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Full Length Research Paper

An Ideal Approach to a Master Plan of the Umtrew River Sub-basin of Meghalaya India

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Abstract
The essence of preparing a Master Plan is identification of the problems and outlines the measures to tackle the same. It also includes identification of different schemes for optimal utilization of water resources considering the basin/sub-basin as a unit. Management of water resource potential for Umtrew sub-basin is intended to achieve a multidimensional objective involving simultaneous consideration of large numbers of factors in a multidisciplinary and multi-user scenario. Though the aim of the study mainly focuses on the benefit and welfare of the society, the economic output is achieved by increasing the agricultural output, industrial activities, drinking water supply along with improving the quality of life of the people of the region as a whole, while taking due care of the environment and ecological aspects.

In this paper an attempt has been made to estimate the total population of various districts falling under the Umtrew sub-basin, food grain requirement and water required for irrigation purposes by the end of 2051, domestic water requirement for urban and rural population for different decades, livestock population and corresponding water demand projection for different decades with the assumption that the annual growth rate of livestock population is 1%, industrial water demand projections, availability of surface and ground water , water balance study for present as well as future condition at critical points and net surface water balance at 75% and 50% dependability by the year 2051 . These projected data can be utilized for the coordinated development and management of water, land and the related resources to maximize the resultant economical and social welfare in an equitable manner without compromising the sustainability of vital ecosystem and environmental aspects.

Keywords: *Master plan, Umtrue sub basin, water demand projection, livestock population, water*

Introduction

Master plan is written document covering all the aspects of a river basin. Formulation of river basin master plan involves consideration of a large number of factors related to various disciplines connected to water resources and an in-depth study and understanding of basin's developmental requirements, priorities and limitations. River basin planning concentrates the planning effort into the natural hydrologic unit, the river, and suggests that rational and integrated planning of the water resources in a basin is possible and is also essential. River basin planning offers a framework for bringing about integration in planning. Though easier said than done, such integrated planning brings about greater economies of scale and greater benefits from any investment or actions proposed in the river basin.

The purpose of preparing river basin master plan may be enumerated as follows:
i) To prepare a long term perspective plan for the development of basins water resources.
ii) To develop a comprehensive and integrated approach to the development of water and other natural resources using water with due regard to the constraint imposed by the configuration of water availability.
iii) To identify and set priorities for promoting water resource development projects.
iv) To formulate a short term action plan consistent with the financial allocations and priorities of Government action plans.
v) To contribute towards the formulation of a long term national master plan for water resources development.

Ideally there should be a short-term programme or action plan covering the immediate 5-6 years and a long term programme covering a period of not less than 20 years. It may therefore be stated that a river basin master plan should cover a period of 20-25 years, revised and updated every five years with an action plan for the next five years that would deal specifically with investment for the next five years.

The need and principle of preparing a master plan arises from the fact that the resource i.e. water is limited while its demand is vast for

many purposes like irrigation, drinking, energy generation, industrial, navigation etc. The various uses of water by storing, lifting and economical use need to be studied in view of losses of water either by evaporation, conveyance, leakage etc. Therefore the guiding factors for integration of water with various parameters like rainfall, runoff, ground water, geological and climatic conditions, irrigation for agriculture, water for drinking and industries, environment, type of soils etc. need to be studied so as to get equitable distribution (present and future) with respect to above parameters with maximum benefits at minimum cost. Management of water resource potential for Umtrew sub-basin is intended to achieve a multidimensional objective involving simultaneous consideration of large numbers of factors in a multidisciplinary and multi-user scenario. Planning of river basin is usually evolved for a long term (generally 50 years), which is broken down to short-term targets, the cumulative of which is the net effect of the basic objective. To achieve this, an in-depth study and understanding of the basin developmental requirements, priorities and limitations are essential.

Materials and Methods

Study area

The Umtrew river originates from west of the sohpetbneng range in East-Khasi Hills district of Meghalaya near Lum Raitong. It flows towards the west till it meets the waters from the Umiam River which is being diverted by the Umiam Hydel Project. It then turns northwest and emerges at Burnihat where the Shillong- Guwahati road crosses this river. Umiam River and the Umtrew are being used stage by stage to form a continuous power potential hydel scheme till it reaches the plains. The Umtrew river sub-basin includes three districts. It is thus surrounded by the East-Khasi Hills, the West- Khasi Hills and the Ri-bhoi district.

West Khasi Hills: According to the 2011 census West Khasi Hills district has a population of 385,601The district has a population density of 73 inhabitants per square kilometer (190 /sq. mi). Its population growth rate over the decade 2001-2011 was 30.25 %. West Khasi Hills has a sex ratio of 981 females for every 1000 males, and a literacy rate of 79.3 %. The district is predominantly inhabited by Khasi tribe. Khasi society has greatly been transformed by many factors which have arisen in recent times. Adoption of the Western style of life, especially among the literate and educated, has been quite rapid although the matrilineal laws of inheritance and succession and the other cultural traits are still retained. The West Khasi Hills district was carved out of the erestwhile Khasi Hills district, which was later dividied into West and East Khasi Hills districts. The district headquarters is located at Nongstoin. The district occupies an area of 5247 km.

East Khasi Hills: East Khasi Hills is an administrative district in the state of Meghalaya in India. The district headquarters are located at Shillong. The district occupies an area of 2752 km².

Shillong is the district headquarters of East Khasi Hills District. East Khasi Hills District forms a central part of Meghalaya and covers a total geographical area of 2,748 km^2. It lays approximately between 25°07" & 25°41" N Lat. And 91°21" & 92°09" E Long. The northern portion of the district is bounded by the plain of Ri-Bhoi District gradually rising to the rolling grasslands of the Shillong plateau interspersed with river valleys, then falls sharply in the Southern portion forming a deep gorges and ravines in Mawsynram and Shella-Bholaganj, community and rural development block, bordering Bangladesh. The district is bounded by the Jaintia Hills District to the east and the West Khasi Hills District to the west. The East Khasi Hills District is mostly hilly with deep gorges and ravines on the southern portion. The most important physiographic features of the district is the Shillong Plateau. Shillong peak lying 10 km from the city, offer a panoramic view of the scenic country side and is also the highest point in the district as well as in the State.

The climate of the district ranges from temperate in the plateau region to the warmer tropical and sub-tropical pockets on the Northern and Southern regions. The whole of the district is influenced by the south-west monsoon which begins generally from May and continues till September. The weather is humid for the major portion of the year except for the relatively dry spell usually between December and March.

According to the 2011 census East Khasi Hills district has a population of 824,059. The district has a population density of 292 inhabitants per square kilometer (760 /sq. mi) . Its population growth rate over the decade 2001-2011 was 24.68 %. East Khasi Hills has a sex ratio of 1008 females for every 1000 males, and a literacy rate of 84.7 %.

Ri-Bhoi district: Ri-Bhoi is an administrative district in the state of Meghalaya in India. The district headquarters are located at Nongpoh. The district occupies an area of 2378 km sq.

The District lies between 90°55'15 to 91°16' latitude and 25°40' to 25°21' longitude. It is bounded on the north by Kamrup District and on the East by Jaintia Hills and Karbi Anglong District of Assam and on the West by West Khasi Hills District. The headquarters of the District is at Nongpoh located at 53 km away from the state capital Shillong and 50 km from Guwahati. This District is characterized by rugged and irregular land surface. It includes a series of hill ranges which gradually sloped towards the north and finally joins the Brahmaputra Valley. The important rivers flowing through this region include the Umtrew, Umsiang, Umran and Umiam rivers.

Demographics: According to 2011 census Ri-Bhoi district has population of 258,380.As of 2011 it is the second least populous

district of Meghalaya .The district has a population density of 109 inhabitants per square kilometre (280 /sq mi) . Its population growth rate over the decade 2001-2011 was 34.02 %. Ri Bhoi has a sex ratio of 955 females for every 1000 males, and a literacy rate of 77.22 %.

Table 1.1: Classification of the umtrew sub- basin

District Sub-basin	Area of the district Km^2	Area of the Sub-basin Km^2	% of area of Sub-basin	Population of the district			Population of the Sub-basin			Sex ratio	Density of population	% of literacy
				Rural	Urban	Total	Rural	Urban	Total			
West khasi	5247	136	2.6	342613	42988	385601	8908	1118	10026	981	73	79.30
East khasi	2748	17	0.618	458010	366049	824059	2831	2262	5093	1008	300	84.70
Ri-Bhoi	2448	913	37.30	233226	25154	258380	86993	9383	96376	951	106	77.22
Total		1066					98732	12763	111495			

Observation and Calculations

Calculation of population of the umtrew sub-basin:

Total area of the Umtrew sub-basin = 1066 km^2

Area of Ri-Bhoi district falling under Umtrew sub-basin = 913 km^2

Area of West khasi district falling under Umtrew sub-basin = 136 km^2

Area of East khasi district falling under Umtrew sub-basin = 17 km^2

Population of Ri-Bhoi district = 258380

Population of Ri-Bhoi district falling under Umtrew sub-basin = 258380 * (913/2448)*100%

= 258380 * 37.3% = 96375.74

Population of West khasi district = 385601

Population of West khasi district falling under Umtrew sub-basin = 385601* (136/5247)*100% = 385601* 2.6% = 10025.626

Population of East khasi district = 824059

Population of East khasi district falling under Umtrew sub-basin = 824059* (17/2748)*100%

=824059*0.618% = 5092.68

Total population of the Umtrew sub-basin = **111494.046**

Water need for irrigation

In the Umtrew sub-basin the ultimate irrigation potential is 4973 ha (calculated from the data of existing and proposed irrigation schemes of Umtrew sub basin) and this area is available for agricultural activity. The crop water requirement depends on factors such as type of soil, crops, topography, climate, method of irrigation etc. For assessing the irrigated water requirement of the sub-basin, it has been assumed that the average annual irrigation water requirement is 1.26 MCM per sq. km. per year. For computing the water demand in different decades for irrigation, it has been assumed that the minimum areas required to meet the food-grain requirement for population of sub-basin in that particular year, will be brought under assured irrigation. To work out the food-grain requirement the per capita consumption has been assumed to be 590gm. and the average yield per ha. for pre-kharif and kharif paddy under irrigated condition is taken as 6 tonne/ha/year. The details of food grain requirement and water required for irrigation purposes are given below.

Table 1.2: Food grain requirement and water required for irrigation purposes

Year	Total population (Thousand No.)	Food grain requirement per year (Ton)	Irrigated area needed (ha)	Maximum available irrigable area (ha)	Water requirement (MCM)
2021	133817	28818	4803	4973	60.51
2031	151481	32622	5437	4973	68.50
2041	167993	36178	6030	4973	75.98
2051	184625	39759	6627	4973	83.50

From the above table, it is observed that the Umtrew sub-basin will be self-sufficient in food-grain even if 50% of the maximum irrigation potential is achieved by the end of 2051 or afterwards. Water required to achieve this target is just about 6% of the surface water potential (75% annual dependable yield) of the sub-basin. The total yearly food grain requirement and water requirement by the end of 2051 is projected.

Domestic and industrial water supply

Urban expansion and water demand projection

Urbanisation is a national feature and it is no different in the case of Umtrew sub-basin also. The urban population in the sub-basin as per 2011 census is about 11.44% and it is assumed that it will uniformly increase and attain the present national level of 38.20% for 2026 by the year 2051. With this assumption, the urban population at the end of different decades is worked out in the following table.

Again assuming that the per capita per day water requirement for the urban population to be 270 litres, the domestic water requirement for urban population at the end of different decades is worked out as below:

Table 1.3: Domestic water requirement for urban population at the end of different decades

Year	Total population (No.)	Urban Population		Water demand (MCM)
		(%)	(No.)	
2021	133817	18.13%	24261	2.4
2031	151481	24.82%	37598	3.7
2041	167993	31.51%	52935	5.2
2051	184625	38.20%	70527	7.0

Rural population and water demand projection

The rural population as per 2011 census is 88.56%, which is presumed to be uniformly reduced to the present national level of 62.80% for 2026 by the year 2051. With this assumption, the rural population at the end of different decades is calculated. Further, it is also assumed that the per capita per day domestic water requirement for rural population is 135 litres. The domestic water requirement for rural population at the end of different decades is calculated as below:

Table 1.4: Domestic water requirement for rural population at the end of different decades

Year	Total population (No.)	Rural Population		Water demand (MCM)
		(%)	(No.)	
2021	133817	81.87	109556	5.39
2031	151481	75.18	113884	5.61
2041	167993	68.50	115076	5.67
2051	184625	61.80	114099	5.62

Livestock population and water demand projection

The livestock population in the sub-basin is 401730 Nos. out of which the large animals and small animals for the sub-basin are worked out to be 74580 and 327149 respectively. The livestock population and corresponding water demand projection for different decades have been worked out with the assumption that the annual growth rate of livestock population is 1%. The total requirement of water for large and small animal are as tabulated below:

Table 1.5: Water requirement for livestock population at the end of different decades

Year	Livestock Population Large (No.)	Water requirement @ 29 lit/day (MCM)	Livestock Population Small (No.)	Water requirement @ 4.5 lit/day (MCM)	Total water requirement (MCM)
2011	74580		327149		
2021	82038	0.86	359864	0.59	1.45
2031	90242	0.95	395851	0.65	1.60
2041	99267	1.05	435436	0.715	1.765
2051	109194	1.15	478980	0.786	1.936

Industrial water demand projections

There is no data available regarding present or future projection of industrial development in the sub-basin. The future industrial development also may not be on a very large scale. Hence it is assumed that the industrial requirement of water will be equal to one third of the domestic water requirement which works out to be as under:

Table 1.6: Industrial water requirement

Year	Domestic Water Requirement (MCM)				Industrial water requirement (MCM)
	For urban population	For rural population	For Livestock population	Total	
2021	2.4	5.39	1.45	9.24	3.08
2031	3.7	5.61	1.60	10.91	3.64
2041	5.2	5.67	1.765	12.63	4.21
2051	7.0	5.62	1.936	14.56	4.85

***Note**: All the above datas has been taken from the statistical handbook of Meghalaya and the calculations are done as per the Master Plan of Kynshi sub-basin as prepared by the Brahmaputra Board.*

Availability of surface and ground water and their quality:

The surface water resources of Umtrew sub-basin have been assessed to be **9491.57** MCM. The annual yield at 50%, 75% and 90% dependability is found to be 24,992.16 mcm, 16,540.77 mcm and 15,277.01 mcm respectively. It is assumed that 75% of annual dependable runoff can be planned for utilization for the purpose of irrigation, public health, industrial use, etc. The quality of surface water of the sub-basin can be used for all purposes after necessary treatment.

Present and future demand for water and strategy to meet the demand in a planned manner:

The present as well as future water demand for various purposes of Umtrew sub-basin has been identified and categorized as below:

a) Domestic water demand
b) Industrial water demand
c) Irrigation water demand

Water balance study for present as well as future condition at critical points

The present as well as future water requirement for rural and urban population and also for livestock population is to be met from surface and ground water combined. For working out surface and ground water requirement separately it is assumed that the full requirement for livestock and 20% of the requirement for the rural population will be met from ground water resources. The full requirement for urban population and 80% of the requirement of the rural population are proposed to be met from surface water resources. The projected surface and ground water requirement for domestic purposes at the end of different decades are shown below:

Table 1.7: Projected surface and ground water requirement for domestic purposes

Year	2021	2031	2041	2051
(i) Rural Population (20% of total requirement)	1.078	1.122	1.134	1.124
(ii) Livestock	1.45	1.6	1.765	1.936
Total G.W. requirement (MCM)	2.528	2.722	2.89	3.06
(i) Rural Population (80% of total requirement)	4.312	4.488	4.536	4.496
(ii) Urban Population	2.4	3.7	5.2	7.0
Total S.W. requirement (MCM)	6.712	8.188	9.736	11.496
Total water requirement for domestic purposes (MCM)	9.24	10.91	12.626	14.556

Regeneration: A substantial portion of domestic and industrial water and some portion of irrigation water is available as return flow to the stream. The following assumptions have been made for the estimation of regeneration of the water utilized.

(i) 80% of the surface water which is utilized for domestic purpose is assumed as return flow to the stream.

(ii) 10% of the water utilized for irrigation purposes is assumed to be regenerated to the stream.

(iii) 80% of the surface water used for industrial purpose is assumed to be regenerated to the stream.

Table 1.8: Livestock population of umtrew sub-basin

District	Cattle	Buffalo	Sheep	Goat	Horses and ponies	Pigs	Others	Total large livestock	Total small livestock	Total livestock	Remarks
1	2	3	4	5	6	7	8	9	10	11	12
West khasi	179430	4210	4210	76497	468	98254	_	363069	659940	1023009	Calculated as per area proportionate basis
Umtrew sub-basin	4665	110	110	1989	13	2555	_	9440	17159	26600	Area of sub-basin 1066sq km i.e 2.6% of the district
East khasi	321000	8000	8000	137000	1000	177000	_	330000	322000	652000	Calculated as per area proportionate basis

Umtrew sub-basin	1984	50	50	847	7	1094	_	2040	1990	4030	Area of sub-basin 1066sq km i.e 0.618% of the district
Ri-Bhoi	83714	1962	1962	35643	218	45780	_	169168	825737	169168	Calculated as per area proportionate basis
Umtrew sub-basin	31226	732	732	13295	82	17076	_	63100	308000	371100	Area of sub-basin 1066sq km i.e 37.3% of the district
Total of umtrew	37875	892	892	16131	102	20725		74580	327149	401730	

Net water balance of umtrew sub- basin surface water

a) Gross annual yield
   i) At 75% dependability = 3729.75 MCM
   ii) At 50% dependability = 2486.5 MCM
b) Surface water import = Nil
c) Surface water export = Nil
d) Over all availability
   i) at 75% dependability = 3729.75 MCM
   ii) at 50% dependability = 2486.5 MCM

Table 1.9: Detail of surface water balance

PARTICULARS	2021	2031	2041	2051
A. Availability of water in MCM				
a) 75% dependable b) 50% dependable	3729.75 2486.5	3729.75 2486.5	3729.75 2486.5	3729.75 2486.5
B. REQUIREMENT IN MCM				
a) For irrigation use	60.51	68.50	75.98	83.50
b)Domestic				
i) Urban	2.4	3.7	5.2	7.0
ii) Rural	5.39	5.61	5.67	5.62
iii) Livestock	1.45	1.60	1.765	1.936
Total of (b) =	9.24	10.90	12.64	14.56
For industrial use	3.08	3.63	4.21	4.85
Total of (B) =	72.83	83.03	92.83	102.91
C. REGENERATION IN MCM				
a) From irrigation use 10%	6.051	6.85	7.598	8.35
b) From domestic use 80%	7.392	8.72	10.112	11.648
c) From industrial use 80%	2.464	2.904	3.364	3.88
Sub-total of (C) =	15.907	18.474	21.078	23.878
D. SURFACE WATER BALANCE IN MCM				
i) 75% dependable	3672.827	3665.194	3658.00	3650.718
ii) 50% dependable	2429.577	2421.944	2414.748	2407.468

*Net surface water balance at 75% and 50% dependability works out to **3729.75MCM** and **2486.5 MCM** respectively by the year 2051.*

Conclusion

The following conclusions can be drawn from the study

i) The total population of east khasi , west khasi and ri-bhoi district falling under Umtrew sub-basin is 111494.046

ii) The total yearly food grain requirement and water requirement by the end of 2051 is projected as 39759 ton and 83.50 MCM. It is observed that the Umtrew sub-basin will be self-sufficient in food-grain even if 50% of the maximum irrigation potential is achieved by the end of 2051 or afterwards. Water required to achieve this target is just about 6% of the surface water potential (75% annual dependable yield) of the sub-basin.

iii) The water requirement for urban, rural, livestock and industrial population at the end of 2051 is calculated as 7, 5.62, 1.936 and 4.85 MCM respectively.

iv) The surface water resources of Umtrew sub-basin have been assessed to be 9491.57 MCM. The annual yield at 50%, 75% and 90% dependability is found to be 24,992.16 mcm, 16,540.77 mcm and 15,277.01 mcm respectively. It is assumed that 75% of annual dependable runoff can be planned for utilization for the purpose of irrigation, public health, industrial use, etc. The quality of surface water of the sub-basin can be used for all purposes after necessary treatment.

v) The projected surface and ground water requirement for domestic purposes at the end of 2051 is 11.496 MCM and 3.06 MCM respectively.

vi) The net surface water balance at 75% and 50% dependability works out to 3729.75MCM and 2486.5 MCM respectively by the year 2051.

The above projected data for different decades can be utilized in an effective manner to meet the present and future population demand of the umtrew sub basin.

Limitations of master plan

In the Master Plan, the correctness and consistency of the data incorporated therein needed to be reviewed from time to time and need to be modified/updated in view of ever changing scenario of the policy making body of the Government. The present practice of conjunctive use of surface and ground water is not based on ecological and economic consideration but based on convenience. There is no systematic and planned way of using ground water as it is dealt with separate organization. The economic feasibility and the viability of such schemes have to be studied and the conjunctive use to be plan accordingly.

Separate department deal with the use of water for industry, domestic, minor irrigation, ground water and lift irrigation etc. they have not prepared their Master Plans. In absence of such a plan, the water requirement for domestic, industrial, irrigation etc. has been computed on the basis of some assumption.

Most of the studies and planning are carried on the basis of available districts and block level data. The study can be more realistic once the village level data is incorporated. Similarly water availability study for small tributaries and minor irrigation project sites are important for a minor level analysis of the basin which could not be covered in the Master Plan due to unavailability sufficient data.

Most of the data available are the departmental reports, which are necessarily abstract in nature. Many of them have neither been updated nor extensively collected since long. The report can be updated after collecting the latest micro level data from the original sources.

References

Brahmaputra Board (1997): “Master plan of Brahmaputra Main Stem Part-I”.
Brahmaputra Board (2011-12): “Master plan of Kynshi Sub- basin”
Statistical Handbook of Meghalaya (2008-2009).
www.censusindia.govt.in