Application Of Arc Gis For Estimation Of Basin Potential (A Case Study - Kharun River Basin)

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Abstract: Application of ArcGIS for estimation of basin potential(a case study-Kharun river basin, Chhattisgarh, India) has been presented in this paper. The objective of the present work is to find out the balance water available in the basin after assessing the present water use including industrial water demand and projected water demand to be fulfilled by Kharun river. Water resources of the world in general and India are under heavy stress due to increased demand and limitation of available quantity. Sustainable water management of a river basin is required to be made to ensure a long-term stable and flexible water supply to meet crop water demands as well as growing municipal and industrial water demands

Geographic Information System (GIS) is one of the most simple and straightforward way of providing a management tool for planning of water allocation policy in irrigation system. ArcGIS application which allows user to access information and spatial analysis and produce results in the form of maps, tables and graphs to support planning and decision making.

The Arc GIS software is used for analysis. Scanned toposheets were georeferenced. Various thematic layers such as basin boundary, river, drainage, raingauge station, G&D sites, district boundary, schemes and anicuts location map were generated by digitization. The raingauge stations in and around Kharun river basin were considered for analysis. Theissen polygon is generated using raingauge station layer to find out the influencing area and the influencing factors of each raingauge station and by considering the annual rainfall and the influencing factor of each raingauge station, weighted rainfall is computed . Pathardih G&D site is considered for runoff analysis. The rainfall-runoff relation is established. This equation was linear in nature. 75% dependable rainfall is calculated and basin yield is also calculated. Balance water available is 710.32MCM.

Index Term-rainfall,runoff yield,Arc GIS,runoff coefficient,75%dependability

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1 Introduction

Water is one of the most important natural resources and a key element in the socioeconomic development of a state. Water resources of the world in general and India are under heavy stress due to increased demand and limitation of available quantity. Proper water management is the only option that ensures a squeezed gap between the demand and supply. Sustainable water management of a river basin is required to be made to ensure a long-term stable and flexible water supply to meet crop water demands as well as growing municipal and industrial water demands. Water resources structures need appropriate planning to ensure fulfillment of the goals of water management.

Geographic Information System (GIS) is one of the most simple and straightforward way of providing a management tool for planning of water allocation policy in irrigation system. ArcGIS application which allows user to access information and spatial analysis and produce results in the form of maps, tables and graphs to support planning and decision making. It also allows to make queries to the database in order to extract an answer for the future planning under wide range of different scenarios. The benefits with the use of ArcGIS in watershed and hydrologic analysis include improved accuracy less duplication, easier map storage, more flexibility, ease of data sharing, timeliness, greater efficiency and higher product complexity.

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Water resources development and management should be planned for a drainage basin as a whole after assessing the present water use and projected water use .

2 Study area

The study area, KHARUN RIVER BASIN forms a part of Seonath (A tributary of Mahanadi) river basin.The area selected for the study is the Kharun River Basin and is situated inside the Seonath basin of well known Mahanadi river basin in Chhattisgarh(India) . Entire study area of Kharun river basin falls within the state of Chhattisgarh. Kharun is one of the main tributary of Seonath river. It is a non-perennial river, originating from village Petechua of Balod Tehsil in the south-east of Durg district and after flowing about 164 km joins Seonath river near Somnath in the north. The total catchment area of Kharun river is 4191 km^2, lying upstream to the point where the river merges with Seonath river and is situated between the geographical co-ordinates 20^0 33' 30" - 21^0 33' 38" N latitude and 81^0 17' 51" E - 81^0 55' 25" E longitude. The gauge and discharge site of Central Water Commission on the river Kharun at "Pathardih", comprises an area of 2511 km^2.. The gauging site "Pathardih" is located at 21^0 20' 28" N latitude and 81^0 35' 48" E longitude. The study area falls in four districts viz.

Durg, Dhamtari , Raipur and Kanker covering 1978 km^2, 517 km^2 ,1684 km^2 and 13 km^2 areas respectively (Table 2.1).

Table 2.1: Area of different districts in Kharun river basin

Districts	Area (km^2)	Percentage of total area
Durg	1978	47.20
Dhamtari	517	12.33
Raipur	1684	40.18
Kanker	13	00.30

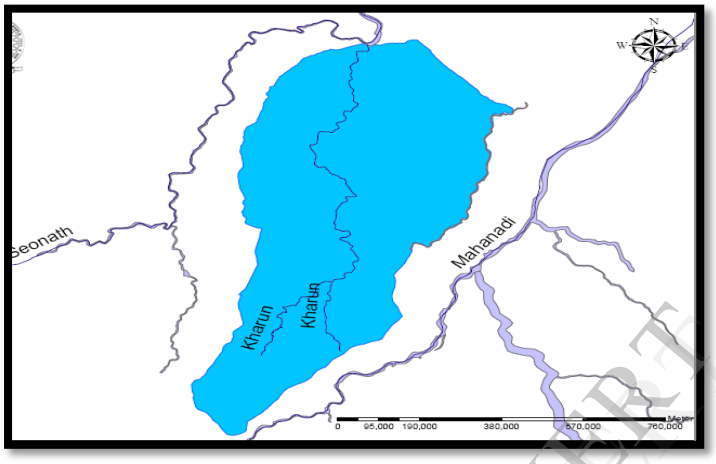

Figure 2.1KHARUN RIVER MAP

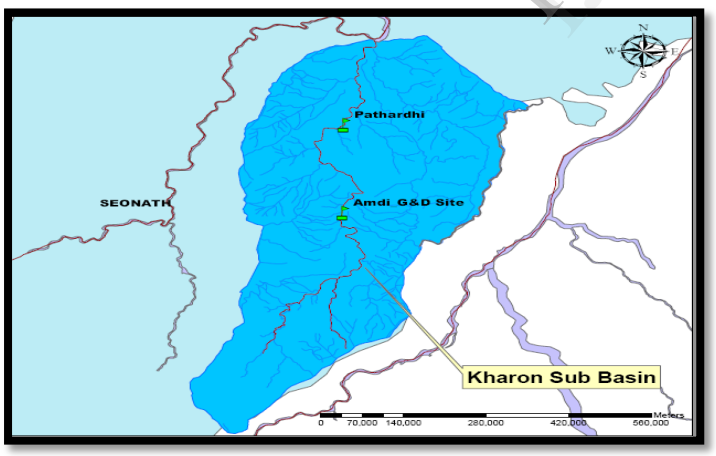

Figure 2.2G&D SITE IN KHARUN RIVER BASIN

3 Methodology and Analysis

Step wise methodology is as follows:

1. Collection of hydrologic data and details of existing, ongoing schemes .
2. Georeferencing of scanned toposheets.
3. Digitization of maps.
4. Delieation of basin.
5. Creating different layers.
6. Making attribute table for each layer.
7. Generating Theissen polygon.
8. Computation of weighted rainfall.
9. Computation of 75% dependability.
10. Computation of annual runoff.
11. Establishing rainfall runoff relationship and computation of runoff coefficient.
12. Computation of Yield of Basin
13. Calculation of total CCA created.
14. Computation of present water use.
15. Computation of Balance water available.

3.1DATA COLLECTION

The annual and monsoon runoff data were obtained from Central Water Commission, Raipur, Chhattishgarh .Rainfall data, details of schemes, toposheets were collected from Water resources Department, Govt. of Chhattisgarh.

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3.2 COMPUTATION OF AREA AND INFLUENCING FACTORS OF INFLUENCING RAINGAUGE STATIONS.

Area and influencing factors of influencing raingauge station were calculated and shown in Table 3.1

3.3 COMPUTATION OF WEIGHTED RAINFALL

Weighted rainfall is computed by considering the annual rainfall and influencing factor of the each raingauge station. The annual rainfall from 1975 to 2008 is generated for all raingauge stations. Considering the rainfall of each station and influencing factor raingauge station, weighted rainfall has been calculated .Initially 95% is considered monsoon rainfall of total rainfall.(shown in table 3.2)

3.4 COMPUTATION OF ANNUAL AND MONSOON RUNOFF

Annual and monsoon runoff of every year were calculated and shown in Table 3.3

3.5 ESTABLISHING RAINFALL RUNOFF RELATION

Rainfall and Runnoff relationship for annual and monsoon were established and shown in Figure 3.3

3.6 COMPUTATION OF 75% DEPENDIBILITY

75%dependable rainfall and 75%dependable monsoon rainfall were calculated. (shown in table 3.4)

3.7 COMPUTATION OF YIELD

By using Runoff rainfall equation runoff coefficient was calculated and Basin yield is also calculated(shown in table 3.4)

3.8 COMPUTATIO OF PRESENT WATER USE AND BALANCE WATER AVAILABLE

CCA created, water use by anicuts, annual industrial water demand and projected annual water demand to be fulfilled from kharun river and Present water use and Balance water in the river basin is calculated(shown in table 3.5)

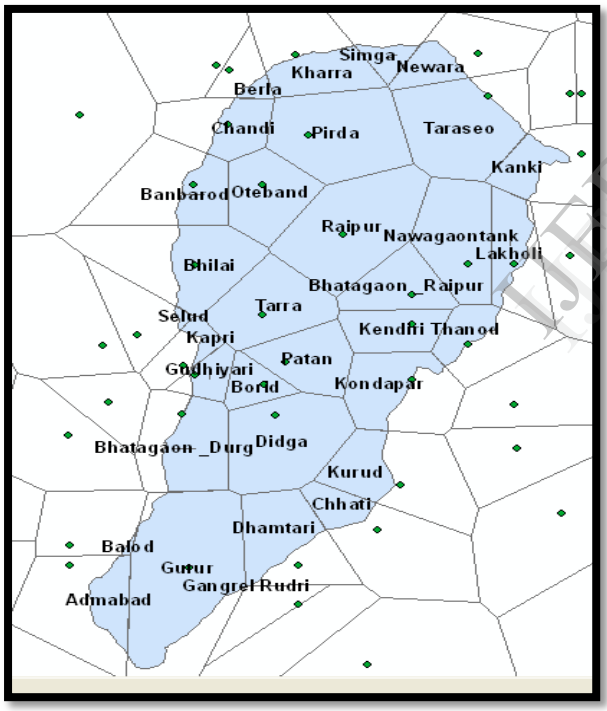

Figure3.1MAP SHOWING RAINGAUGE STATION& THEISSEN POLYGON OF KHARUN RIVERBASIN

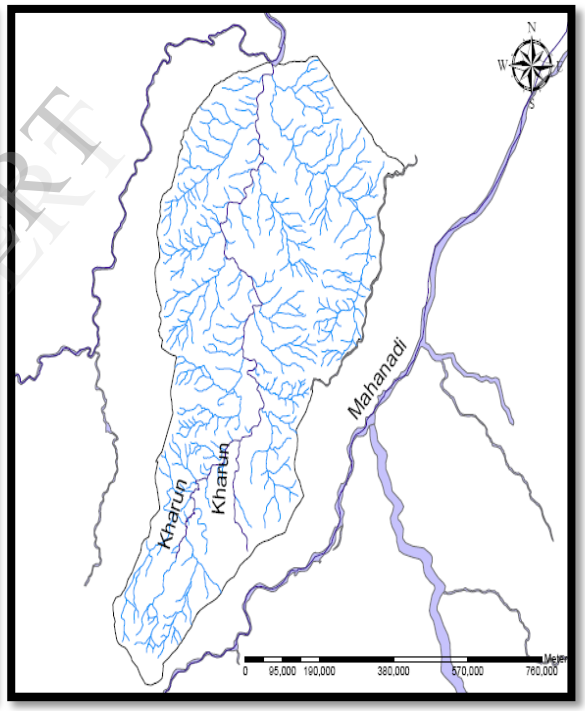

Figure3.2DRAINAGE MAP OF KHARUN RIVER BASIN

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Table 3.1 AREA OF INFLUENCING RAINGAUGE STATION AND THEIR INFLUENCING FACTORS

Sl.no	Name of the Raingaguge Stations	Name of the sub Basin	total area of the sub-basin in sq.km	Area of the Influence in sq.km	Influnce Factors
1	BHATAGAON	Kharun Basin	4191.303358	144.39733	0.034
2	SELUD	Kharun Basin	4191.303358	6.365273	0.002
3	BHILAI	Kharun Basin	4191.303358	161.754234	0.039
4	RAIPUR	Kharun Basin	4191.303358	336.353306	0.08
5	DHAMTARI	Kharun Basin	4191.303358	142.82085	0.034
6	SIMGA	Kharun Basin	4191.303358	36.568536	0.009
7	KURUD	Kharun Basin	4191.303358	100.275476	0.024
8	BHATAGAON (RAIPUR)	Kharun Basin	4191.303358	136.410874	0.033
9	CHHATTI	Kharun Basin	4191.303358	59.040725	0.014
10	PATAN	Kharun Basin	4191.303358	144.961978	0.035
11	GURUR	Kharun Basin	4191.303358	426.576394	0.102
12	Admabad	Kharun Basin	4191.303358	71.845511	0.017
13	Balod	Kharun Basin	4191.303358	3.594215	0.001
14	Banbarod	Kharun Basin	4191.303358	83.432449	0.02
15	Berla	Kharun Basin	4191.303358	14.693082	0.004
16	Borid	Kharun Basin	4191.303358	66.553708	0.016
17	Chandi	Kharun Basin	4191.303358	81.437157	0.019
18	Didga	Kharun Basin	4191.303358	279.231086	0.067
19	Gangrel	Kharun Basin	4191.303358	0.22243	0
20	Gudhiyari	Kharun Basin	4191.303358	49.603603	0.012
21	Kanki	Kharun Basin	4191.303358	71.21538	0.017
22	Kendiri	Kharun Basin	4191.303358	116.935462	0.028
23	Khapri	Kharun Basin	4191.303358	26.183493	0.006
24	Kharra	Kharun Basin	4191.303358	113.837232	0.027
25	Kondapar	Kharun Basin	4191.303358	131.323689	0.031
26	Lakholi	Kharun Basin	4191.303358	94.239368	0.022
27	Nawagaontank	Kharun Basin	4191.303358	224.060674	0.053
28	Newara	Kharun Basin	4191.303358	59.88518	0.014
29	Oteband	Kharun Basin	4191.303358	170.403817	0.041
30	Pirda	Kharun Basin	4191.303358	297.511742	0.071
31	Taraseo	Kharun Basin	4191.303358	266.380417	0.064
32	Tarra	Kharun Basin	4191.303358	209.749583	0.05
33	Thanod	Kharun Basin	4191.303358	63.439102	0.015
				4191.303356	

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TABLE 3.2 WEIGHTED RAINFALL

Sl.NoS	Year	Weighted Rainfall in mm	Weighted Mansoon Rainfall in mm
1	1975	839.27	797.31
2	1976	742.39	705.27
3	1977	829.11	787.65
4	1978	817.23	776.36
5	1979	543.93	516.74
6	1980	918.85	872.91
7	1981	673.52	639.84
8	1982	656.65	623.81
9	1983	719.53	683.55
10	1984	707.51	672.13
11	1985	793.80	754.11
12	1986	721.03	684.98
13	1987	580.46	551.43
14	1988	451.35	428.78
15	1989	630.25	598.73
16	1990	924.74	878.51
17	1991	698.26	663.35
18	1992	717.71	681.83
19	1993	707.25	671.89
20	1994	1109.08	1053.63
21	1995	703.54	668.36
22	1996	667.27	633.90
23	1997	723.82	687.63
24	1998	705.14	669.89
25	1999	684.23	650.01
26	2000	485.04	460.79
27	2001	713.25	677.59
28	2002	555.94	528.14
29	2003	888.07	843.67
30	2004	664.26	631.05
31	2005	952.45	904.83
32	2006	663.55	630.38
33	2007	778.19	739.28
34	2008	634.70	602.96

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Table 3.3 ANNUAL AND MONSOON RAINFALL AND RUNOFF

Year	Annual Volume (MCM)	Mansoon Volume (MCM)	Percentage of Mansoon Rainfall to Total Annual Rainfall	Annual Runoff depth in (MM)	Mansoon Runoff depth in (MM)	Percentage of Mansoon Runoff to Total Annual Runoff	Annual Rainfall in mm	Mansoon Rainfall in mm
1991	1087.9	1006.6	92.52689	433.3	400.9	92.5225	698.26	646.052
1992	1315.9	1250.4	95.02242	524	496	94.65649	717.71	679.3616
1993	819.5	668.7	81.59854	326.3	266.3	81.61201	707.25	577.2045
1994	2148.1	1992.9	92.77501	855.2	793.7	92.8087	1109.08	1029.324
1995	1392	1194.3	85.79741	554.4	475.6	85.78644	703.54	603.5394
1996	824.5	682.1	82.72893	328.5	271.6	82.67884	667.27	551.6889
1997	800.6	691.6	86.38521	318.8	275.4	86.38645	723.82	625.2861
1998	559.7	378.1	67.55405	222.6	150.6	67.65499	705.14	477.0644
1999	817.8	701.4	85.76669	325.7	279.3	85.75376	684.23	586.7495
2000	385.2	370	96.054	153.4	147.4	96.08866	485.04	466.0687
2001	1066.3	973.9	91.33452	424.6	387.9	91.35657	713.25	651.6015
2002	317.3	254.8	80.30255	126.4	101.5	80.30063	555.94	446.4244
2003	1175.9	939.8	79.92176	468.3	374.3	79.9274	888.07	709.814
2004	899.6	826.9	91.91863	358.2	329.3	91.93188	664.26	610.6672

Catchement Area: in SQ.KM 2511

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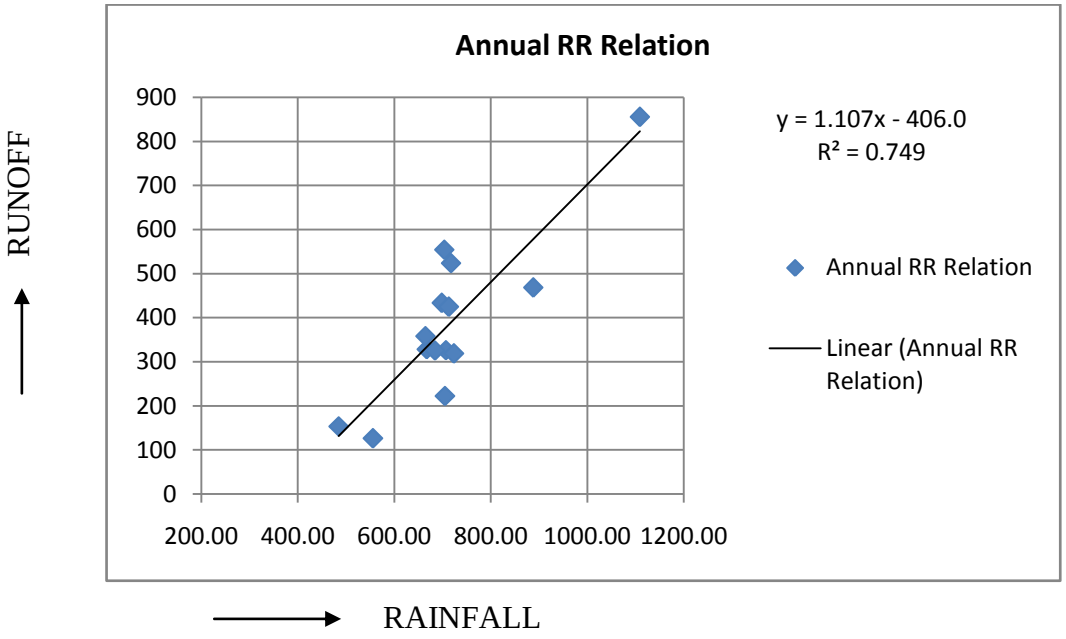
FIGURE 3.3 ANNUAL AND MONSOON RAINFALL- RUNOFF RELATION GRAPH.



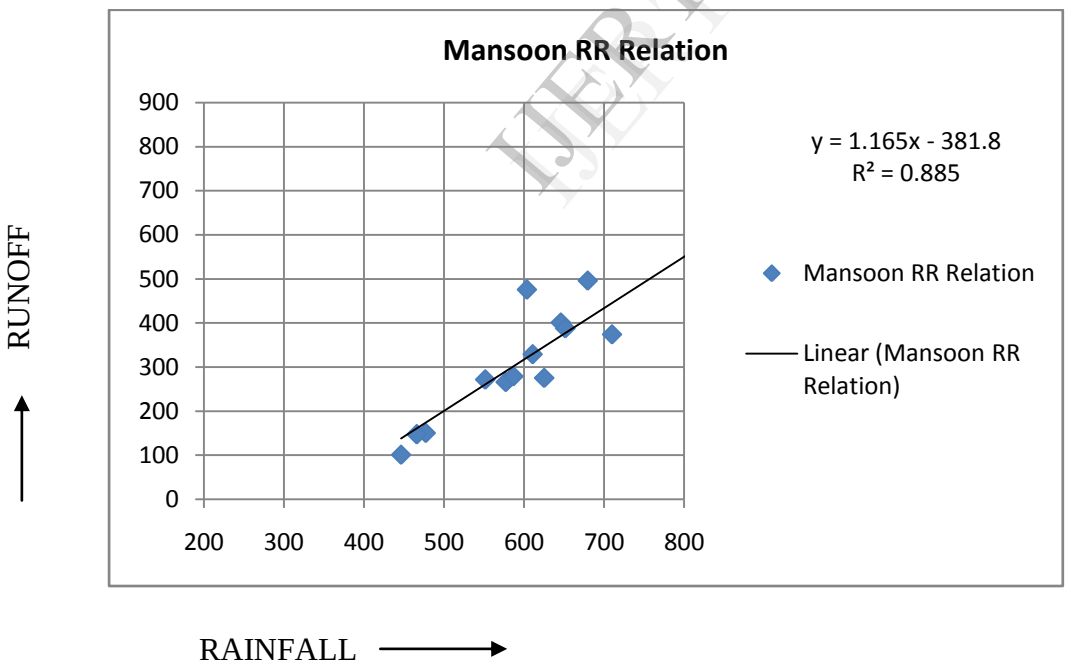


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Table 3.4 ANNUAL AND MONSOON KHARUN RIVER BASIN YIELD.

Sl.No	Year	Weighted Rainfall in mm	Weighted Mansoon Rainfall in mm	%Dependability
1	1994	1109.08	1053.63	2.94
2	2005	952.45	904.83	5.88
3	1990	924.74	878.51	8.82
4	1980	918.85	872.91	11.76
5	2003	888.07	843.67	14.71
6	1975	839.27	797.31	17.65
7	1977	829.11	787.65	20.59
8	1978	817.23	776.36	23.53
9	1985	793.80	754.11	26.47
10	2007	778.19	739.28	29.41
11	1976	742.39	705.27	32.35
12	1997	723.82	687.63	35.29
13	1986	721.03	684.98	38.24
14	1983	719.53	683.55	41.18
15	1992	717.71	681.83	44.12
16	2001	713.25	677.59	47.06
17	1984	707.51	672.13	50.00
18	1993	707.25	671.89	52.94
19	1998	705.14	669.89	55.88
20	1995	703.54	668.36	58.82
21	1991	698.26	663.35	61.76
22	1999	684.23	650.01	64.71
23	1981	673.52	639.84	67.65
24	1996	667.27	633.90	70.59
25	2004	664.26	631.05	73.53
26	2006	663.55	630.38	76.47
27	1982	656.65	623.81	79.41
28	2008	634.70	602.96	82.35
29	1989	630.25	598.73	85.29
30	1987	580.46	551.43	88.24
31	2002	555.94	528.14	91.18
32	1979	543.93	516.74	94.12
33	2000	485.04	460.79	97.06
34	1988	451.35	428.78	100.00

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1	75% dependabale Rainfall	663.91	mm	
2	75%dependabaleMansoonRainfall	630.72	mm	
3	Total Catchment Area of Kharoon River basin	4191		Sq.Km

RR Equation:

4 **Annual RR Equation**

Runoff = 1.107 x Rainfall - 406

Regression coefficient = 0.749

5 **Mansoon RR Equation**

Runoff = 1.165 x Rainfall - 381.8

Regression coefficient = 0.885

6	75% dependabale Annual Runoff	328.95	mm		
7	75% dependabale Mansoon Runoff	352.99	mm		
8	75% dependabale Annual Runoff coefficients			0.329	MCM/Sq.KM CA
9	75% dependabale Annual Runoff coefficients			0.353	MCM/Sq.KM CA
10	Annual Kharun River Basin yield	1378.6	MCM		
11	Mansoon Kharon River Basin yield	1191.0	MCM		

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TABLE 3.5 PRESENT WATER USE AND COMPUTATION OF BALANCE WATER

1	Total water use (as per available data)	43.59	MCM
2	Total CCA created (as per available data)	44491	Ha
3	As per WRD norms, 1 MCM water creates 150 ha of CCA, then water use by all schemes	296.6	MCM
4	Water Use by Anicuts	69.14	MCM
5	Industrial water Demand	52.54	MCM
6	Projected Annual Water Demand to be fulfilled from Kharun River	250	MCM
8	Total water already used in Kharun river sub-basin=	668.28	MCM
	Balance Water Availabilty in the river sub-basin	710.32	MCM

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4 Result

Water resources potential of the Kharun river basin is being exploited through one medium and many minor irrigation schemes, and also by constructing anicuts/ stop dams. The present analysis of water use and water available shall be helpful for proper planning and management of water resources in Kharun basin.Water use in any basin depends on the precipitation in that year and changes year to year .The demand of water for various purposes such as irrigation, industrial, domestic have been increasing day by day therefore the comprehensive strategic planning for integrated use of water resources is essential. Water resources development and management should be planned for a drainage basin as whole taking into account of surface and ground water considering the quantity and quality aspects as well as environmental aspect.

The result obtained from the present study can be summarized as below:

1. Annual Runoff coefficient of the basin is 0.329 MCM per Sq.Km. CA(Table 3.4)
2. Annual Basin Yield is 1378.60 MCM(Table 3.4)
3. Present Water Use including industrial water demand and projected water demand to be fulfilled from Kharun river is 668.28 MCM(Table 3.5)
4. Balance water available in Kharun river basin710.32MCM(Table 3.5)

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In the present study, balance water available has been computed by considering the yield generated in the basin and present water use including industrial water demand and projected water demand to be fulfilled from Kharun river.

Balance water available =Yield generated in the basin - present water use including industrial demand and projected water demand to be fulfilled from Kharun river.

5 Conclusion

The demand of water for various purposes such as irrigation, industrial, domestic has been increasing day by day, therefore, the comprehensive strategic planning for integrated use of water resources is essential. Water resources development and management should be planned for a drainage basin as a whole after assessing the present water use and projected water use. The approach of present study is to develop Water Resources database using modern techniques such as Arc GIS for the whole basin. The benefits with the use of Arc GIS

includes improved accuracy, less duplication, easier map storage, more flexibility, greater efficiency.Surface runoff and stream flow are characterised by large variability from one year to another. The variability of precipitation also results in variations in the use of water from year to year, therefore comprehensive basin wide approach is essential for water management of a river basin.

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