Priority Driven Water Resource Management in Subernarekha River Basin

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Abstract:* *The Subernarekha river basin is having very much importance for the development of newly born Jharkhand State, rich in mineral deposits, hosting many medium and large industries including Tata Steel, HCL, UCIL,AIDA and many more to come. As on date ,there is no methodological distribution of water resource available for different stakeholders. WATER EVALUATION AND PLANNING (WEAP) provides a seamless integration of both the physical hydrology of the region and water management infrastructure that governs the allocation of available water resources to meet the different water needs. It is an Integrated Decision Support System (IDSS) designed for planning and balancing of water resource generated through watershed. It is a priority driven software, employs priority –based optimization algorithm as an alternative to hierarchal rule based logic that uses a concept of Equity Group to allocate water in time of inefficient supply. Through the application of WEAP, how can the scarce resources available in the basin under study be optimally allocated to different uses, depending up on the priority of needs, is the prime objective of this paper.

Keywords: Integrated Decision Support System, Priority, Physical Hydrology, Stakeholders, ***Hierarchal***

Introduction: Modeling and analysis methods for evaluating the water distribution capabilities of reservoir/river systems are fundamental to the effective management of the highly variable water resources of a river basin. Both hydrologic and institutional considerations are important in assessing water availability and reliability of such assessments. Analysis methods must deal with the stochastic nature of stream flows and other pertinent variables. River basin management and associated water availability modeling (WAM) involve complex interactions between multiple uses and numerous water users within a framework of various water allocation arrangements and configurations of storage and conveyance facilities.

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WEAP based on DSS interfaced with GIS facilitates the disaggregate representation of individual demands, water supply, intake, link flow, return flow and River system. The model development effort reported by this paper integrates institutional and hydrologic considerations reflecting basin wide interconnections in assessments of water availability required to support practical water management decisions. With growing demands on limited water resources, effective allocation and management of stream flow and reservoir storage have become increasingly important throughout the world. Numerous water users share limited water resources.

Case study: The Subernarekha, a rain fed peninsular river, originates near Nagri Village of Ranchi District (23^0-18'N and 85^o-11'E), 15 Km South West of Ranchi at an elevation of 740 m above MSL. It is extending over 19296 square kilometer, the smallest of the fourteen river basins of India, covers 0.6% of geographical area and contributes 0.4% of total surface water resources. In this paper, out of four proposed hydraulic structures funded by World Bank likely to start operation, only one- the Kharkai Barrage is taken for consideration. There are two canal systems off taking from each bank are linked to different Demand sites, which are named after the canal which is intended to cater the demand such as KLBC (Kharkai Left Bank Canal) Town . The schematic diagram of the proposed study is shown in fig. 1

The Data used in modeling for current account year start of Study period (2002-2020) is given in table T -1. For allocation of available resources a number of option tested by developing several scenarios and future water demands are also projected. The project annual activity level (population) for only one demand sites KLBC Town is given in fig 2..The annual Water demand for KLBC Town is shown in fig. 3

Scenario Development : The following Scenarios are under consideration:

(1) Added Proposed Water Resources : In which all the Water Resources are linked to the demand sites and future projected demands are considered and it is observed that demands are not fully met.

(2) Priority Scenario 1:

In the Proposed Water Resources Scenario, the demands are maximum for all demand sites and all the possible water resources existing as well as proposed are linked to demand sites, it is observed that the demands are not fully met, so there is need to take a measure for fulfillment of the demand by changing the policy of supply assigning the different priority levels to demand sites (the lower digit indicates higher priority). Here the first Priority is given to Municipal water supply.

In this Scenario the priorities assigned are :

For municipal supply: 1

For Industrial demand : 2

For Agricultural need : 3.

(3) Priority Scenario 2:

This Scenario pays more weightage to Industries and priorities assigned are as follows :

For municipal supply: 2

For Industrial demand: 1

For Agricultural need : 3

keeping in the mind the fact that, if the Government changes its policy to give more weightage to the industries ,what will be the possible impact on other demands .

(4) Priority Scenario 3:

As the increase in population is bound to occur, a proportionate increase in production of food grains is essential to save the humanity from starvation. Hence, under such consideration more weightage is to be given to Agricultural Demand and its impact on Supply Delivered, Unmet Demand and Coverage of Demand for all demand sites are to be observed .The priority in this scenario assumed are as follows :

For municipal supply 3,

For Industrial demand 2,

For Agricultural need 1.

(5) Priority Scenario 4:

In this Scenario, assuming domestic and municipal need of water at the highest priority for desired human health and hygiene and also an almost equally important need for Agriculture and Industries, the assumed priorities for demands are as follows:

For Municipal supply 1

For Industrial demand 2

For Agricultural needs 2 ,

the effects on Supply Delivered and Unmet Demand are to be observed.

Table T-1
Data for Current Account Year

Demand sites			Annual Activity Level			Annual Water Use Rate		
KLBC TOWN	Adityapur		130000 persons			110 m^3/capita/yr		
	Jugsalai		87000 persons			82 m^3/capita/yr		
	Chotagobindpur		26000 persons			82 m^3/capita/yr		
	Bagbera		83500 persons			82 m^3/capita/yr		
KRBC TOWN	Judgoda		26,200.0 persons			82 m^3/capita/yr		
KLBC Industries	a)Tayo, AIDA, Gamaria, manufacturing Steel and C.I. Rolls Steel billets		Demands Are Clubbed together as one unit			7.3 Million m^3/yr		
	b) Tata growth shop ... AIDA Adityapur							
	c)Usha Martin Industry & Usha Alloy Steel manufacturing steel wire, rods, steel billets							
	d)Jamshedpur Beverage							
	e)Steel City Beverage AIDA							
	f) Jamshedpur Cement Plant							
KLBC Agriculture	Kharif	Types of crops	Paddy	Maize	Oilseeds	Pulse	Vegeta bles	Non-cultivated lands
		Area(ha)	349	35	30	35	35	14
		Annual water use rate(m^3/ha)	1431	0	1134	0	1282.5	0
	Rabi	Types of Crops	Wheat	Pulse	Oil seeds	Veget ables	Fodder	Non-ultivated lands
		Area(ha)	149	30	50	65	20	184
		Annual water use rate(m^3/ha)	4,673.0	3,590.0	3,437.00	4,373.00	4,266.0	0
	Summer Crops	Types of Crops	Pulse	Ground nuts	Vegetables	Fodd er	------	Non-ultivated lands
		Area(ha)	15	22	22	15	------	424
		Annual water use rate(m^3/ha)	4,424.0	4,677.0	5,999.00	5,734.0		
KRBC Agriculture	Kharif	Types of Crops	Paddy	Maize	Oilseeds	Pulse	Vegitab les	Noncultivated lands
		Area (ha)	9,714	971	833	971	971	417
		Annual water use rate(m^3/ha)	1431	0	1134	0	1282.5	0
	Rabi	Types of Crops	Wheat	Pulse	Oilseeds	Veget ables	Fodder s	Noncultivated lands
		Area(ha)	4,163.00	833	1,388.00	1,804.00	555	5134
		Annual water use rate(m^3/ha)	4,673.00	3,590.00	3,437.00	4,373.00	4,266.00	0
	Summer Crops	Types of Crops	Pulse	Ground nuts	Vegetables	Fodd ers	-----------	Noncultivatedl ands
		Area(ha)	416	625	625	416	----------	11,795.00
		Annual Water use Rate	4,424.00	4,677.00	5,999.00	5,734.00	------	0

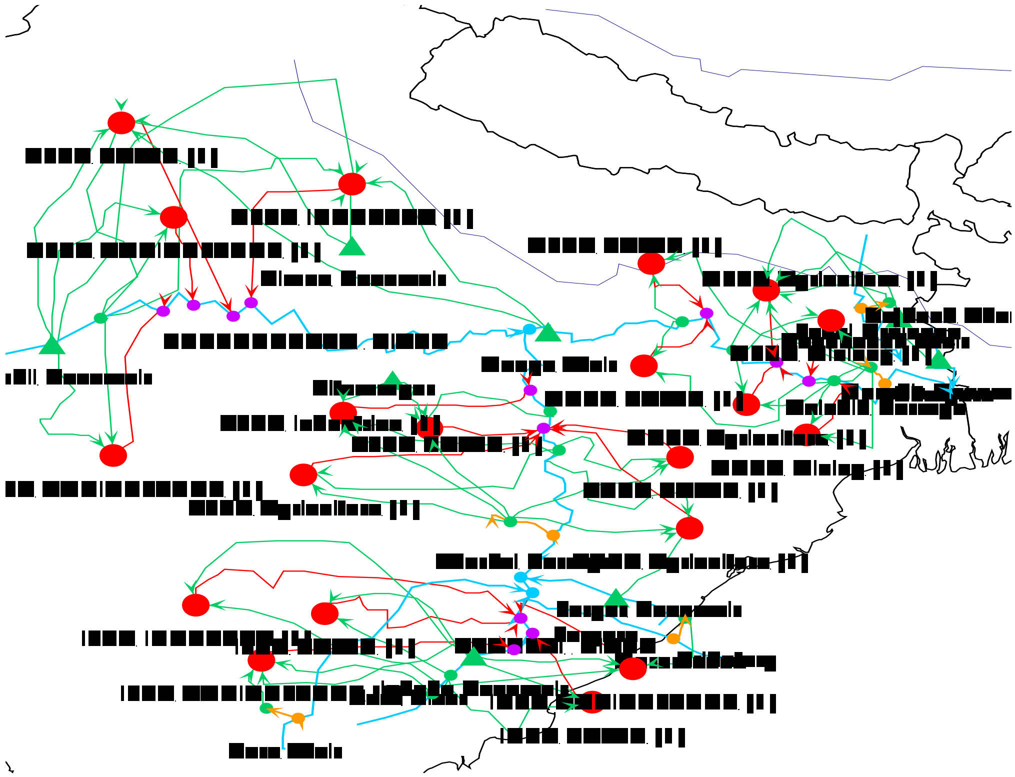


Fig 1 Schematic diagram of proposed study. (Not to scale)

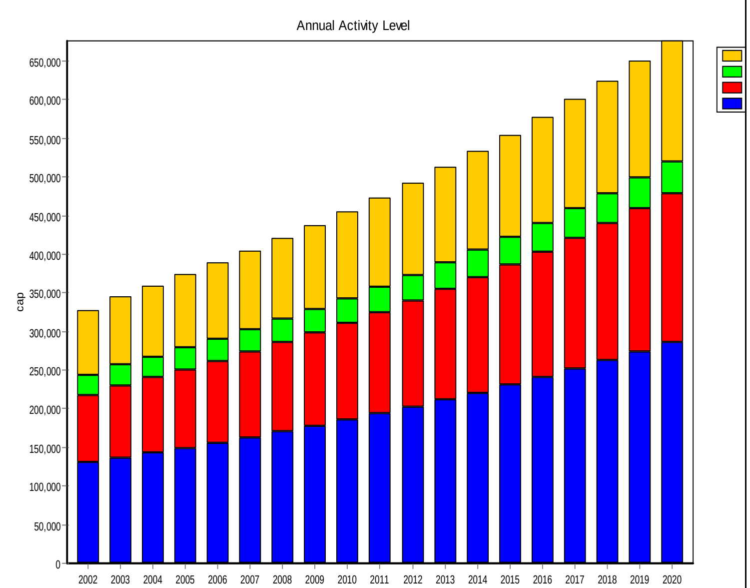
KLBC Town Adityapur	ExpForecast(1981, 53421, 1991,78184, 2001,128436)	
Jugsalai	ExpForecast(1981, 34119, 1991,63741, 2001,82352)	
Chotagovindpur	ExpForecast(1981, 14950, 1991,19636, 2001,25018)	
Bagbera	ExpForecast(1981, 42710, 1991,59109, 2001,85590)	

Fig 2 Projected Annual Activity Level(Population) for KLBC TOWN

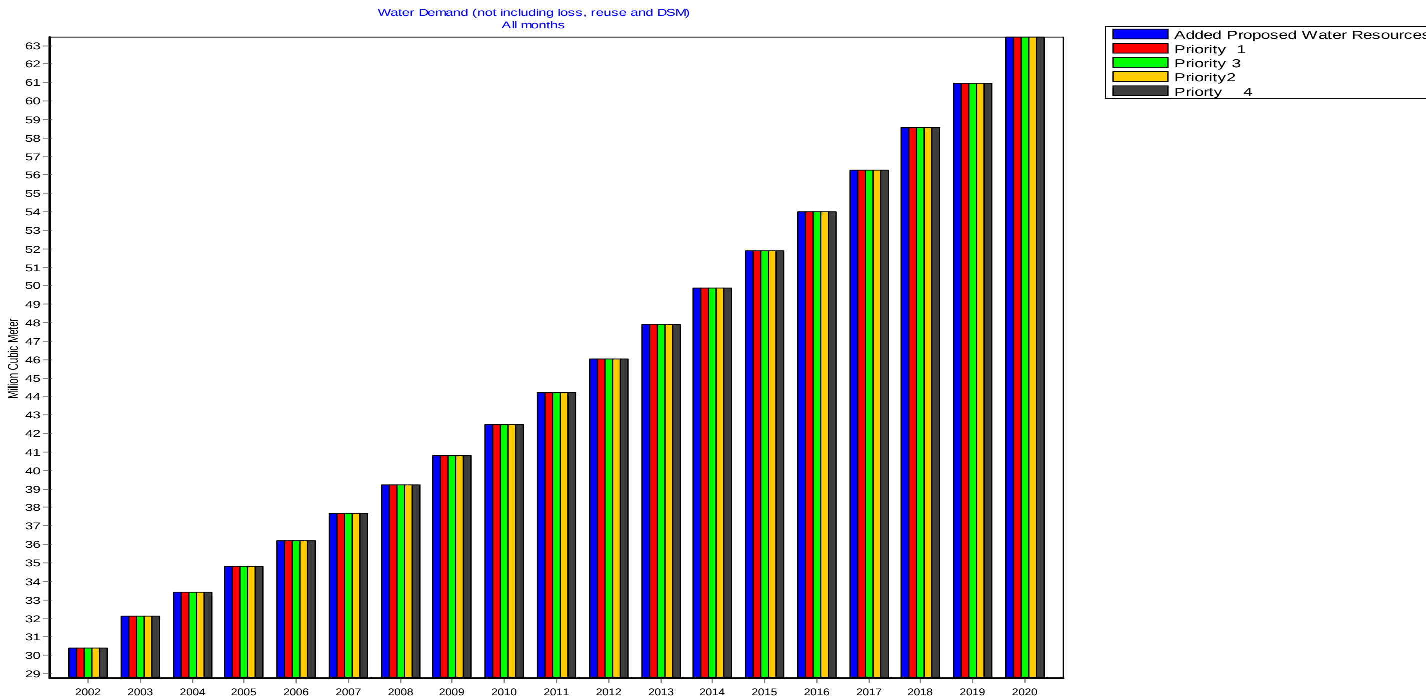


Fig 3 Water Demand KLBC TOWN

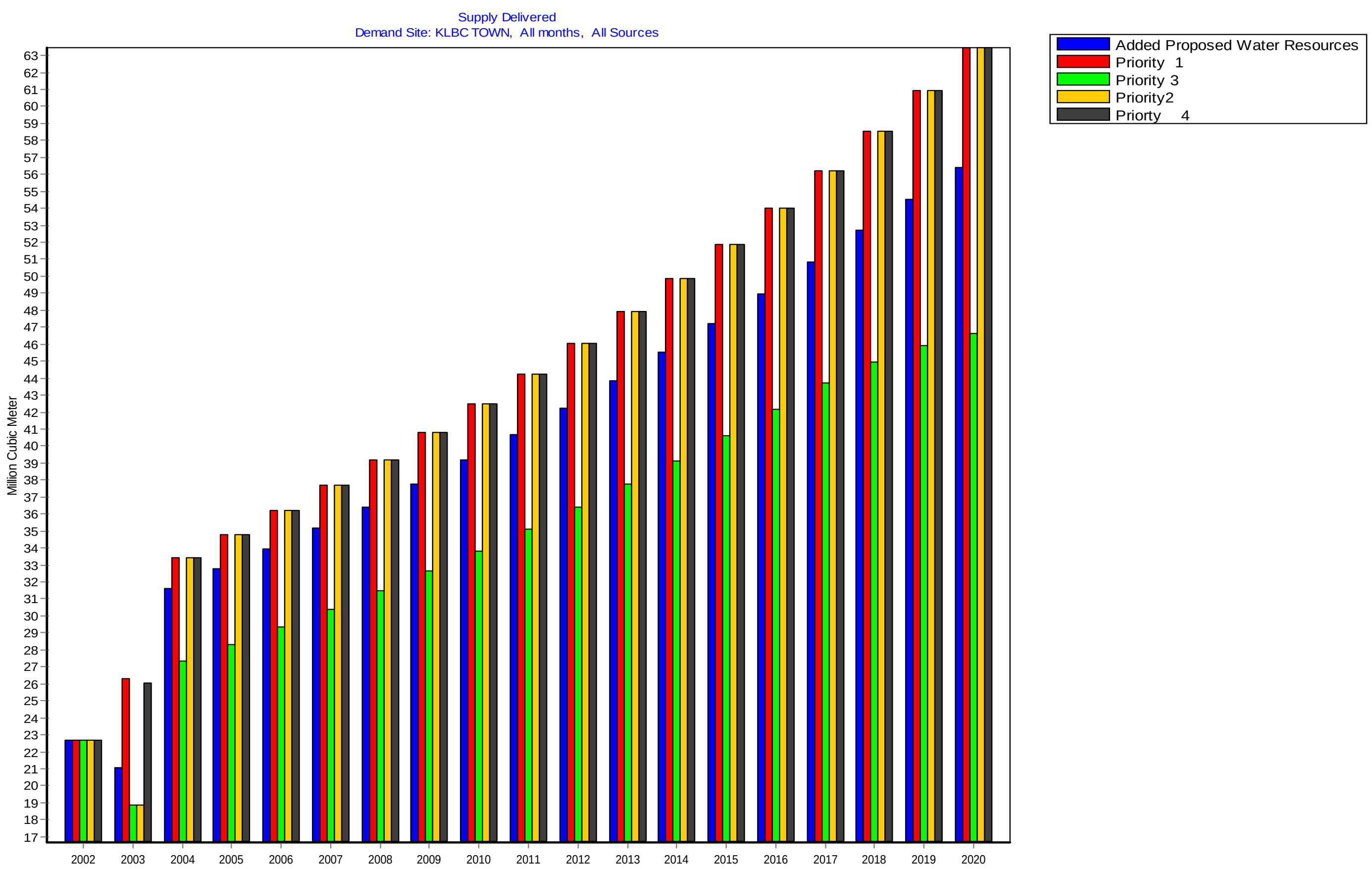


Fig 4 Supply delivered to KLBC Town from all sources

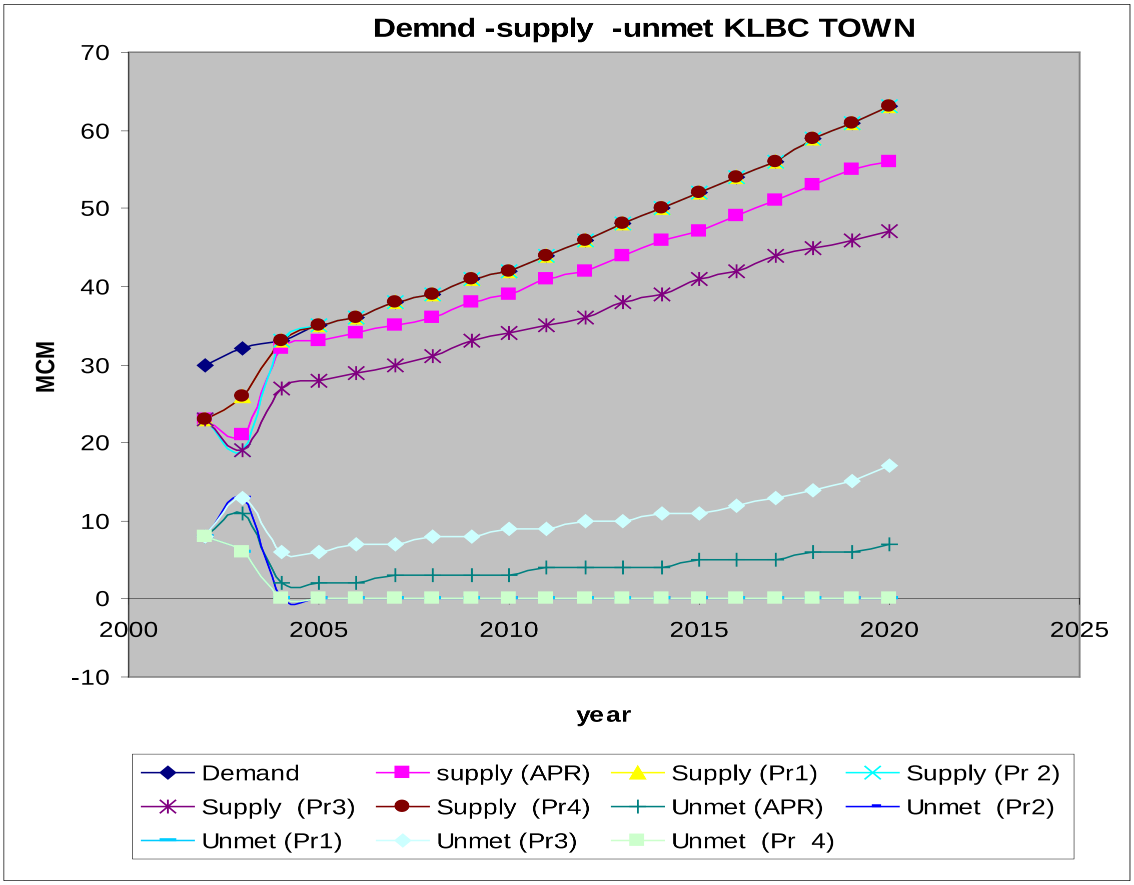


Fig 5 Comparison of demand ,supply and unmet demand for KLBC Town

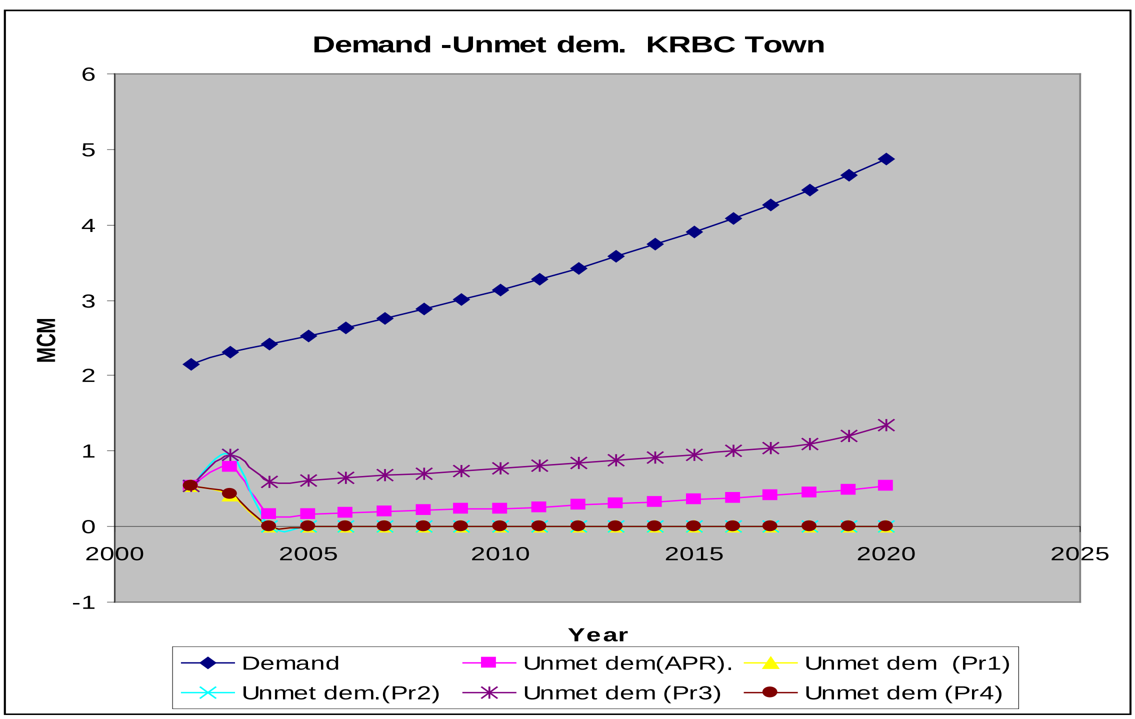


Fig 6 Comparison of demand and unmet demand for KRBC Town

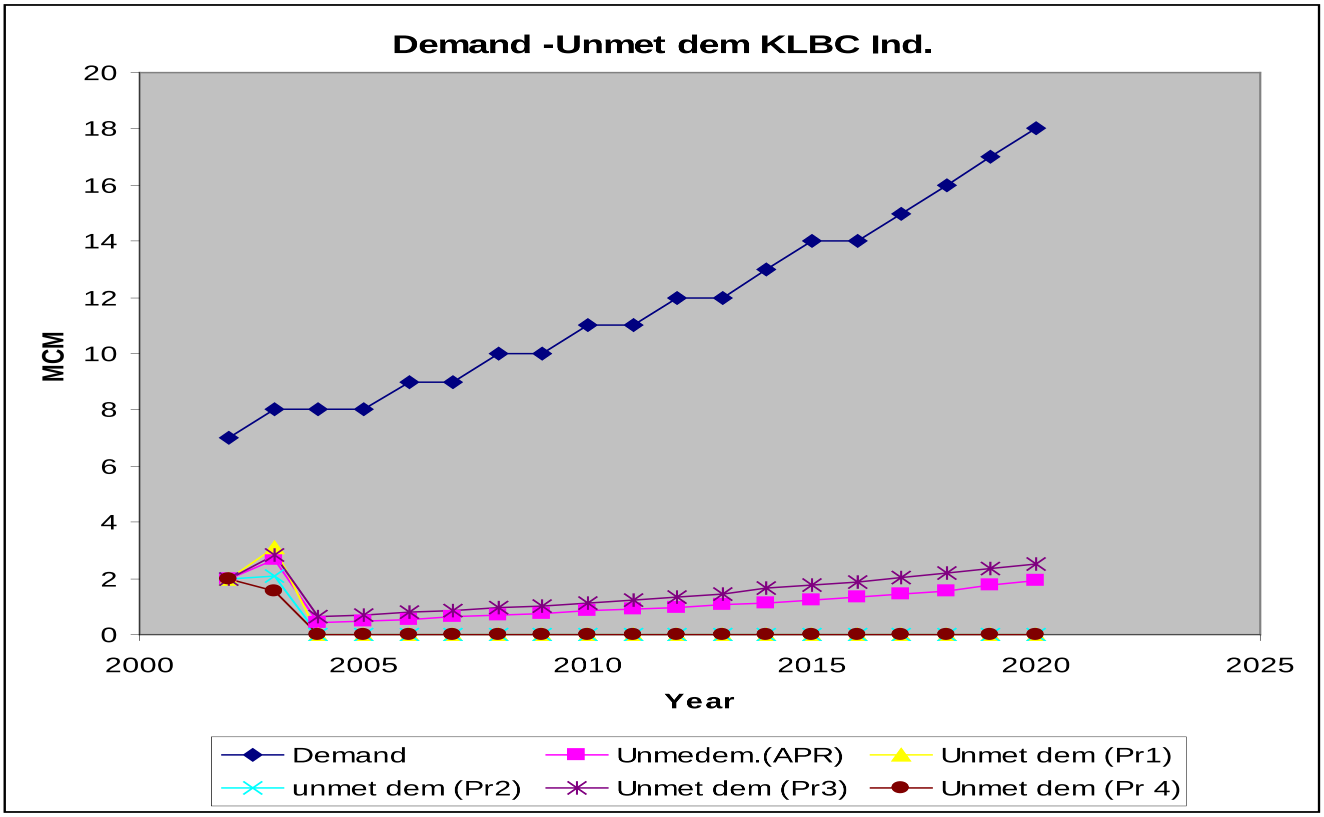


Fig 7 Comparison of demand and unmet demand for KLBC Industries

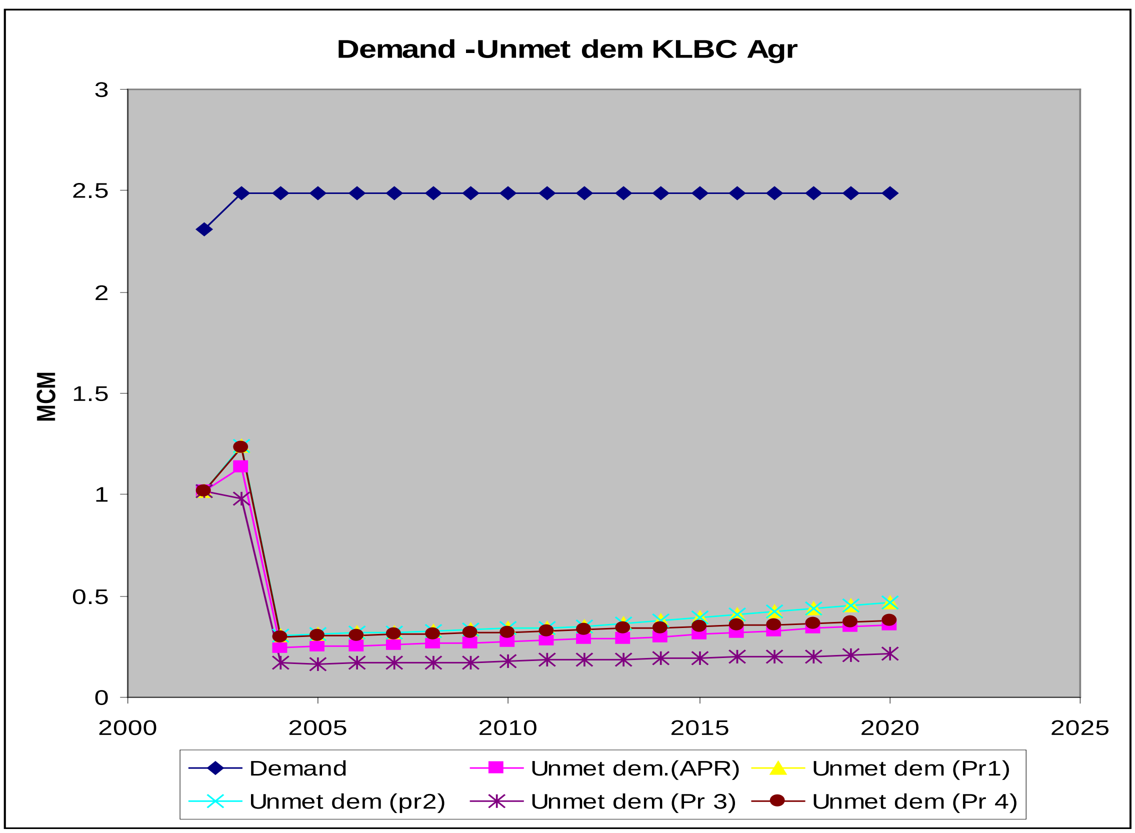


Fig 8 Comparison of demand ,supply and unmet demand for KLBC Agriculture

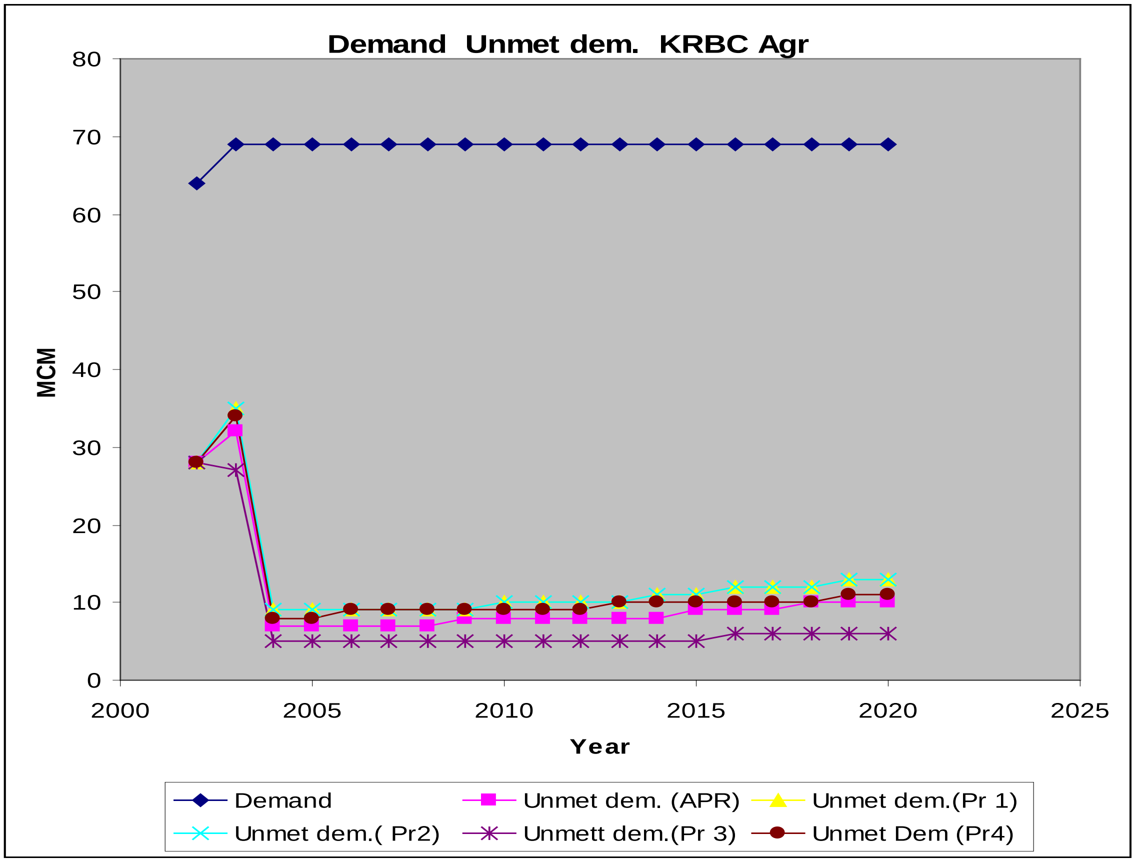


Fig 9 Comparison of demand and unmet demand for KRBC Agriculture

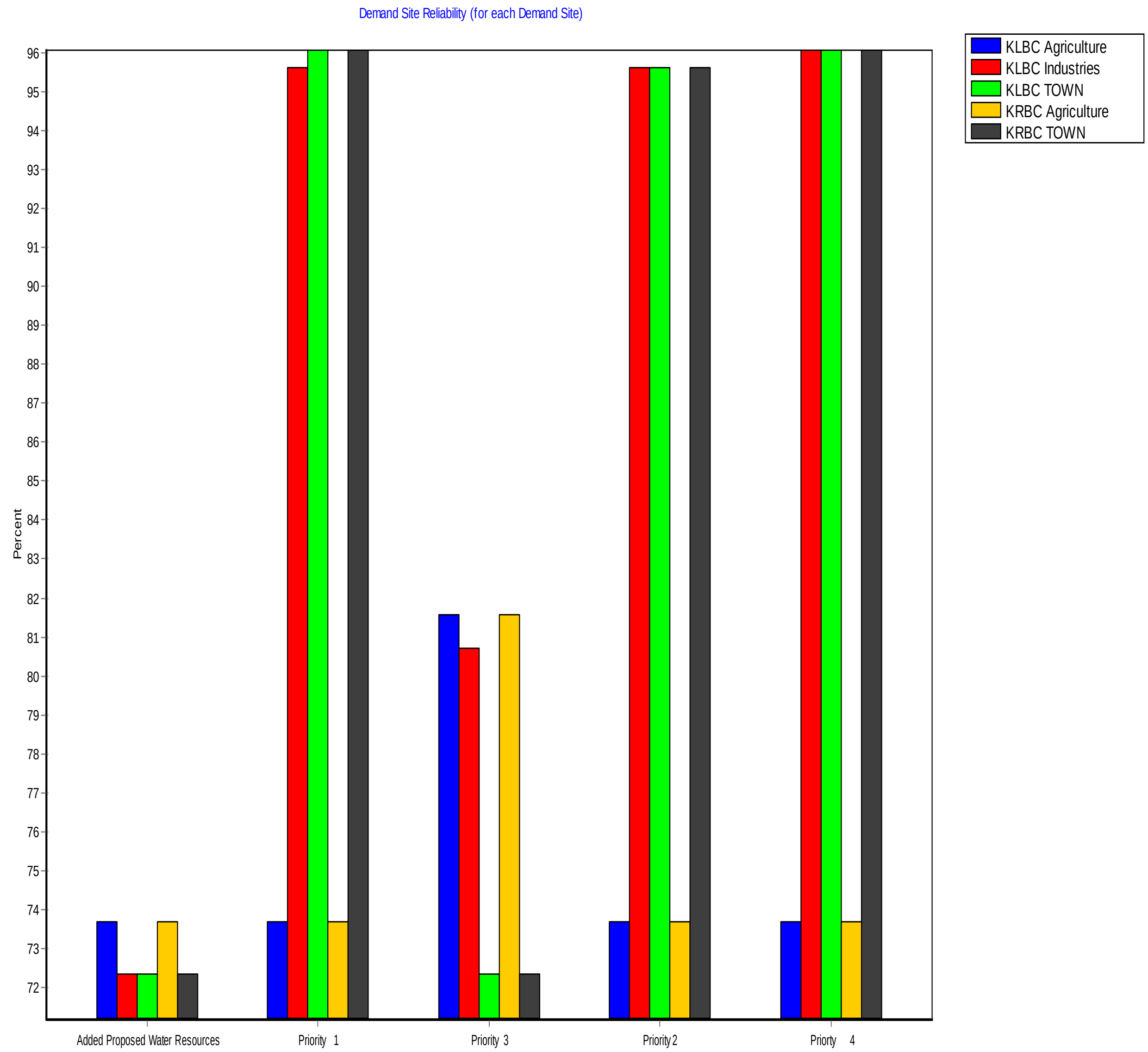


Fig 10 Reliability of management option for all demand sites and all scenarios.

The comparison of demand , supply and unmet demand for KLBC Town has been shown in fig 5. The demand and unmet demand for KRBC Town shown in fig 6,that for KLBC Industries shown in fig 7, that for KLBC Agriculture shown in fig 8 and, that for KRBC Agriculture shown in fig 9. The demand for KLBC Town, KRBC Town and KLBC Industries are increasing continuously but the Agricultural demands have   increased once in 2003 and remained constant for succeeding years. In the Proposed Resource Added Scenario the demand for all demand sites have attained maximum values and all the sources are linked to the demand sites.

Analysis and Discussion of Results: When priority of all demand sites are same, as in the case of Added Proposed Resource Scenario, available water resources are allocated in proportions to the demands. When the Priority 1 is assigned to Towns the supply increases, temporarily holding the supply to lower priority demands and the unmet demands are zero.The effects of one management option on the other demand sites may be seen from table 2.When priority 1 is assigned to municipal supply the unmet demand for town is nil but demand for agriculture increases. In the year 2020, KRBC Agricultural demand becomes 69 MCM, in Added Proposed Resource Scenario unmet demand is 10 MCM, in Priority 1 &2 unmet demand is 13 MCM, in Priority 3 unmet demand is 6 MCM. In year 2020 demand for KLBC Town becomes 63 MCM, unmet demands are 7,0,0,17, & 0 for respective Scenarios as mentioned above.

Table 2

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Demand		K	30	32	33	35	36	38	39	41	42	44	46	48	50	52	54	56	59	61	63
Unmet dem.	APR	L	8	11	2	2	2	3	3	3	3	4	4	4	4	5	5	5	6	6	7
	PR1	B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR2	C	8	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR3	T	8	13	6	6	7	7	8	8	9	9	10	10	11	11	12	13	14	15	17
	PR4		8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dem and		K	2.15	2.31	2.42	2.52	2.63	2.75	2.87	3.01	3.14	3.28	3.42	3.58	3.74	3.91	4.08	4.27	4.46	4.65	4.86
Unmet	APR	R	0.54	0.579	0.162	0.171	0.184	0.198	0.212	0.227	0.244	0.262	0.281	0.302	0.325	0.353	0.384	0.412	0.443	0.489	0.54
	PR1	B	0.54	0.545	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR2	C	0.54	0.953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR3	T	0.54	0.953	0.592	0.619	0.646	0.675	0.705	0.737	0.770	0.804	0.840	0.878	0.917	0.958	1.001	1.046	1.092	1.203	1.34
	PR4		0.54	0.437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dem and		K	7	8	8	8	9	9	10	10	11	11	12	12	13	14	14	15	16	17	18
Unmetdem	APR	L	1.95	2.67	0.43	0.48	0.55.	0.62.	0.69.	0.77	0.83	0.90	0.97	1.05	1.13	1.23	1.35	1.46	1.57	1.74	1.94
	PR1	B	1.95	3.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR2	C	1.95	2.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PR3	I	1.95	2.82	0.637	0.69	0.78	0.87	0.97	1.0	1.10	1.21	1.33	1.46	1.65	1.76	1.89	2.04	2.19	2.35	2.51
	PR4		1.95	1.53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dem and		K	2.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Unmet demand	APR	L	1.02	1.14	0.247	0.249	0.254	0.259	0.264	0.269	0.275	0.280	0.286	0.293	0.299	0.310	0.323	0.330	0.338	0.346	0.35
	PR1	B	1.02	1.237	0.303	0.31	0.316	0.322	0.327	0.333	0.339	0.345	0.352	0.363	0.378	0.395	0.412	0.424	0.437	0.451	0.465
	PR2	C	1.02	1.27	0.303	0.309	0.316	0.322	0.327	0.333	0.339	0.345	0.352	0.363	0.378	0.395	0.412	0.424	0.437	0.451	0.465
	PR3	A	1.02	0.981	0.168	0.17	0.168	0.168	0.168	0.171	0.178	0.182	0.185	0.189	0.191	0.194	0.199	0.201	0.204	0.208	0.212
	PR4		1.02	1.23	0.298	0.30	0.306	0.310	0.315	0.319	0.323	0.328	0.333	0.339	0.344	0.349	0.354	0.360	0.366	.373	0.381
Dem and		K	64	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69
Unmet demand	APR	R	28	32	7	7	7	7	7	8	8	8	8	8	8	9	9	9	10	10	10
	PR1	B	28	35	9	9	9	9	9	9	10	10	10	10	11	11	12	12	12	13	13
	PR2	C	28	35	9	9	9	9	9	9	10	10	10	10	11	11	12	12	12	13	13
	PR3	A	28	27	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6
	PR4		28	34	8	8	9	9	9	9	9	9	9	10	10	10	10	10	10	11	11

APR= Added Proposed Resources,Pr1= Priority 1, Pr 2= Priority 2,Pr 3= Priority 3,Pr4= Priority 4
KLBCT =KLBC Town, KRBCT= KRBC Town, KLBCI=KLBC Industries, KLBCA= KLBC Agriculture, KRBCA=KRBC Agriculture

Conclusion : Water Resource Planning although being practiced in India for long period but an integrated approach for the utilization of scarce water resource among the various stakeholders has yet to be conceptualized and implemented. Such an approach is a must for a country like India having a vast population ,huge population growth, remarkable industrial and economic growth rates, but very limited in land water resource. In the present paper the authors have tried address one such problem involving Subernarekha river basin .The intelligent programme WEAP has been used for the purpose of water resource planning . It is capable of addressing conflicts among stakeholders by changing the policy of supply. Since based upon the participatory approach , one of the requirement of IWRM, results can be modified at any stage of operation. How much water have to be released from which source to a particular demand site at pre requisite time to achieve the desired objective can also be evaluated. The reliability of the management option can be obtained for a given Priority Scenario . For example, the reliability for meeting the demand for agriculture is 74 % and for industries and towns it is 98 % under Priority Scenario 4. This immediately helps in assessing the status in a quantified and objective manner .

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