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TANK STUDIES IN BELGAUM DISTRICT

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CHAPTER I

1.0. Introduction.

Water, besides being essential for sustaining of life, is an important input in a number of economic activities. Due to its scarcity in many regions of the world and increasing depletion in other regions because of growing population greater emphasis is being placed on better understanding of the hydrologic cycle for a complete quantitative estimation of the yield from a catchment. A knowledge of estimation of yield can give a significant contribution towards the better resource management of reservoir, irrigation tanks and ground water resources.

A tank is a small reservoir behind an earthen embankment. The tanks have been the traditional sources of irrigation and drinking water in the areas of low and erratic rainfall for many centuries and have played an important role in providing substantial protection to the drought prone area and sustaining the rural economy.

Tanks are a common feature of the south Indian cultural land scape and are built in the 18th and 19th centuries by the Kings, Zamindars and to some extent by the British rulers. The tanks are one of the important and oldest source for irrigation and domestic use. Though the tanks are found in all parts of India, they are mainly concentrated in South Indian states, Viz: Andhra Pradesh, Karnataka and Tamilnadu. The concentration is very high in these states because of the topographical features. They also help to conserve the locally produced runoff for the irrigation and for drinking purposes in arid and semi arid areas. The average annual rainfall of this part of the country is 500mm to 900mm. Most of the rainfall is received during the four months of South-West and North-East monsoon benefits the tank filling. Variation in the rainfall in the monsoon period heavily influences the tank filling and the tank irrigation. It was observed that in a 10 years period, two years the tank get full supply, three years complete failure and in the rest five years, the tank get inadequate filling (Palaniswamy, 1990).

The tanks have been classified based on the source of supply and command area for which tank supply water for irrigation.

1. Based on source of supply

In this group, tanks can be placed under system and non-system based on the source of supply.

The system tanks are those tanks which receive supplemental water from nearby streams in addition to the yield from their own catchments. This supplemental flows help in stabilising irrigation supplies and in most cases lead to an additional crop possible. Irrigation through system tanks is possible even if there is no rain in the location of the tank but due to the water from the feeder streams.

Non-system tanks depend mainly upon the rainfall in their own catchments. These tanks are not connected to any river system. But a non-system tank may receive the surplus water from an upstream tank of the same kind. Mostly single crop is generally possible through non system tank. During the years of excess rainfall, a second crop is possible if the tank gets a second filling in a year.

2. Based on command area

For any irrigation system, storage constitute the main item. Of late, an irrigation project has been classified based on the command area for which the tank supply water for irrigation. They are,

I). Minor irrigation scheme : This scheme cover the command area to an extent of 2000 ha.

II).Medium irrigation scheme : Irrigation scheme covering command area between 2000 ha to 10,000 ha.

III). Major irrigation scheme : The command area under this scheme is more than 10,000 ha, with water distribution through the system of canals.

1.1 Tank Irrigation in Karnataka

Karnataka State has a well kint system of irrigation tanks constructed since a long time for the purposes of storing surface water for irrigation. Out of the geographical area of 1,92,791 sq.km., the net sown area of the state is 10.6 M.ha and nearly 75% of this is drought prone. It is interesting to note that the tank construction began during the 4th century A.D. by Kadamba Rulers. The Kadamba, Ganga, Chalukya, Rashtrakuta, Hoysala, Vijayanagar, Bana, Chola and Mysore Rulers have contributed to the construction of tanks mostly in the Southern Karnataka. Construction of tanks was at its peak during the 11th, 12th and 13th centuries. According to Kuppaswamy (1980-81), the dynasty wise tanks construction are listed below

Hoysala	215
Vijaynagar	77
Gangas	23
Chalukyas	27
Cholas	20
Rashtrakuta	4
Kadamba	7
Yadavas	8
Mis (Mysore State)	163

The state receive generally the south-west monsoon from June to September and there is great need for proper management of these monsoon flows. The annual normal rainfall of the state is 1138 mm and rainfall varies from 569 to 4029 mm. About 70% of the annual normal rainfall is received during south-west monsoon, about 17% during North-East monsoon and the remaining is received during pre-monsoon period. The erratic behaviour of rainfall has resulted in uncertainty in crop production both under rainfed as well as irrigated areas. More than 2/3 of the total geographical area of the state receives an annual rainfall of about 750 mm or less. The major parts of the districts like Bangalore, Kolar, Tumkur, Chitradurga, Bellary, Raichur, Gulburga, Bidar, Belgaum, Bijpur and Dharwad are falls under chronically drought prone areas. Even the assured rainfall regions of the state like Dakshina Kannada and Uttara Kannada and Kodagu districts experience drought in some years. Though the surface water resource is about 97,000 MCM, out of which, only about 48,000 MCM has been utilised. The irrigation potential from surface water is estimated at 4.5 M.ha. The irrigation through the system of tanks is about 1 M.ha. Though the groundwater resources of the state cannot be termed as very good due to topographical and geological factors, it has considerable ground water resources in certain areas only. It is estimated that about 1M.ha of area can be brought under irrigation using the available groundwater resources. By March 1988, under minor irrigation scheme, an irrigation potential of 0.85 M.ha had been created. Whereas an irrigation potential of 0.65 M.ha is already in practice using the groundwater sources.

The present study is carried out using the data of tank which is located near Belgaum city. The main purpose of this tank is to supply water to the Belgaum city for domestic purposes. In the recent past, it is observed that the amount of water stored during the monsoon season is not sufficient for the domestic purpose in the city throughout the year. Keeping this in mind, a study is planned to estimate the dependable yield of the tank and also the evaporation from the tank. The data required for the study was collected from the Department of Karnataka Urban Water Supply and Drainage Board (KUWS&DB), Belgaum and WRDO Bagalkot.

The catchment area of the tank is 80 sq.km. The major part of catchment area lies in Maharashtra state. The catchment receives rainfall during the monsoon (June to Sept) with the mean annual rainfall of about 1800 mm. The soil in the catchment varies from red sandy soil to red sandy loam. The major crops of the area is Ground nut and sugarcane.

CHAPTER II

2.0. Literature Review

It is well known fact that the technology of utilising runoff water is deeply rooted in Indian culture and some of the tanks have inscription dating back one thousand years ago. Historians and anthropologists have pointed out that there is a dialectic relationship between population and tank irrigation, which are reinforcing one another. Here are some of the excerpts of the study carried out by different researchers on tank irrigation, water utilisation and the managerial activities of tank water from time to time.

Mayya (1987) has analysed a single tank system with the available field data and then a system of ten tanks under the influence of a medium size reservoir. A linear programming model was developed for an existing single independent tank considering different parameters. The economic optimisation model maximises the net returns from the irrigated crop under the influence of the prevailing agricultural technology, food practices of people, fodder for the livestock, human and animal energy inputs etc. An attempt is also made to analyse the effect of deficit water supply on irrigation, as well as delayed start of agricultural operations for rice crop on tank irrigation system under different irrigation efficiency levels. The effect of drought on the irrigation system relating to Marconahally reservoir is also studied.

Van Oppen and Subba Rao (1987) scientists of ICRISAT have studied the status of tank irrigation in Andhara Pradesh and Maharashtra considering 32 surface water irrigation tanks. This study summarises four objectives, namely-

a) Geological distribution of tank irrigation in India.
b) Measuring the economics of tank irrigation.
c) Exploring the physical and administrative factors affecting the performance of irrigation tanks.
d) Proposing ways to improve tank irrigation or alternative watershed- management systems

Palanisami and Easter (1987) and Palanisami and Flinn (1989) have studied the tank irrigation system in Ramanathapuram district, Tamilnadu. This district falls into traditionally drought prone area. They have proposed mathematical models for economic utilisation of water from tanks as well as open wells to realize maximum yield of rice crop. The scientists have considered maximum number of parameters affecting tank irrigation process.

Reddy, et al., (1993) have studied different aspects affecting tank irrigation system in eight districts which are declared as drought prone area in Andhra Pradesh. According to them, incentives given to the farmers for utilisation of groundwater through open wells and tube wells have also affected traditional tank irrigation system. Also, they have suggested measures to improve tank irrigation system.

Lakshman Rao et al., (1990) applied watershed Bounded Network Model for small watersheds in Karnataka. The model uses the inherent and intimate relationship between the catchment geomorphology and its hydrological characteristics. Using the data of the small watersheds in Karnataka, they optimised the model parameters like 'c' and 'n'. Then the rainfall characteristics were related with that of the model parameter like 'c'. The optimised parameters values of 'c' and 'n' are, c = 1.68 and n = - 0.23.

Karmegam & Ravikumar (1990) used the simplified tank model to simulate the daily runoff of Adianallur tank near Madras with the total catchment of 6.85 sq.kms. The simplified model represent only surface runoff and infiltration i.e., the top tank. And the tank parameter like A0,A1,A2, SM, HA1 and HA2. This assumption is made since the catchment area is small, and the possibility of the sub-surface flows appearing in the outlet point is remote . Hence the only top tank is considered for the analysis. The results obtained by the study depicts that the shape of the observed and the estimated hydrographs are matching with the estimated error for the peak flow is 8.0% and the error in total volume of surface runoff is 2.5%.

A.D. Bapat and K.V. Raman Murthy (1990) formulated the following mathematical model to assess the inflow to the tank with inadequate data,

I = Qgate + Q weir + dL + E

where

I = Inflow

Q gate = Discharge through gate

Q weir = Discharge through weir

dL = storage per unit time

E = Evaporation

The results indicate that the inflow estimate using the proposed model are satisfactory and can be assumed to be realistic.

Sushma Hardikar and K.V. Ramana Murthy (1990) assessed the yearly water availability at Pagara Dam on Asan River. The study was conducted for 26 water years by formulating the mathematical formulae using the data of daily water level, storage and outflows from the tank. The mathematical formulae is

Inflow = dL + evap + $disch_i$ + $disch_w$

where

Inflow = Inflow volume into the reservoir

dL = Change in reservoir storage

Evap = Evaporation

$Disch_i$ = Release from reservoir for irrigation

$Disch_w$ = Release over waste weir

A linear regression relationship was developed between annual weighed rainfall and yield at dam site for the year 1961-87. This relationship was used for the estimation of runoff for the years previous to 1961. Using the yield calculated, a probability analysis was made to estimated the dependable yield (107.48 MCM) from the lognormal distribution.

Govardhanaswamy (1994) carried out a study on economic feasibility of modernisation of tanks and water requirement for optimum yield of rice crop applying the SHAZAM model using the data of tanks in Bangalore, Kolar and Tumkur district. This study uses the feed back data obtained from the farmers coming under the command, regarding utilisation of water, crop rotation and fertilizers used. The study analysed the cost benefit for the modernisation of the tanks by improving the canals, desilting of the tanks and reclaiming the land which was occupied by the farmers. The study analyse the effect of the above factors with the rice crop grown in the command area.

CHAPTER III

3.0. DESCRIPTION OF STUDY AREA

The Rakaskop tank is built across Markandeya river which originates in the western ghat section of Maharashtra state and flows through the Belgaum district. The catchment area extends between 74° 18' to 74° 25' E longitude and 15° 45' to 15° 50' N latitude and encompasses an area 80 sq. Km.. The Markandeya river is one of the tributary to Ghataprabha river which joins near Gokak town in Belgaum district. The fig.1 shows the catchment area, the stream network in the catchment. The catchment receives rain during the monsoon season having an average of 1800 mm annually. The tank was constructed in 1970 with the main purpose of supplying the water to Belgaum city for domestic use and to Indian Aluminiun Factory for industrrial use. In recent times it is found that the water stored in the tank is not sufficient for which it was built. Keeping this in view, it was planned to carry out a study to estimate the yearly inflows into the tank and analyse the estimated series for the dependable yield. The details of the tank is given below

Embankment details

Type of the dam	Earthen dam
Length of dam	1175 fts
Height of dam	66 fts
Top width of dam	20 fts
Bottom width of dam	370 fts
U/S slope	1:3
D/S slope	1:2
Storage details	
Gross storage	587.00 MCft
Dead storage	17.80 MCft
Maximum submergence area	13.00 sq.miles

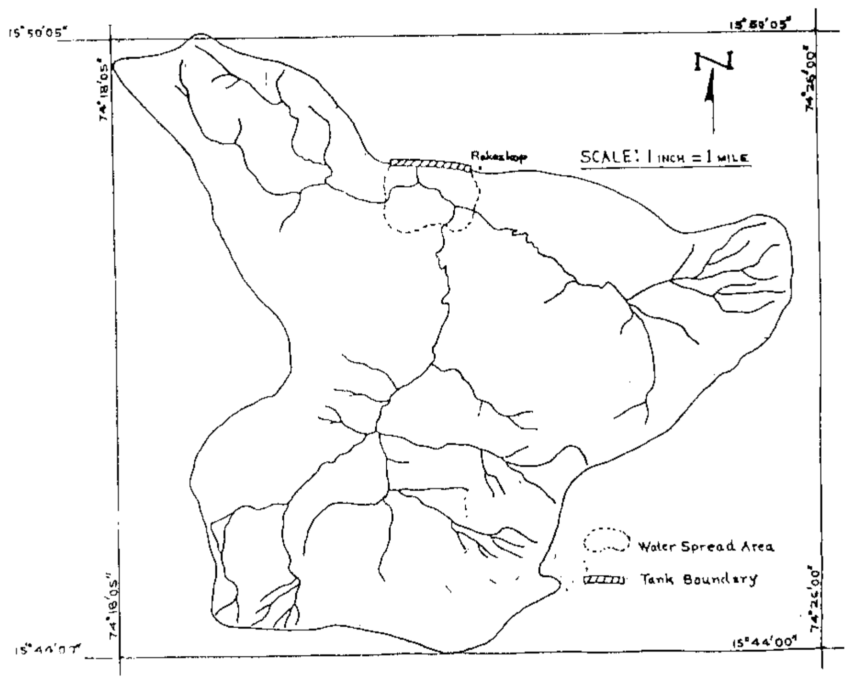

Fig. 1. Catchment Area of Rakaskop tank.

FSL	2475.00 ft
Sill level	2446.00 ft
Lowest level	2424.00 ft

A spillway is construct across the river. The spillway is operated by 3 gates. The details of the spillway is not available.

Soil : The type of the soil varies from red sandy soil to sandy loam having the average soil moisture retention capacity. The major crops of the area are Ground nut and two seasonal crop like sugarcane. The region is more potential for irrigation and mostly depend on the irrigation.

Land Use ; The upper part of the catchment is covered with the deciduous forest. The scrubs and degraded forest is occurs in southern and the western part of the catchment. Whereas the eastern part of the catchment is used for agricultural purpose.

Climatic condition over the study area

The catchment is mainly influenced by the south-west monsoon which normally sets in the mid June and recedes by the end of September. This four month rainfall accounts for about 89.26% (table.1) of the annual rainfall. Another 10.74% of the annual rainfall is spread over the rest of the year. The average rainfall over the catchment is about 2000 mms. This clearly indicates that, the generation of runoff from the catchment is restricted to monsoon period only. Whereas the low flows are observed in the stream till December. The temperature in the basin varies between 19.2° C to 29.5° C.

Table. 1. The annual rainfall distribution

Months	Rainfall	% of annual rainfall
Jan	1.411	0.062
Feb	0.028	0.0012
March	8.622	0.380
April	37.88	1.67
May	56.06	2.47
June	485.04	21.40
July	809.00	35.69
Aug	585.58	25.83
Sept	143.89	6.348
Oct	102.58	4.52
Nov	32.76	1.445
Dec	3.97	0.175

Water Utilisation of the Tank ; As it was stated earlier in this chapter, the tank water is supplied to Belgaum city for domestic use. Apart form this, the tank water being used for fish culturing at tank site and to Indian Aluminium Company. The table.2. describes the daily needs of individual consumers

Table.2. The different water users of Rakaskop Tank

Public water supply in Belgaum City	5 MGD
Supply to INDAL Company	5 MGD
Fish culturing and other uses	1 MGD
Total	11 MGD

CHAPTER IV

4.0. METHODOLOGY

4.1. Estimation of Inflow

Computation of daily inflows at various locations is required to know the quantity of water available for its optimal utilisation. The accuracy of annual/monthly yield assessment depends on the accuracy with which daily inflows are computed. To extend the observed series, various stochastic and deterministic models can be used effectively. The water movement in the basin is taken into account by the deterministic models either explicitly or implicitly. Generally, the explicitly accounting models require much more data than the implicit models. As a consequence, choosing a particular model, mostly depends on the availability of continuous records on various parameters. Some of the explicitly accounting models are Stanford Watershed model (SWM), Kentucky Watershed model (KWM) and SSARR model. Tank model is an example of implicitly accounting model. However, in many situations non-availability of data becomes a constraints in applying an elaborate deterministic models. This non-availability of data leads to develop simple procedures which make best use of the available data.

For the assessment of inflows into a reservoir, data on parameters such as precipitation, evaporation, gauging of the releases through the canals etc., are essential along with the elevation-area-capacity curve of the reservoir. If there is an ungauged weir, the values of the coefficients of the discharge should be computed from the records of observed discharges over the weir, if the weir rating curve is not available. In the absence of data on some of the above formulated parameters or in case of inadequacy of data for certain period for the same parameters, inflows(annually) into the reservoir may be estimated as described below

I = C A R

Where

I = Inflow estimated m3/sec

C = Inflow coefficient

R = annual rainfall (dependable)

A = Catchment area of the stream.

The values of inflow co-efficeint 'C' is obtained through an indirect estimation of inflow. This is done by conducting the water balance exercise of the project using the daily data of reservoir water level, evaporation and the outflows.

I = dL + ES + CR + CS + SP

I = Inflow

dL = Difference in daily tank water level.

ES = Evaporation

CR = Canal release

CS = Seepage loss

SP = Discharge through spillway or overflow.

Change in storage in the reservoir from previous day to the current day was found out using storage data. Based on the elevation in the reservoir, surface area and the corresponding storage is found out by interpolating the elevation-surface area-capacity table. This area is multiplied by the depth of the evaporation gives the evaporation volume.

Canal Releases

The volume of canal release can be calculated using the data of gate openings. When the water level is above the top of the gate level. The discharge through gate can be computed using the orifice formula.

$Q = 2/3\ C_d\ L\ (2g)^{1/2}\ (H_2^{2/3} - H_1^{2/3})$

where

C_d = Discharge coefficient

L = width of gate

g = Acceleration due to gravity

H_1 = Height of water column from the gate opening to water level in the tank

H_2 = Height of water column from the sill level of the gate to water level in the tank

When water level is below the top of the gate level, the discharge through gate

$Q = 2/3\ C_d\ L\ (2g)^{1/2}\ H^{2/3}$

where

H = Height of water column from sill level of the gate to water level

Discharge over the Waste Weir

Discharge over the weir can be estimated using weir equation

$Q_{weir} = C_d\ L\ H^{2/3}$

where

C_d = Discharge coefficient

L = Length of weir

H = Height of water column

Tank Seepage

In water budget method, it is likely that the inflow of surface and sub-surface flow will cause fluctuation of the tank water surface in addition to those due to evaporation. Under these circumstances, surface inflow and outflow and precipitation can be measured directly and used to correct the change of water level in the tank. The net sub-surface seepage can be evaluated by

$$dh = Ea + S$$

dh = is the net change of water surface elevation adjusted for surface inflow and outflow and the precipitation onto the water surface. An elevation volume curve for the tank is needed for the adjustment. During the period of no surface inflow or outflow. This is simply the fall of water surface which can be evaluated through repeated observation of water level as a graduated staff set in the reservoir.

Ea = Evaporation

S = Net ground water seepage

If dh is plotted against U2 ($e_{sa} - e_a$), where U2 is wind velocity and e_{sa} is vapour pressure of water surface and e_a is vapour pressure of air. The water level recession rate at the zero value of U2 ($e_{sa} - e_a$) is the seepage rate of that tank.

4.2. Statistical Analysis of the estimated inflows

Runoff into the tank is largely dependent on the intensity and duration of precipitation prevailed over the catchment apart from all other hydrological and catchment characteristics. Therefore it is stochastic in nature rather than deterministic. Hence water resources projects often require frequency analysis of magnitudes, volumes, duration or depth of hydrological variables. In most of the cases the frequency with which the flood of a particular magnitude will equalled or exceeded is frequently needed, but in the present study some of these techniques have been used for assessing the probable water available in the tank for the use. The methodologies used for estimation of probable water availability are (1) Plotting position method and (2) Probability Distribution. The methods are described below.

Plotting Position Methods

Plotting position method involves fitting of an assumed probability distribution to observed data. If the data is arranged in a descending order of magnitude, this will give an estimate of exceedence probability. Many plotting position formulas are available in various literature and three of then which are used here has been enumerated below

Weibull (1939)	M / (N+1)
Chegodayev	(M-0.3) / (N+0.4)
Hazen	(M-0.5) / N

where M is the rank of the proposed value and N is the total number of variables.

Probability Distribution

There are four principle characteristics or moments of probability distribution that is central tendency, dispersion, skewness and Kurtosis. Descriptive statistics is a current hydrologic practice and involves analysis of sequences to give observed distribution. Frequency distribution are available quite large number. Four of then which are used are described below

1. **Gauss or Normal Distribution**

The normal distribution has a symmetrical bell shaped probability density function having two parameters, the mean μ and the standard deviation σ . The function can be written as

$$f(x) = 1 / \sigma\sqrt{2\pi} * \text{Exp}[- (\{x - \mu\}/2\sigma)^2] ; \; - \infty < X < \infty$$

2. **Log-Normal Distribution**

Logarithmic transformation reduces the random variable to be approximately normally distributed. Therefore probability density function of a log normal distribution can be expressed as

$$f(x) = 1 / \sigma\sqrt{2\pi x} \; \text{Exp}[- (\text{Ln}\, x - \mu_y)^2/2\sigma_y^2] ; \quad X > 0$$

The parameters are μ_y and σ_y^2, which can be estimated by first transforming all of X_i's to Y_i's as

$$Y_i = \ln X_i$$

3. Gumbel Distribution

Gumbel (1958) has shown that the N largest values of a sub sample asymptotically follow an extreme value type I distribution with probability density function given as

$$f(x) = 1/\alpha \ \mathrm{Exp}[- \{(x-\mu)/\alpha\} - \mathrm{Exp}(- \{(x-\mu)/\alpha\})]$$

Where α and μ, are parameters of scale and location.

4. Pearson Type III distribution

This distribution is a three parameter Gamma distribution and its probability density function can be written as

$$f(x) = 1/ a\Gamma b \ \{ (x-c)/a)\}^{b-1} \ \mathrm{Exp} \{ -(x-c) / a\}$$

here a, b and c are scale, shape and location parameters respectively and $\Gamma(b)$ is a gamma function.

CHAPTER V

5.0. ANALYSIS OF DATA AND RESULTS

5.1. Hydrological data availability

The daily data of reservoir water level for 18 years from water year 1978 to 1995 are available. The elevation-area-capacity values of the tank, which are required in computing the volume of evaporation and inflow into the tank were taken from the literature provided by the Karnataka Urban Water Supply and Drainage Board, Belgaum. There is a ordinary raingauge station existing at the tank site for the daily measurments. The rainfall data of this station is available from 1978 onwards. Since there is no measurment of evaporation in the study area, the nearest evaporation station at Khanapur, for which daily pan evaporation data are available. These value are used in computing the evaporation from and the inflows into the tank.

5.2. Derivation of Water Balance componet for Rakaskop Tank

5.2.1. Computation of Evaporation from Tank

The availability of water over the year depends upon the spatial and temporal variation of precipitation. Because of the nature of monsoons over India, water may be abundant during the monsoon season viz, June to October and scarce during the non monsoon season, when it is most needed. The ingenuity of man, therefore, lies in his ability to modify the pattern of availability of water to suit the needs. One of the most common form of such modification is storage of water during the monsoon season and use it in the lean period. However, storage over the ground for irrigation, domestic and industrial consumption necessarily involves large losses, of which, the most important are evaporation and seepage. The evaporation losses are very high in a tropical country like India because of higher temperature, larger overall aridity and large number of sunshine days. The common man often fails to appreciate the magnitude of evaporation losses as the process takes place slowly and gradually. The annual evaporation losses from the reservoirs in arid and semi arid areas vary from 1.5 to 3 m, out of which about 50% of the evaporation may be in the summer months. Thus it is evident that evaporation is the prime cause of water loss from all water storage.

The most common method of estimation of evaporation from open reservoir surface is based on the data obtained from evaporation pans. For this purposes, the evaporation values from the pan is multiplied by a pan coefficients which is about 0.5 to 0.9. The result represents evaporation from larger surface or from the open water surface. This coefficient depends on the climate of the region being investigated, such that, the drier the climate, smaller the coefficient, and the wetter the climate, larger the coefficient.

In the present study area there is no measurement of pan evaporation. However, the pan evaporation values from the nearby station namely, Khanapur has been considered for the computation of evaporation. The pan coefficient considered for the present study is 0.7. The available computer programme was modified to compute the evaporation form the tank. The flow chart of procedure used in estimating the amount of evaporation from the tank is shown in the fig.2. In the present procedure, the daily water levels and the corresponding water spread area of the tank is considered for the computation of the evaporation. The estimated value of the evaporation is tabulated in the table.3.

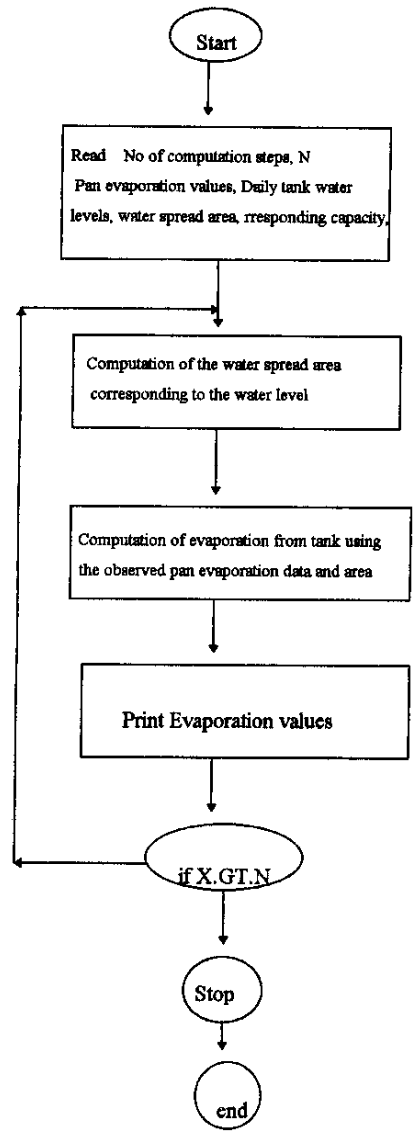

Fig.2. Flow Diagram for the Computation of Evaporation from tank Surface

Table. 3. Estimated amount of Evaporation from Tank

Sl.NO	Year	Observed Pan Evaporation at Khanapur in MM	Evaporation in MCFt
1	1978	1346.5	31.01
2	1979	1358.1	26.11
3	1980	1371.3	24.02
4	1981	1358.6	24.12
5	1982	1334.0	25.96
6	1983	1430.9	20.97
7	1984	1392.4	21.59
8	1985	1507.2	41.18
9	1986	1506.6	36.8
10	1987	1272.9	27.63
11	1988	1386.7	23.98
12	1989	1263.2	31.82
13	1990	1320.4	46.66
14	1991	1276.3	34.54
15	1992	1488.3	40.07
16	1993	1496.7	49.86
17	1994	1458.0	47.26
18	1995	1320.0	38.24

The table.3. indicates that the evaporation from the tank is as high as 50 MCFt and as low as 20 MCFt. Also, it is observed that, the evaporation from the tank is generally very high in the month of April to May. The inflows into the tank during the high evaporation time (April to May) is nil. Hence, huge amount of stored water is lost through the evaporation. This large amount of evaporation decreases the water availability in the tank, and at the same time, it create shortage in the water storage for the domestic supply.

5.2.2. Seepage for the tank

The information collected for the KUWS&DB, Belgaum, indicates that there is no seepage from the tank bed as the tank bad is covered by the massive hard rock. However, the water which is seeped through the embankment is not being measured at the tank site. The seepage loss through the embankment of tank is considered as the 0.01% of the daily outflow.

5.2.3. Canal Releases

This reservoir is mainly used for supplying water to Belgaum city for domestic purpose and Indian Aluminium Factory. The daily release (outflows) from the tank is almost constant and it accounts about 110 lakhs gallons (table 2). Based on the every day consumption (release) from the tank, the total yearly consumption would accounts to be 800 MCft.

5.3. Estimation of Annual yield

The estimation of the annual yield of the Rakaskop tank carried out using the water balance approach as described in chapter.4. The flow chart of the computer program (Majumdar, 1980) used for the computation of inflows is show in the fig.3. The data required for the estimation were collected from the Karnataka urban water supply and drainage board, Belgaum. The calculation is carried out using the area, capacity of the tank, increment of two successive daily water levels, daily evaporation losses, seepage loss, canal release and flow over the spillway. The calculation gives the total inflow into the tank. The table 4. shows the estimated inflow and rainfall for the different years considered for the study.

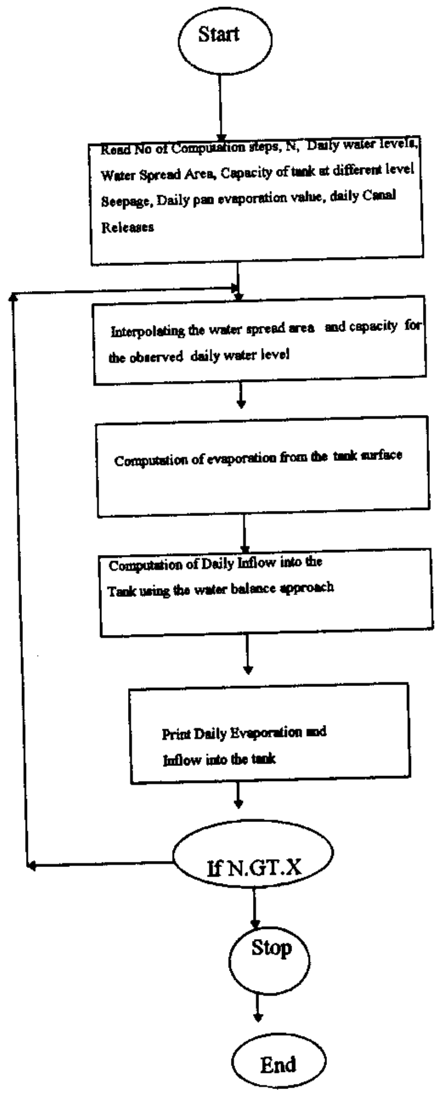

Fig. 3. Flow Diagram for the computation of Inflows into the tank

Table 4. Estimated Annual Yield of the Tank

Catchment Area Sq.Km	Year	Rainfall In Mts	Yield in MCFt	Evaporation MCFt	% of water lost through Evaporation
80.0	1978	2.76	809.016	31.01	3.833
	1979	2.29	638.716	26.11	4.080
	1980	2.92	647.293	24.02	3.710
	1981	2.60	742.203	24.12	3.249
	1982	2.48	1077.209	25.96	2.390
	1983	2.93	1175.473	20.97	1.783
	1984	1.95	839.23	21.59	2.570
	1985	1.86	928.71	41.18	4.434
	1986	1.65	931.924	36.80	3.948
	1987	1.50	659.4	27.63	4.190
	1988	2.28	820.75	23.98	2.921
	1989	1.66	817.921	31.82	3.890
	1990	2.05	796.39	46.66	5.858
	1991	2.41	935.199	34.54	3.693
	1992	2.40	1285.02	40.07	3.118
	1993	2.02	694.5	49.86	7.179
	1994	3.41	895.61	47.26	5.276
	1995	1.59	691.366	38.24	5.531

The table 4. depicts that the yield of the tank varies from 638 MCFt to 1285.02 MCFt , corresponding to the yield, the water lost through the evaporation is 4.1% and 3.1%. Whereas the water lost through evaporation is as high as 7.179%. This variation gives a fair idea of the yield and the water lost through the evaporation.

5.4. Yield Analysis

5.4.1. Probability Analysis

The results of the statistical analysis gives the following characteristics

Mean	854.736
Standard Deviation	181.212
Coef. Of Variability	0.212
Coef. Of Asymmetry	0.424

While checking the confidence limit for the mean value, it has been found that for 95% level of confidence the mean is within 764.61 to 944.85 Mcft and for 99% level of confidence, it is found that mean is within 730.95 to 978.51 MCft.

The results of the Empirical probability calculated from weibull, Chegodayev and Hazen methods has been tabulated in table.5. These are excedence probabilities, that is the probability of a value being greater than or equal to the ranked value. This shows that 75% dependable values on the basis of weibull plotting position method comes out to be 693.00 MCft, where as the other two method gives slightly higher side and is 694.50 MCft.

Table.5. Showing the excedence probabilities for different plotting position methods

Sl No	Variables	Emperical Probability		
		M/ (N+!)	(M-0.3)/(N+0.4)	(M-0.5)/N
1	1285.022	0.053	0.038	0.028
2	1175.473	0.105	0.092	0.083
3	1077.209	0.150	0.147	0.139
4	935.199	0.211	0.201	0.194
5	931.924	0.263	0.255	0.250
6	928.710	0.361	0.310	0.306
7	895.611	0.368	0.364	0.361
8	839.237	0.421	0.418	0.417
9	820.757	0.474	0.473	0.472
10	817.121	0.526	0.527	0.528
11	809.016	0.579	0.582	0.583
12	796.390	0.632	0.636	0.639
13	742.203	0.684	0.690	0.694
14	694.500	0.737	0.745	0.750
15	961.366	0.789	0.799	0.806
16	659.490	0.842	0.853	0.861
17	647.293	0.895	0.908	0.917
18	638.716	0.947	0.962	0.972

The probability distribution used are Gauss, Lognormal, Gumbel and Pearson distribution. These probability distribution was fitted using the derived statistical parameters from the yield series. The 75% dependable yield was estimated using these distributions is tabulates below. The estimated values of the yield using different distributions is presented in the fig. 4 to 7.

Gauss	676.94 MCft
Log Normal	678.44 MCft
Gumbel	686.01 MCft
Pearson Type III	675.75 MCft

From these observation, it is found that the results obtained from these estimation are nearly identical. Whereas the estimates of the plotting position methods gives a little higher values.

5.4.2. Best Fit Curves for the estimated Inflows

The best fit curves were fitted using the yearly values of average rainfall and the estimated inflow into the tank. The different fits were tried for the rainfall and inflow series, they are linear, power, logarithemic and exponential (fig.8 to 11). The relationship thus developed is tabulated with the coefficient of determination for the fit are listed in the table.6.

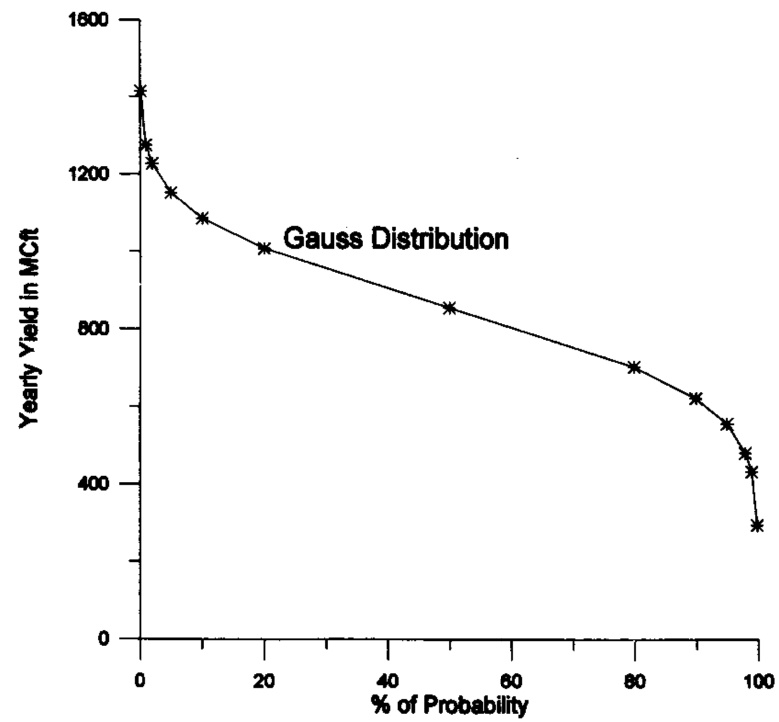

Fig.4. Showing the distribution of Yearly yield

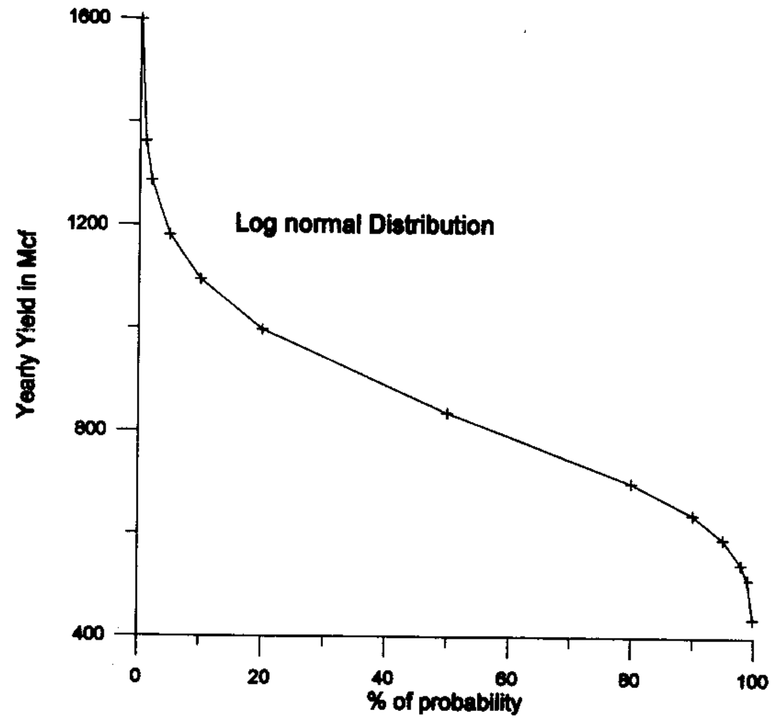

Fig.5 . Showing the Distribution of Yearly Yield.

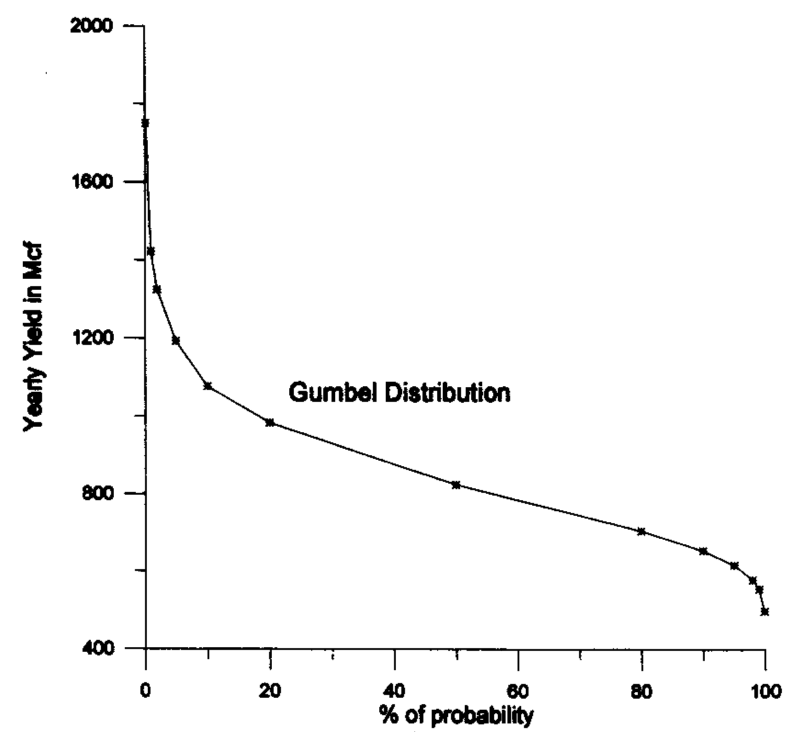

Fig. 6. Showing the Distribution of Yearly Yield.

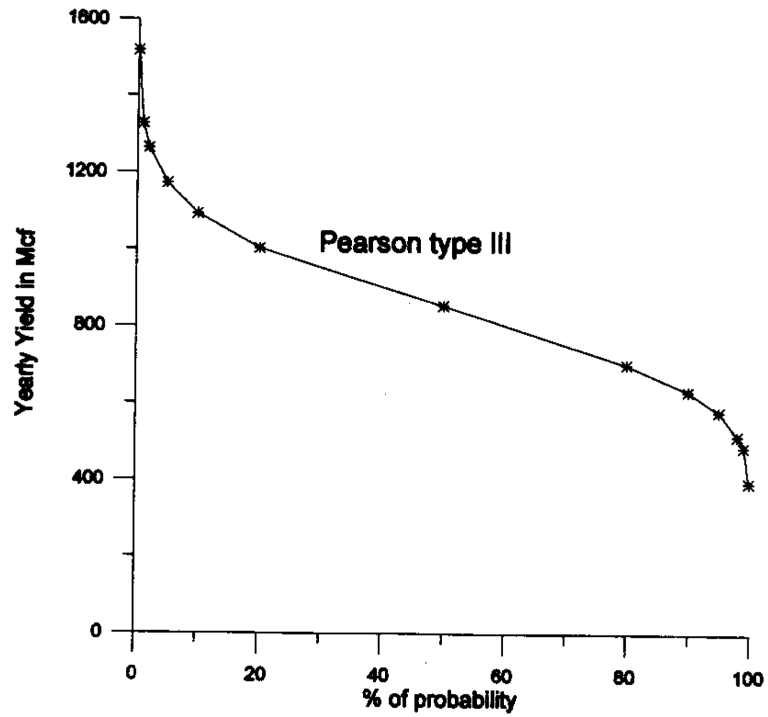

Fig.7 . Showing the Distribution of Yearly Yield.

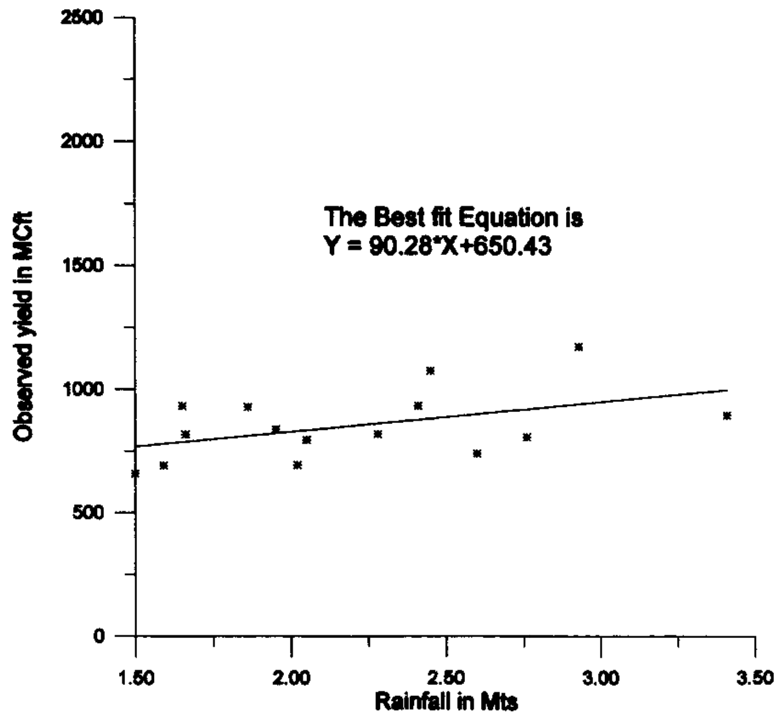

Fig. 8.The Linear relationship between rainfall and yield

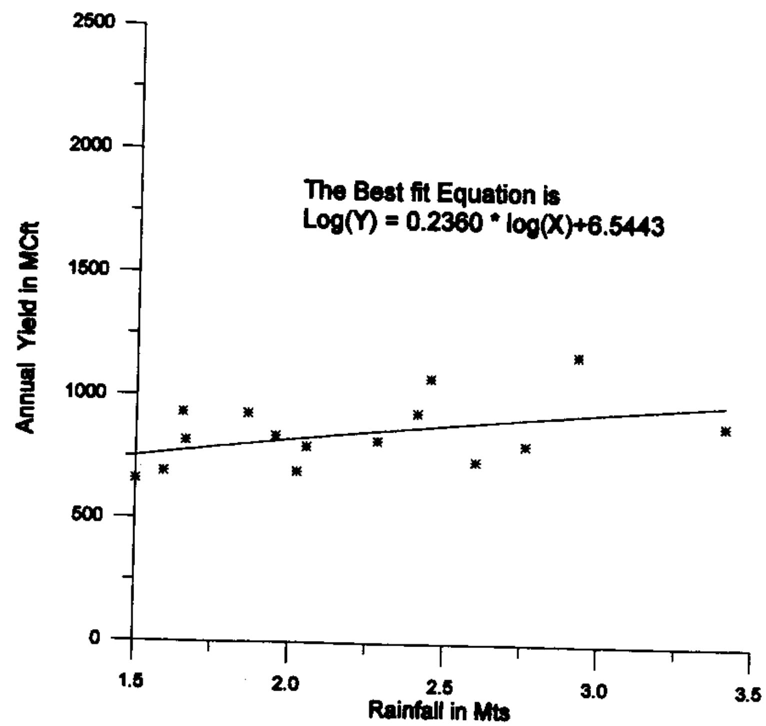

Fig.9. The Power relationship between rainfall and yield

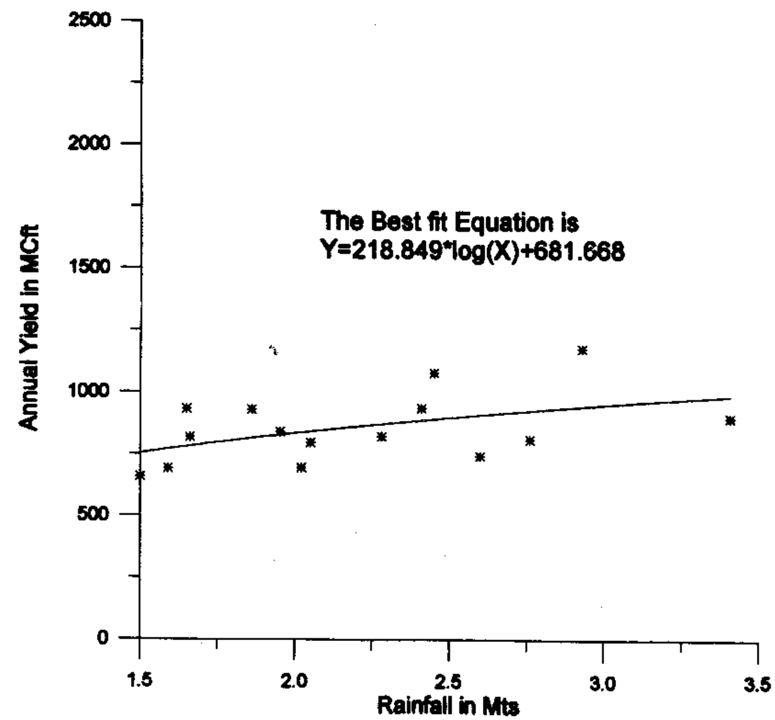

Fig.10. The logrithmic relationship between rainfall and yield

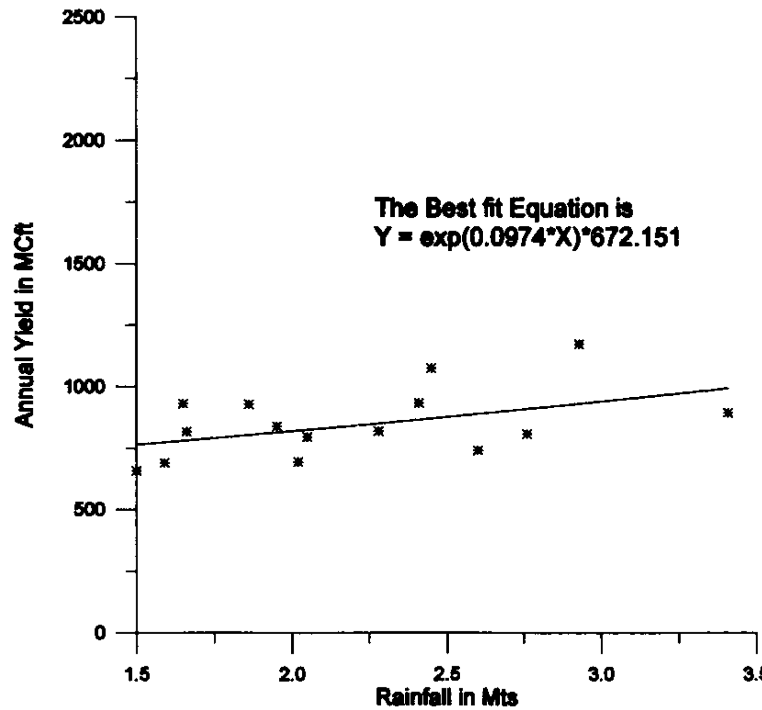

Fig.11.The Exponential relationship between rainfall and yield

Table.6. Best Fit Relationship derived using different fits.

Sl no	Best fit	Relationship	Coefficient of determination
1.	Linear	Y = 90.28 X +650.43	0.21766 (0.4665)*
2.	Power	log(Y) = 0.2360 * log(X) +6.5443	0.23888 (0.48875)*
3.	Logarithemic	Y = 218.849 * log(X) +681.668	0.231464 (0.4811)*
4.	Exponential	Y = exp(0.0974*X) * 672.151	0.2222 (0.4719)*

note. (*) is correlation coefficient

The relation established above gives an insight to the estimated yield series. The coefficient of determination for all the best fit varies from 0.21 to 0.238. Looking at this, it is noted that the yield series follows power or logarithmic relationship to some extent.

CHAPTER VI

6.0 Suggestions

The yield of the Rakaskop tank was estimated using the water balance approach. The results obtained are analysed for dependability. The estimates depicts that the 75% dependable yield is 680 Mcft. Where as the total utilisation (table.2.) works out to be 800 Mcft. Hence, it indicates that, there is a deficit of 120 Mcft of water. This deficit can be met by heightening the bund by 8ft at which an additional storage of 352.35 Mcft of water can be stored. On the other hand, this heightening by 8ft create a submergence of about 13 sq.mi of land. Since, the land on the fore ground of the tank is being used for agricultural purposes. In order to propose this heightening of the bund, a cost-benefit analysis should be carried out to know the benefits that are expected by impounding the water at the cost of the submerging agricultural land.

The estimates of the evaporation (table 3 & 4) indicates that the large amount of water is lost in the form of evaporation especially in the summer period, when there is no inflow into the tank. If the evaporation losses from the tank is minimised, that extra quantity of the water is available for the domestic and other use in the summer months.

Also, it is suggested that, an improved pipe line network is needed in the city to minimise the conveyance loss. It is also suggested that, the regression relationship established between rainfall and estimated yield using the logarithmic and power can made used for extending the yield series.

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