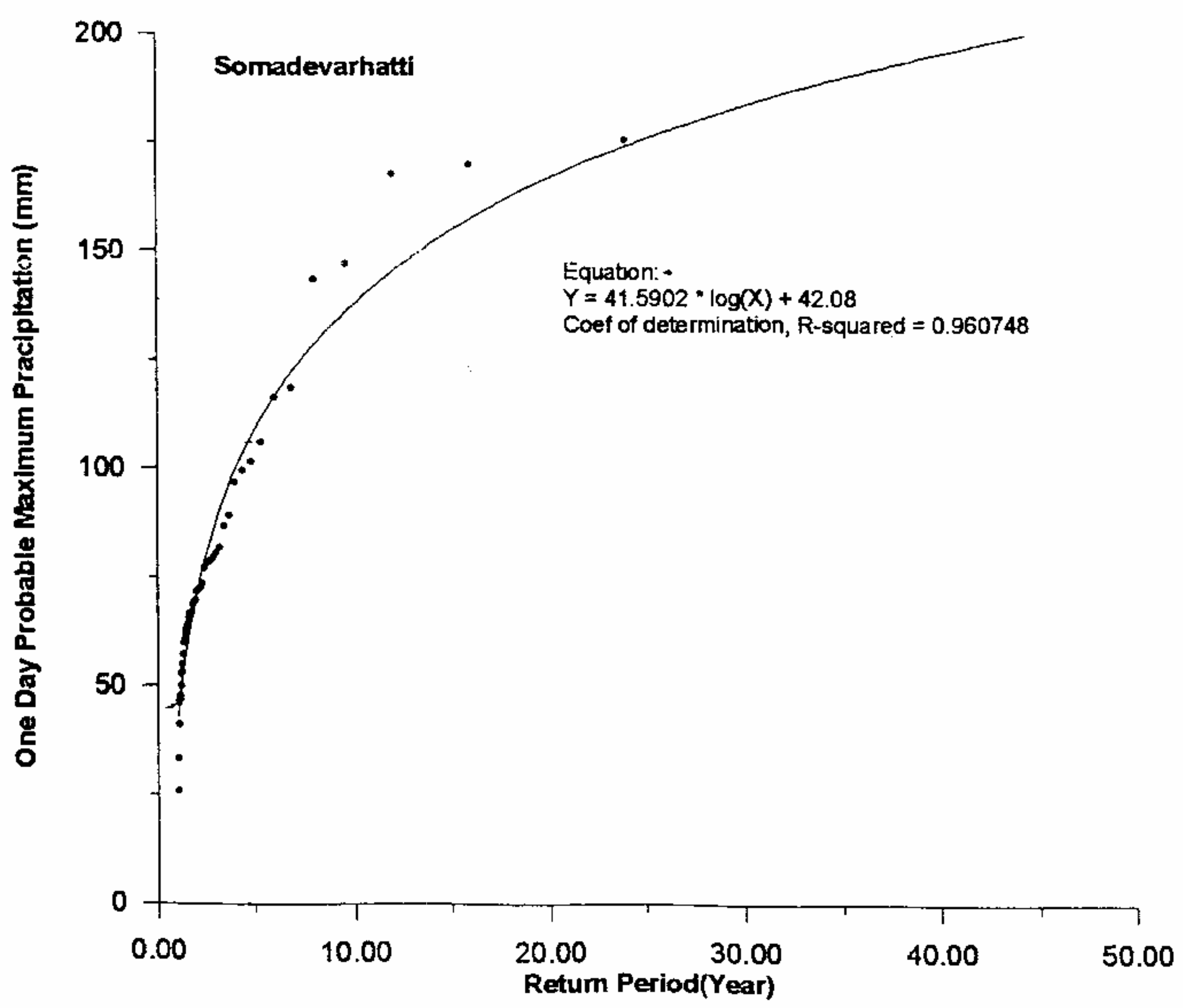


Figure 34.Relationship between Return Period and One Day PMP

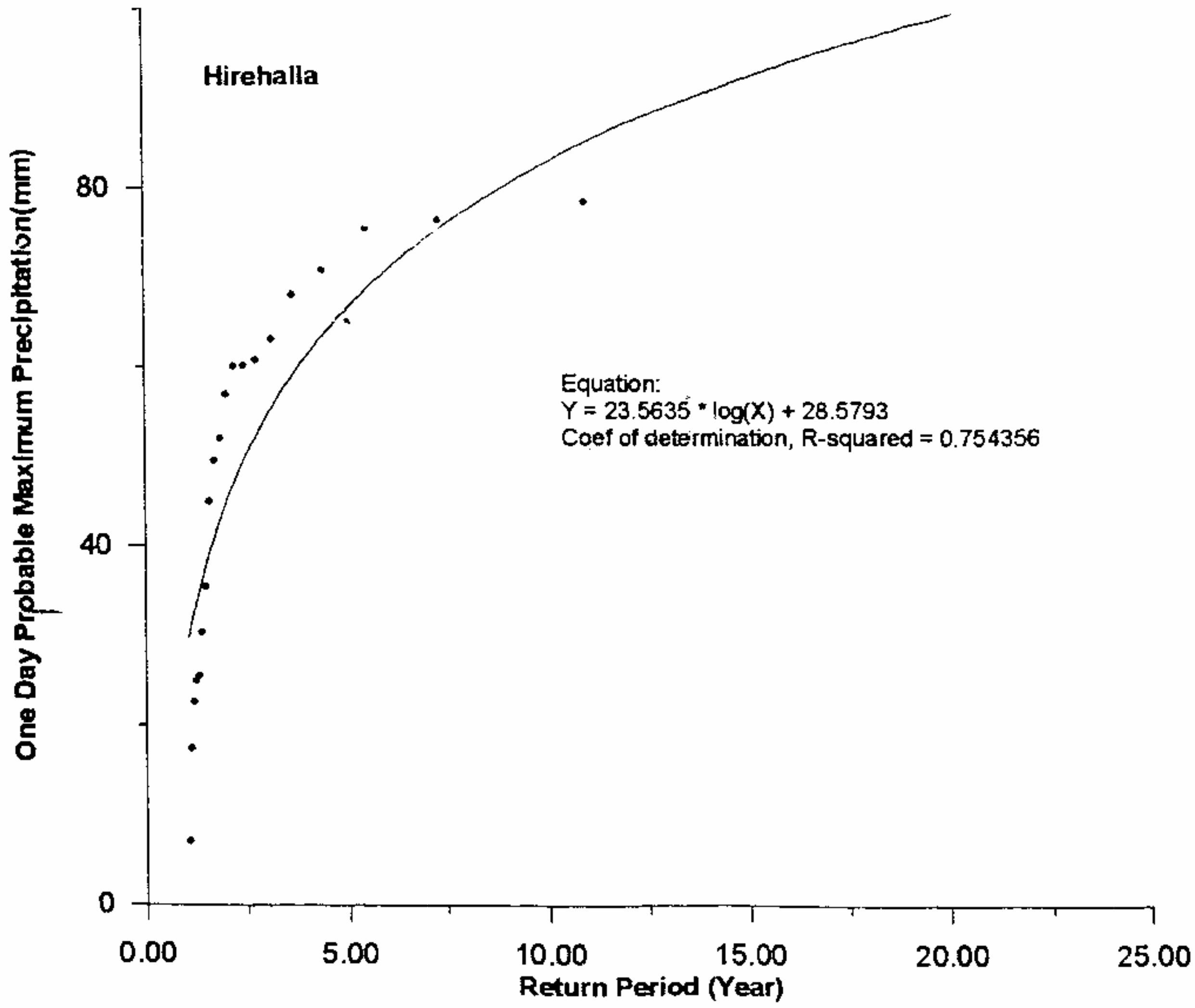


Figure 35 Relationship between Return Period and One Day PMP

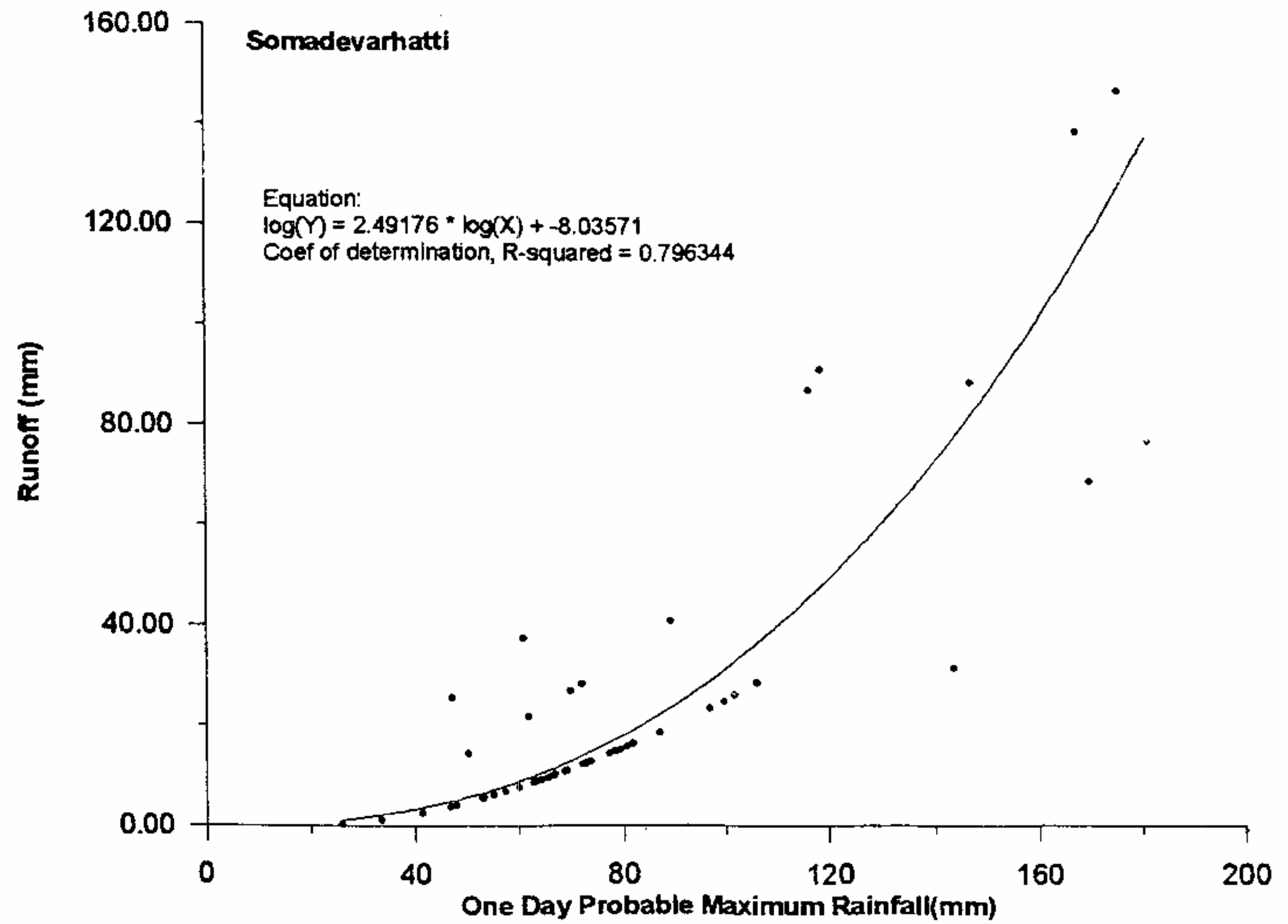


Figure 36. Relationship Between One Day Probable Maximum Rainfall and Runoff

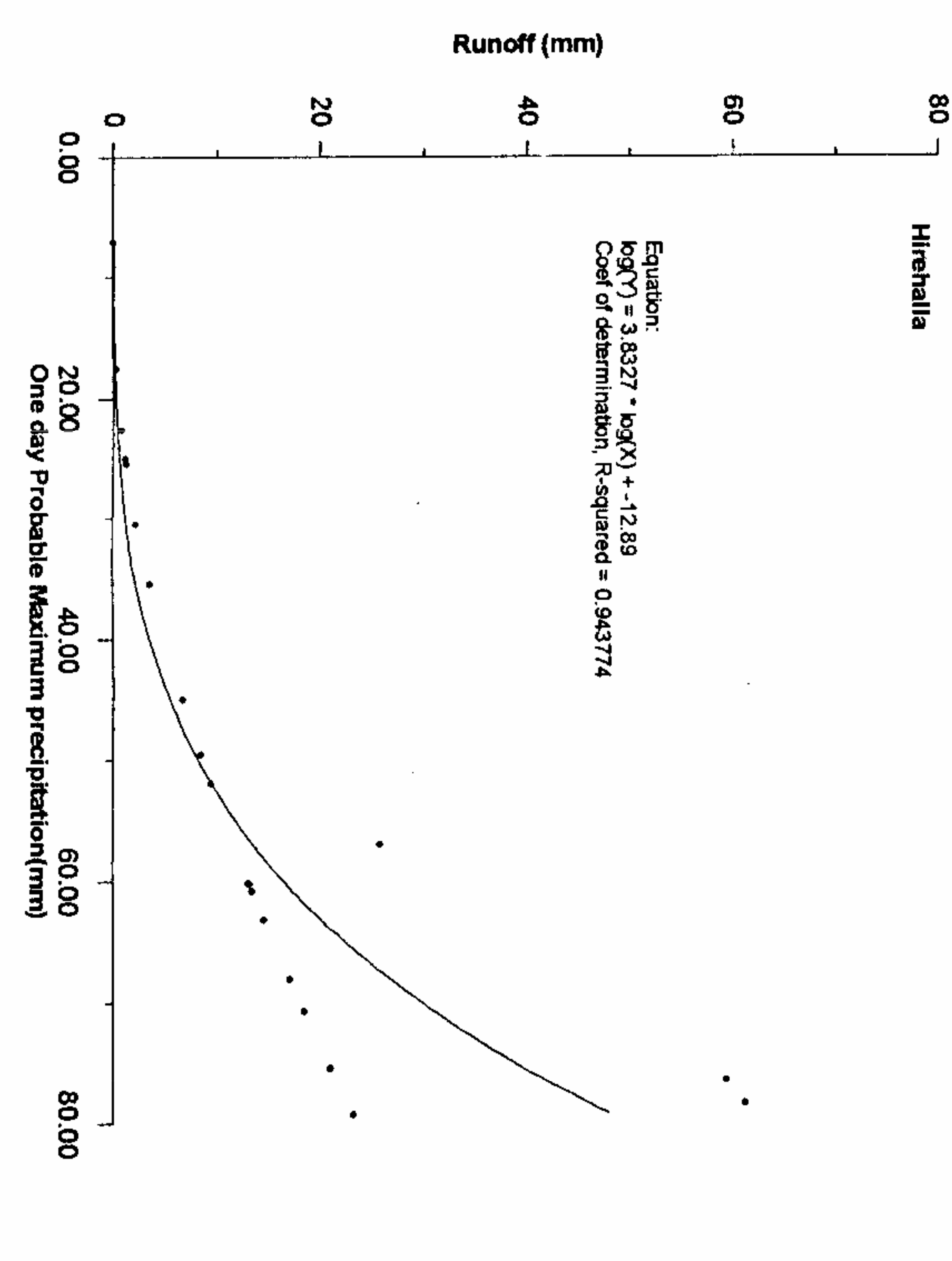


Figure 37.Relationship Between One Day Probable Maximum Rainfall and Runoff

Table 12: PMP Value Estimated by Hershfield Technique

Sl. No.	Name of the Watershed	One day PMP Value in mm	Return Period in Years
1	Somadevarahatti	176.00	24
2	Hirehalla	80.67	24

4.5 Field Survey

Rural development programmes based on people's participation have the commonly stated objective to assist local communities in their own efforts to improve their livelihood sustainability, often in harsh environmental conditions such as dry lands with scarce resources and erratic rainfall. For the thorough understanding of local situations and existing management systems, the field survey was carried out.

During the rainy season in Somadevarahatti watershed, upper reaches, middle reaches and lower reaches experiencing overflow over the tanks, nalabunds, check dams, and nala outlet of the village. Outflow will vary depends on the rainfall and its intensity. Outflow from the village is said to be of considerable magnitude. During the field visit, it is noticed that lower reach of the drainage system still has flow and is of considerable amount. Only one minor irrigation tank is available for domestic and live stock use, however it has limited storage time due to its lower capacity of storage and leakage through the tank bund. In the case of Hirehalla watershed, during the rainy season, upper reaches, middle reaches and lower reaches experiencing overflow over the tanks, nalabunds, check dams, and nala outlet of the village. Outflow will vary depends on the rainfall and its intensity. Outflow from the village is said to be of considerable magnitude. A stretch of the left side main nala is affected by the quality (salinity) problem. Apart from a small storage tank, there is no existing minor irrigation tank exclusively for the irrigation purposes. Hence the whole village is depend on rain for rising the crops.

The survey on existing soil and water conservation structures enables us to find the merits and demerits of the indigenous structures. Recommendations for the improvement of the existing structures were made. The gist of the existing soil water conservation structures are presented in tables 13 to 16, alongwith the farmers remark. The typical watershed management structures were in practice for both watersheds presented in appendix-III.

Table: 13. Abstract of Soil and Water Harvesting Structure

WATERSHED: SOMADEVARAHATTI		VILLAGE: SOMADEVARAHATTI		
Sl. No.	**Structure**	**Farm Bunds**	**Check dam**	**Nala Bunds**
1	Technology	Indigenous	Introduced	Indigenous
2	Nos. Surveyed	6	3	7
3	Age in Years	1-30	1-5	2-20
4	Location	Lower/Upper Reach	Lower reach	Middle/Lower Reach
5	Purpose	Protect field Boundary Reduce soil erosion and Loss of nutrients, and to Improve soil moisture	Storage water for Live stock and Irrigation and Improve ground-Water table.	Check the soil Erosion and nutrients, reclaim the valley for cultivation, and water conservation
6	Approximate Cost	Rs. 10,000-25,000	------	Rs. 10,000-25,000
7	Working Status	Good	Good	Good
8	Defective/Effective	Effective	Effective	Effective
9	Management	Good	Poor	Good
10	Assistance Needed	Financial assistance for Management and Construction of bunds	Management of Stream bank	Financial assistance for management of bunds
11	Recommendation	Intermediate trenches, Harrowing	Proper Maintenance of Gates/life of the Structure should be Assured.	Negotiation of Surplus water, Economic height bunds

Table: 14. Abstract of Soil and Water Harvesting Structure

WATERSHED: SOMADEVARAHATTI		VILLAGE: SOMADEVARAHATTI		
Sl. No.		Tank	Diversion drain	Well
1	Technology	Introduced	Indigenous	Indigenous
2	Nos. Surveyed	1	2	7
3	Age in Years	25	5-10	2-20
4	Location	Middle reach	Middle reach	Middle/Lower Reach
5	Purpose	Store water for live stock and irrigation, and recharge groundwater aquifer	Collect surface Runoff from the Upland and divert It safely to a nala or Water way.	Check the soil erosion and nutrients, reclaim the valley for cultivation, and water conservation
6	Approximate Cost	-------	5000-10000	Rs. 10,000-25,000
7	Working Status	Poor	Poor	Good
8	Defective/Effective	Not effective	Effective	Effective
9	Management	Poor	Moderate	Good
10	Assistance needed	Financial help to improve the storage capacity and maintenance of the bunds	Financial help for Improvement of Channel.	Financial assistance for management of bunds
11	Recommendation	Control seepage through The bund, improve the storage capacity.	Gradient of bed Should be Maintained to carry The surplus flow.	Negotiation of surplus water, economic height bunds

Table: 15. Abstract of Soil and Water Harvesting Structure

WATERSHED: HIREHALLA			VILLAGE: KANDGAL	
Sl. No.		**Tank**	**Diversion drain**	**Well**
1	Technology	Introduced	Indigenous	Introduced
2	Nos. Surveyed	3	3	5
3	Age in Years	100	10-50	2-15
4	Location	Middle/lower reach	Middle/lower reach	Middle/Lower Reach
5	Purpose	Store water for Irrigation, and Recharge groundwater Aquifer	Collect surface Runoff from the Upland and divert It safely to a nala or Water way.	Irrigation and Domestic
	Approximate Cost	-------	5000-10000	Rs. 30,000-50,000
7	Working Status	Poor	Poor	Good
8	Defective/Effective	Not effective	Effective	Not effective as less Yield
9	Management	Poor	Moderate	Good
10	Assistance needed		Financial help for Improvement of Channel.	Financial help for more Number of wells.
11	Recommendation	Improve The storage capacity.	Gradient of bed Should be Maintained to carry The surplus flow.	Recharge condition Should be increased.

Table: 16. Abstract of Soil and Water Harvesting Structure

WATERSHED: HIREHALLA			VILLAGE: KANDGAL
Sl. No.	**Structure**	**Farm bund**	**Nala bund**
1	Technology	Indigenous	Indigenous
2	Nos. Surveyed	3	2
3	Age in Ycars	1-20	3-10
4	Location	Lower/upper reach	Middle reach
5	Purpose	Protect field boundary, reduce soil erosion and loss of nutrients and to improve soil moisture	Check the soil erosion and nutrients, reclaim the valley for cultivation, and water conservation.
6	Approximate Cost	10,000-15,000	45000-50000
7	Working Status	Poor	Poor
8	Defective/Effective	Not effective	Not effective as defect in the waste weir placement
9	Management	Moderate	Poor
10	Assistance needed	Financial assistance for the management and construction of bunds.	Financial assistanace for the management of the bunds and weirs.
11	Recommendation	Intermediate trenches, harrowing, placement of waste weir.	Negotiation of surplus water and economic height of bunds and waste weir

5.0 Remarks and recommendations

Surface water resource

As per the field survey, upper reaches, middle reaches and lower reaches of the watersheds experience overflow over the tanks, nala bunds, check dams, and nala outlet of the village, especially during the rainy season. Outflow from the village is said to be of considerable magnitude, as also obtained from the SCS method for peak rainfall series. The lower reach of the drainage system shows significant quantity of flow, which is due to baseflow. Therefore, groundwater aquifer may be utilised for irrigation purposes. However, in some of the areas, gully erosion and breaching of nala bunds and farm bunds has been noticed. It may be attributed to the inadequate number of soil and water conservation structures in the area and scope for further developmental measures. Design of weirs and outlets could be designed based on Harshfield one day PMP values by the methodology established in the present study.

Farm Bunds

The placement of waste weir in the existing structures were found to be inappropriate and hence the proper location should be chosen. In some of the farm bunds, it is noticed that there is breach and overflows. In such cases, waste weir may also be considered at suitable location which may lead to diversion drain.

Breaches of bunds and on site erosions are noticed due to the inadequate passage for flow from upland. Under these circumstances, diversion drain may be provided to divert excess surface runoff from nala or natural waterway during the rainy season to avoid the breaches of bunds and field erosions.

About one fourth of the height of the farm bund may be made out of soil at the bottom to conserve the water more effectively in the case of boulder bund and where slope is more than 2%. Harrowing or ploughing before the rainy season is recommended. After the survey, it is noticed that there is ample of opportunity to develop farm bunds to enable conservation of soil and water.

Breaches of bunds, erosion of field and silting of field are noticed due to the improper drainage from the field. These problems can overcome by the diversion drain to divert excess surface runoff from nalas or natural waterway.

Nala Bund

Nala bunds very effective in most of the cases. However, in some cases, breaching as well as not serving the purpose due to the non-existence of the waste weir or improper location of waste weir. Hence, waste weir may also be considered at suitable locations which may lead to the waterway.

Nala bund, made out of soil, is very effective for water conservation purposes as it recharges the groundwater aquifer. Normally, breaching takes place in the bund due to non- existence of waste weir or deficiency in the placement. Hence, waste weir should be provided in the case of earthen bund.

Nala bund may be gradually raised till sufficient area suitable for cultivation is created by sedimentation instead of constructing maximum height of the structure at a time. Downstream side of bund may be provided with vegetative cover to protect the bund.

Check dams/Vented dams/Bhandaras

Water being stored and used to irrigate agriculture field and groundwater table (aquifer) have been improved after the construction of the structure. The groundwater table improvement may be assured by these measures provided water is supplemented by upstream tank during lean period of rainfall. However, the durability and maintenance on the structure should be assured.

It is found that, bank erosion has taken place where the height of the dam is at the bank level, hence the height of the bhandara may be restricted to well below the bank of the nala or flood plain.

Leakage is taking place through the bank of the nala or abutment of the dam. Therefore, check dam should be constructed with suitable abutment and wing wall. A series of low level bhandara may be adopted instead of vented dam in the tail ends of the river course which does not require monitoring of gates.

Tanks

The existing percolation tank is having leakage through the tank body and breach in the bund was also noticed. To increase the storage capacity and detention time of the storage, tank bund may be provided with inner clay layer (core) and strengthening the foundation of the bund.

These ponds may be provided with spillways/waste weir/diversion outlet at proper level to avoid the breaching of the bund as well as to impound required quantity of water to facilitate the improvement in groundwater table.

During the rainy season, a large quantity of overflow takes place over the waste weir for long period and the minor irrigation tank is filled in the beginning of the rainy season. Considering these facts, it is necessary to increase the height of the waste weir as well as the dam for the utilisation of waste water.

Wells

Open wells are mostly situated in weathered and fractured zones of basalt. Most of the wells are getting dried during summer in the pre-water conservation structures (minor irrigation tank, check dams) situation. However, after the inception of water conservation structures there is lot of improvement in the groundwater table which comes under the zone of influence. Under these circumstances, number of wells may be increased only after the possible measures taken to harvest water in the lower reach.

Diversion drain

Bank of the diversion nala is breached and erosion is also noticed in some cases. It may be due to insufficient capacity of the drain to carry flow from the upland. In such cases, widening of the channel and proper gradient of the channel bed should be maintained.

General Recommendations

1. Low consumptive use plants may be grown to stabilise the bunds.
2. Top of the hills, which is flat in nature, is to be provided with farm bunds.
3. There is hydrologically and geographically suitable site for the minor irrigation tank and percolation tank where water can be harvested in the middle reaches.
4. Upper reach and middle reach may be provided with contour bund/mound which may lead to gully checks in the valley portion.
5. Lower reach is suitable for the nala bunds.

Water conservation measures for replenishing the water table should be taken up only after assessing the present recharge and discharge condition.

6.0 Conclusions

The average annual rainfall varies from 399mm in Somadevarahatti to 422.00mm in Kendgal. However, rainfall is distributed from May to October in Somadevarahatti, where as in the case of Kendgal from April to November. Analysis of time-series data on annual rainfall clearly shows a declining trend in both the watersheds. The agricultural development and declining in the rainfall magnitude may have serious implications on the future farming in these watersheds unless until proper water conservation measures taken up.

As for the distribution, most of the total annual precipitation is received between July to October. The major part of annual rainfall is received in 25 - 60 rainy days in rather torrential storms causing enormous loss of this precious natural resource through huge runoff. The runoff of as high as 146.29mm per day in the case of Somadevarahatti watershed where as in the case of Hirehalla is 61.39mm/day has caused severe loss of conservation structure and invaluable top and fertile soils rendering the area, especially the upper and middle reach, unfit for viable farming. As per the estimate about 40 per cent of the rain water received in the watersheds were lost through runoff as the indigenous structures to control the runoff is too inadequate and also beyond the means of the farmers. Finally, the crux of the problem lies in unfavourable soil and water conditions caused by adversities are unattended by human. An important characteristic feature of rainfall in these watersheds is uncertainity both in terms of quantity, and time of occurrence and distribution.

Soil and water, the most valuable natural resources for farming, are not preserved in-situ and conserved for future use owing to the inadequacies and ineffectiveness of the existing structures and measures. Some boulder bunds, field boundary bunds and small structures like 'nala' bunds and chek dams are constructed by the farmers but they get very limited success in controlling the problems of runoff and soil erosion as well as in providing irrigation to the crops through surface or groundwater sources. More percolation tanks at the appropriate locations and land levelling, especially in the middle and lower reaches, would help not only in containing the problems of runoff and soil erosion but also in providing irrigation to the crops. Farmers are most likely to accept improved soil water conservation technique that address their priorities. As a result, the soil conservation technique that is best for the farmer may not be that which conserve the most soil. This usually results in two major differences at the implementation level. Firstly, the recommended SWC structures are positioned on the contour while farmer's choice of technologies are boundary based. Secondly, its emphasis long term productivity benefits from maximum protection of the soil.

References

Dhar, O. N. and P. P. Kamte, A pilot study of Estimation of Probable Maximum Precipitation Using Hershfield Technique, Indian Journal of Meteorological Geophysics, Vol.22,No.3,pp. 121-125(1971)

Dhruvanarayan, U. V,, Soil and Water Conservation Research in India 1993.

Karnataka Watershed Development Programme (KWDP), Bijapur District, karnataka State, Chandakavate , Integrated Watershed Project(1999).

Ministry of Agriculture, 1972 'A Guide for estimating irrigation water requirement '. Department of Agriculture., Water Management Division, New Delhi.

Misra G. C., Assessment of Water conserved through Watershed Management Practice.

Premkumar P. D., 'Farmers are Engineers' Indigenous Soil and Conservation Practices in a Participatory Watershed Development Programme.

Sarma V. V. J. , and Narayanswamy, A. (1982), Areal distribution of monsoon rainfall in Vishakapattanam Basin, Proc. of the Seminar on Hydrlogical Investigations during the last 25 years in India, waltair, 23-24 May.

Shukla M. K., Hukkum Singh, Design of Surface drainage System for Bhulandshahr Area, NIH Report CS (AR) 135 (1993-94).

Singh R. P., Field mannual on Watershed management, central Research Institute for Dry land Agriculture, Hyderabad, India 1990.

Soil Conservation Services(1972), 'National Engineering hand Book', Section 4, Hydrology, Washington, D. C.

Soil and Water conservation in dry land, MYRADA.

Soni B. and Dr. G. C. Misra, Soil and Water Accounting Using SCS Hydrologic Soil Classification, NIH Report CS-15(1985-86).

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Appendix I

WATERSHED:		VILLAGE:	
Sl. No.	**Structure**	**Sl. No.**	**General**
1	Technology	1	No. of rainy days
2	Age in Years	2	Drought years
3	Location	3	Running days of Nalas and its level
4	Purpose	4	Flooding situation of flood plains
5	Approximate Cost	5	Max. and Min. Water table level and month
6	Working Status	6	Frequency of drying of wells
7	Defective/Effective		
8	Management		
9	Assistance Needed		
10	Recommendation		

Appendix II- a

Estimation of Runoff by SCS method
Watershed- Somadevarhatti
Rain gauge Station- Bijapur

Year	Month	Days	Rainfall (mm)	AMC	CN	Runoff (mm)
1947	January	1	1.00	I	58	0.000
		30	3.00	I	58	0.000
		31	20.30	I	58	0.020
	Mar.	3	12.70	I	58	0.000
		26	7.10	I	58	0.000
		27	1.50	I	58	0.000
		30	10.10	I	58	0.000
	April.	6	2.50	I	58	0.000
		16	6.30	I	58	0.000
	May	9	7.10	I	58	0.000
		17	1.20	I	58	0.000
		18	0.70	I	58	0.000
		21	24.80	I	58	0.216
	June	7	0.70	I	58	0.000
		8	18.70	I	58	0.001
		13	0.70	I	58	0.000
		19	22.80	I	58	0.103
		21	10.40	I	58	0.000
		23	11.90	I	58	0.000
		27	14.40	I	58	0.000
		29	20.00	I	58	0.014
	July	11	9.10	I	58	0.000
		16	2.70	I	58	0.000
		17	2.20	I	58	0.000
		21	0.50	I	58	0.000
		23	1.20	I	58	0.000
		24	1.00	I	58	0.000
		29	0.70	I	58	0.000
		31	3.00	I	58	0.000
	Aug.	2	2.00	I	58	0.000
		3	0.70	I	58	0.000
		5	0.20	I	58	0.000
		8	0.50	I	58	0.000
		9	7.30	I	58	0.000
		11	25.90	I	58	0.294
		12	14.40	I	58	0.000
		15	23.30	II	76	2.445
		16	1.70	III	89	0.000
		17	7.60	II	76	0.000

		19	1.70	I	58	0.000
		21	13.20	I	58	0.000
		22	12.90	I	58	0.000
		23	3.30	I	58	0.000
	Sept.	1	0.70	I	58	0.000
		13	5.80	I	58	0.000
		14	16.70	I	58	0.000
		15	1.00	I	58	0.000
		16	1.70	I	58	0.000
		17	5.00	I	58	0.000
		18	25.90	I	58	0.294
		19	10.10	II	76	0.053
		20	13.70	II	76	0.375
		22	11.40	II	76	0.137
		27	13.20	I	58	0.000
	Oct.	6	0.50	I	58	0.000
		16	2.70	I	58	0.000
		17	5.00	I	58	0.000
	Nov.	10	7.60	I	58	0.000
		11	1.20	I	58	0.000
	Dec.	15	0.70	I	58	0.000
		18	3.30	I	58	0.000
	Total		459.20			3.951
1964	Aprl.	106	15.00	I	58	0.000
		119	18.00	I	58	0.000
	June	160	25.80	I	58	0.287
		169	25.00	I	58	0.229
	July	19	19.20	I	58	0.004
		22	22.00	I	58	0.069
		23	19.60	II	76	1.461
		24	8.60	I	58	0.000
		25	9.00	II	76	0.012
		26	1.00	II	76	0.000
		27	8.40	I	58	0.000
		28	48.00	I	58	4.105
		29	20.00	III	89	5.891
		30	176.00	III	89	146.292
		31	16.00	III	89	3.737
	Aug.	1	4.00	III	89	0.023
		5	2.00	III	89	0.000
		6	19.00	I	58	0.002
		7	1.60	I	58	0.000
		18	13.40	I	58	0.000
		29	4.80	I	58	0.000
		30	4.20	I	58	0.000
		31	16.20	I	58	0.000
	Sept.	1	37.20	I	58	1.745

		2	0.00	III	89	0.000
		3	0.00	III	89	0.000
		4	27.80	III	89	10.849
		5	14.00	III	89	2.792
		6	36.00	III	89	16.806
		7	38.00	III	89	18.343
		11	22.40	III	89	7.324
		13	38.00	I	58	1.889
		14	52.60	III	89	30.257
		18	2.00	III	89	0.000
		28	2.40	I	58	0.000
		29	113.40	I	58	32.360
		30	15.00	III	89	3.252
	Oct.	1	12.40	III	89	2.110
		2	26.00	III	89	9.633
		3	117.00	III	89	89.252
		5	5.20	III	89	0.127
		7	14.40	III	89	2.973
		12	3.00	I	58	0.000
		13	5.20	I	58	0.000
		29	5.00	I	58	0.000
		30	13.00	I	58	0.000
	Nov.	8	0.20	I	58	0.000
		9	43.00	I	58	2.904
	Dec.	24	9.70	I	58	0.000
		25	12.20	I	58	0.000
	Total		1161.90			394.725
1992	May	17	10.2	I	58	0.000
		26	7	I	58	0.000
	June	11	15	I	58	0.000
		23	7.2	I	58	0.000
	July	11	2.5	I	58	0.000
	Aug.	1	1.4	I	58	0.000
		4	0.5	I	58	0.000
		11	1.8	I	58	0.000
		29	0.8	I	58	0.000
	Sept.	1	11.5	I	58	0.000
		18	14	I	58	0.000
		20	6	I	58	0.000
		21	13.6	I	58	0.000
		23	10.6	I	58	0.000
		30	6.4	I	58	0.000
	Oct.	1	3	I	58	0.000
		6	7.5	I	58	0.000
		10	7.2	I	58	0.000
		24	4.3	I	58	0.000
		26	1.2	I	58	0.000

Nov.	9	6.2	I	58	0.000
	17	13.2	I	58	0.000
	18	63.2	I	58	8.777
	19	18	III	89	4.775
	20	8.5	III	89	0.782
Total		240.800			14.333

Appendix II- b

Estimation of Runoff by SCS method
Watershed- Hirehalla
Rain gauge Station - Kendgal

Year	Month	days	Rainfall (mm)	AMC	CN	Runoff (mm)
1973	June	3	3	I	67	0.000
		26	2	I	67	0.000
		27	4	I	67	0.000
		28	6	I	67	0.000
	Aug.	1	17	I	67	0.156
		2	33	I	67	2.884
		4	2	II	83	0.000
		5	37	II	83	12.062
		6	34	III	93	20.108
		20	18	I	67	0.231
		21	21	I	67	0.539
	Sept.	16	13	I	67	0.002
		17	8	I	67	0.000
		18	16.3	I	67	0.111
		29	6	I	67	0.000
		30	31	I	67	2.381
	Oct.	1	4	II	83	0.000
		2	57	II	83	25.842
		3	5	III	93	0.429
		5	2	III	93	0.000
		6	18	III	93	7.352
		9	8	I	67	0.000
		10	2	I	67	0.000
		18	6	I	67	0.000
		22	7	I	67	0.000
		23	8	I	67	0.000
		24	21	I	67	0.539
		25	7.9	II	83	0.133
		26	12	II	83	0.786
		27	26.8	III	93	14.076
		28	3	III	93	0.059
		29	51	III	93	35.329
	Nov.	1	5	III	93	0.429
		2	7	III	93	1.070
			502			124.5175209

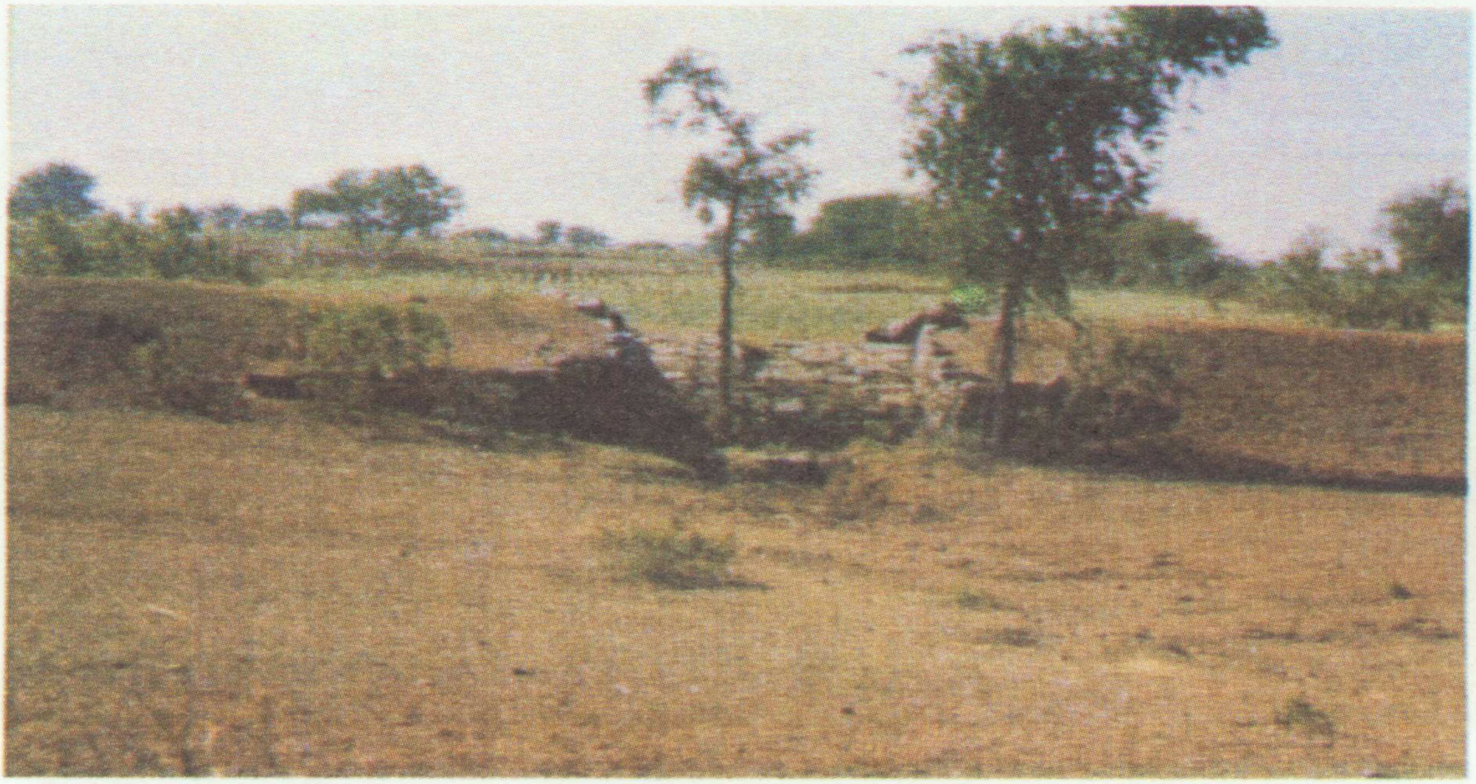
1980	Apr.	4	4	I	67	0.000
		17	10.2	I	67	0.000
		26	13	I	67	0.002
	May	2	12.2	I	67	0.000
		18	2.3	I	67	0.000
	June	2	2	I	67	0.000
		3	6.3	I	67	0.000
		5	4.1	I	67	0.000
		12	6.1	I	67	0.000
		27	0.1	I	67	0.000
	July	6	0.1	I	67	0.000
		27	0.2	I	67	0.000
		31	0.1	I	67	0.000
	Aug	11	20	I	67	0.423
		18	13.3	I	67	0.005
	Sept.	20	11.4	I	67	0.000
		25	30.4	I	67	2.238
		27	17	I	67	0.156
		29	3.2	II	83	0.000
			156			2.824
1991	Apr.	4	3.6	I	67	0.000
		21	7	I	67	0.000
		25	4.1	I	67	0.000
		29	2.8	I	67	0.000
	May	7	4	I	67	0.000
		12	6	I	67	0.000
		14	7	I	67	0.000
		22	2	I	67	0.000
		30	1	I	67	0.000
	June	6	35.4	I	67	3.540
		7	6.8	II	83	0.048
		8	4.7	II	83	0.000
		9	2.3	II	83	0.000
		22	4.2	I	67	0.000
		24	12.8	I	67	0.001
		27	64.2	I	67	15.113
		28	76.6	III	93	59.466
		29	61	III	93	44.644
		30	1.3	III	93	0.000
	July	1	9.9	III	93	2.354
		2	5.8	III	93	0.657
		6	2.3	I	67	0.000
		8	3.2	I	67	0.000
		12	12.2	I	67	0.000
	Aug.	2	15.3	I	67	0.061
		3	8.6	I	67	0.000
		6	1.4	I	67	0.000

	8	6.3	I	67	0.000
	9	7.2	I	67	0.000
	10	10.8	I	67	0.000
	11	8	I	67	0.000
	14	9.2	I	67	0.000
	15	1.3	I	67	0.000
	18	3.5	I	67	0.000
Sept.	16	6.4	I	67	0.000
	18	14.4	I	67	0.028
	22	2.6	I	67	0.000
	23	9.4	I	67	0.000
	25	7.8	I	67	0.000
Oct.	4	3.4	I	67	0.000
	16	17.8	I	67	0.215
		473.6			126.125614

Storage Tank

Check Dam

Existing Water Harvesting Structures



Field Bund with Surplussing arrangement

Diversion Nala

Existing Soil and Water Conservation Structures

Existing Soil Conservation structures

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