Rural Technology Journal, 13(1&2), 1995

RURAL TECHNOLOGY JOURNAL

MICRO, MINI & SMALL HYDEL POTENTIAL IN UTTARA KANNADA DISTRICT, KARNATAKA

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Mini, Micro and small hydro plants combine the advantages of large hydro on one hand and decentralised power supply on the other. The disadvantages associated with large hydel plants like high transmission costs, environmental issues like submergence of prime lands (like forests, crop land etc.), displacements of families are not present in the case of small plants. More over, the harnessing of local resources like small hydro resources, being of a decentralised nature, lends itself to decentralised utilisation, local implementation and management, making rural development possible mainly based on self reliance and the use of natural, local resources. In this paper the assessment of potential carried out in some of the streams in Bedthi catchment in Uttara Kannada district of Western Ghats is discussed.

INTRODUCTION

Hydro power owes its position as a renewable resource to the variable but more or less continuous flow of a certain amount of water in the stream. This water, supplied by the rain and always moving, constantly flows from the main land to the sea, where it evaporates back to the atmosphere in an unending cycle controlled by two opposing force namely the heat of the Sun and the earth's gravity. Thus, Hydro potential is a combination of the possible flows and the distribution of gradients. Hydro power is a precipitation dependent resources and thus subject to the uncertainties which this entails. Water runoff can vary within wide limits.

The amount of power available at a given site is determined by the volummetric flow of water and the hydraulic head or water pressure. In hydro schemes the turbines that drive the electricity generators are directly powered either from a reservoir or the "run of the river". Large scheme may include a water storage reservoir providing daily or seasonal storage to match the production of electricity to the demand for the power. Large scale hydro electric schemes have been producing power in the Karnataka state of many years, with the first Hydro Electric station is built in 1942. Due to environmental constraint further construction of storage reservoir is limited and attention has now focussed to developing small scale hydro schemes in an environmental friendly way to cater to the needs of the region.

A micro/mini/small hydro power station can divert only potential energy of the water which would have been dissipated to no benefit in the natural flow along the water course. The domain where mini, micro and small hydropower can have potential impact on development is in domestic lighting and in providing stationary motive power for such diverse productive uses as water pumping, wood and metal work, grain mills and agro processing industries etc.

ENERGY SCENARIO IN KARNATAKA

Karnataka state depends both on commercial and non-commercial forms of energy. Non commerical energy constitutes 53.2%, met mainly by sources like firewood, agricultural residues, charcoal and cowdung, which caters 92% of rural population. Non commercial energy is mainly used for thermal energy requirements such as cooking and water heating in households and in agro processing. From household survey conducted in villages of Uttara Kannada District of Karnatak State reveals that on an average fuelwood consumption for cooking is in the range of 0.8 to 1.25 kg per person per day. While for water heating fuel requirement is in the range of 1.1 to 1.9 kg per person per day. To cater the growing demand of population for domestic use and for industries it is necessary to (1) look for alternate sources of energy which is renewable in nature (2) improving efficiency of end use devices like motor, irrigation pumpsets, cooking and water heating stoves etc. (3) optimising energy source-end use matching to ensure not to use high grade energy such as electricity for low grage thermal applications as cooking etc. This would enable sustainable development of a region.

69.07% population resides in rural areas (3, 10, 69, 413 persons out of 4, 49, 77, 201 as per 1991 census) in Karnataka State. In a large number of villages, the population density is often low, and settlements are frequently far apart and the prevalent simple life style requires less high grade energy per capita compared to urban dwellers. Industrial energy demand is mainly for activities such as agro processing and cottage industries. Thus, electricity demand per unit of area is low and hence supply from grid over long distances and difficult terrain to many low demand consumers spread over a large area, due to present enormous transmission and distribution losses and inefficient end uses is economically not feasible. The consequence of this unfavourable situation regarding electricity supply to rural areas is that a great proportion of the population is remote rural areas has so far not benefitted from the amenities of electricity. In the following section We discuss the possibility of harnessing hydel energy in Uttara Kannada District in Western Ghats region.

Western Ghats : The Western Ghats in Karnataka, which lies along the path of south west monsoon, receives rainfall in the range 1200 to 8000 mm a year, bear good forest cover which includes virgin evergreen forests, moist deciduous forests that harbor timber trees like teak, rosewood etc. and the dry deciduous forests sheltering a wealth of wildlife. Karavali and Malnadu in Karnataka (covering Uttara Kannada, Dakshina Kannada, Chikmagalur, Hassan, Belgaum, Shimoga, Kodagu and Mysore districts are the two regions dominated by Western Ghats. And with the all great rivers like Malaprabha, Tunga Bhadra, Kaveri, Kabini, Sharavathy, Netravathy, Kali, Gangavalli, Aghaniashini, the Western Ghats region has been the backbone of ecology and economy of Karnataka.

Uttara Kannada District : Uttara Kannada district lies between $13^{0}\ 55^{'}$ and

$15^{o}\ 31'$ N latitude and $74^{o}\ 9'$ and $75^{o}\ 10'$ E longitude. It has an area of 10,291 sq. km and with a population of 12, 18, 367. It is located in the mid western part of the state. It is a region of gentle undulating hills; rising rather steeply from a norrow coastal strip bordering the Arabian sea to a plateau at an altitude of 500 m with occasional hills rising above 600 m to 860 m. The annual precipitation largely confined to the monsoon months of June to September, ranges between 3500 mm on coast, rising to 4500-5000 mm on the crestline and declining to 1000 mm on the eastern plateau. As per the landsat imagery of 10291 sq. km geographical area, 67.04% is under forest, 1.94% under paddy and millet cultivation 1.26% under coconut and areca garden, 1.94% under rocky outcrops and the balance of 27.82% is under habitation and reservoirs.

There are four leading rivers, the Kalinadi in the north, the Bedthi or Gangavalli about 32 km south, the Aghanashini or tadri rising far to the south but falling into the sea only about 10 km south of gangavalli and the sharavathi or Gerusoppa river about 24 km south of tadri, when it reaches the foot of the hills and becomes a tidal creek.

Developmental projects in Uttara Kannada :

(A) Hydel Projects

(i) 810 MW	Nagjhari power house	completed project
(ii) 100 MW	Supa dam	of Kali river
(iii) 120 MW	Kodasalli dam	on-going projects
(iv) 150 MW	Kadra dam	of Kali river

(B) Proposed Hydel Projects

Bedthi Basin :

Bedthi stage I	210 MW
Bedthi stage II	210 MW
Sonda pattanadahalla	

Kali Basin :	
Dandeli dam	60 MW
Kali stage III	400 MW
Aghanashini Basin :	
Aghanashini	435 MW
Bennehole scheme	

(C) Nuclear Plants :

Kaiga (under construction)	2 x 235 MW
Kaiga II (proposed)	4 x 235 MW

In the geographic area of 10,291 sq. km so many developmental projects have been taken up or completed. The nuclear power plant, which was supposed to be tried as last resort for power is also being set up in the midst of evergreen forests of Uttara Kannada district. These completed porjects have already caused serious environmental damage in the form of submergence of productive natural virgin forest, horticulture and agricultural lands. This is mainly due to fallacy in planning process, whose main goal is to go in for energy supply expansions. This approach adopted so far in the planning process links economic growth to energy on the assumption that there is correlation between energy use and GDP (Gross Domestic Product). With this approach energy becomes an end in itself, and the focus shifts on meeting increased energy demand through energy supply expansion alone. Currently the energy planning is not an integrated activity. There are many organisations that deal with different aspects of energy. The plans for electricity, coal, oil and firewood are done by respective organisation mostly based on the projection of energy damand. This supply and damand based planning for individual energy form has resulted in problems like more losses, more conversions and low efficiencies. This is evident from the disappearance of forests, village woodlot, and construction of giant hydro electric dams, thermal plants and controversial nuclear plants. This demands for proper Integrated energy planning taking into considera-tion : Satisfying basic human needs through economically feasible, energy efficient, environmentally sound and viable options, Promoting energy efficiency improvements,

Beginning a transition to renewable energy sources,

Optimising energy source—enduse matching. This highlights the necessity for Integrated regional energy planning, based on a detailed book at how energy is used rather than the traditional preoccupation with energy supply and aggregate demand.

OBJECTIVES

Our main objective in this paper is to identify feasible micro/mini/small hydel sites and assessment of power potential in these sites based on 18 months field survey carried out in the basin of Bedthi river.

METHODOLOGY

Various terminologies and definitions used in this section and results section are listed in appendix.

Reconnaissance Study or Pre-feasibility Study : Pre- feasibility study is carried out in all streams with water head greater than 3 meters water head in the basins of Bedthi And Aghanishini river located in Uttara Kannada District of Karnataka state. There are 26 feasible sites in Bedthi basin to generate electricity in a decentralised way.

Feasibility Study : Measurement of catchment area of all identified sites (in pre feasibility survey) and stream discharge measurements were carried out at some sites. Indirect method of estimating stream flow based on the relation ship of variables run off and precipitation and a rational method by assuming suitable runoff coefficient based on catchment characteristics were also tried. This indirect method of stream flow helps in estimating discharge at ungauged sites in this region. The methods tried by us are discussed in greater detail below :

Measurement of Catchment Area : Catchment boundaries are located by using the contour lines on a topographical map. Boundaries are drawn by following the ridge tops which appear on topo maps as down hill pointing V-shaped crenulations. The boundary should be perpendicular to the contour lines it intersects. The tops of mountain are often marked as dots on a map and the location of roads which follow ridges are other clues. Catchment area thus marked is measured directly from the marked maps using a planimeter.

Stream Discharge : We have adopted both direct and indirect methods to estimate the flow at site. Methods followed in these methods are discussed below:

(a) Direct Estimation of Flows : Stream Discharge is the rate at which a volume of water passes through a cross section per unit of time. It is usually expressed in units of cubic meters per second (m^3/s). The velocity-area method using current meter is used for estimating discharge. The cup type current meter is used in a section of a stream, in which water flows smoothly and the velocity is reasonably uniform in the corss section. As far as possible a cross-section is chosen where the current is reasonably regular over the whole width. The measurement is carried out, for three consecutive days every month for 18 months and 5 readings are taken at each point in order to take into account day to day fluctuations and seasonal variations.

(b) Indirect Estimation of Flows at Site : Runoff is the balance of rain water, which flows or runs over the natural gound surface after losses by evaporation, interception and infiltration. The yield of a catchment is the net quantity of water available for storage, after all losses, for the purposes of water resources utilisation and planning. The runoff from rainfall is estimated both by (1) Empirical formula (2) Rational Method.

(1) Empirical Formula : Regression analysis of variables run off and precipitation for a period of eighteen months, shows the linear relationship between variables Runoff and Precipitation of the form R=0.849*P+30.5, where R=runoff, P=rainfall in cms. This is in conformity with C.C.Ingli's formula for ghat areas.

(2) Rational Method : A rational approach is to obtain the yield of a catchment by assuming a suitable runoff coefficient. Hence , Yield = C*A*P

Where C=runoff coefficient, A=catchment area, P=rainfall. The value of "C" varies depending upon the soil type, vegetation, geology etc.

Type of Catchment	Value of C
Rocky and Impermeable	0.8-1.0
Slightly permeable, bare	0.6-0.8
Cultivated or covered with vegetation	0.4-0.6
Cultivated absorbent soil	0.3-0.4
Sandy soil	0.2-0.3
Heavy forest	0.1-0.2

Power and Energy : The hydraulic power which is naturally available at a given site is defined by P=9.81*Q*H where Q is the discharge in cubic meters per second and H is the height of the waterfall or head in meters. The corresponding electrical energy produced could be E=P*t*n*f, where E is the electrical energy produced in kilowatt-hours, P is the hydraulic power in kilowatts, t is the operating time in hours, n is the efficiency of turbine-generator assembly (usually between 0.5 and 0.9), and f is a coefficient to allow for seasonal flow variations for run-of-river installations.

RESULTS AND DISCUSSION

Catchment Area : Catchment area measured from the marked topo sheets using planimeter for the streams where exploratory survey is carried out is listed in Table – 1.

Table – 1

CATCHMENT AREA COMPUTED FOR VARIOUS STREAMS

Stream/Site	Catchment Area
1	2
Muregor	25.87
Boosangeri	11.29

1	2
Mattigatta	99.30
Bili halla	99.52
Hire halla	66.82
Togse halla	72.92
Shivganga falls	88.48
Sonda River	380.47

Muregor jog has a catchment of 25.97 sq.kms. while Boosangeri stream has a catchment of 11.29 sq.kms. The average channel slope (S_c) is one of the factors controlling water velocity, while the slope of the catchment (S_b) influences surface runoff rates. These two parameters gives an idea about the nature of a stream. Hence S_c and S_b are computed and listed in Table – 2. Shivganga and Mattigatta streams have slopes 43.83^{o} and 40.03^{o}, while Muregor has a slope of 6.27^{o}.

Table – 2

COMPUTATION OF STREAM SLOPE AND CATCHMENT SLOPE

Stream	Stream slope		Catchment slope	
	Slopes	Degrees	Slopes	Degrees
1	2	3	4	5
Muregor jog	0.11	6.27	0.18	10.2
Boosangeri jog	0.04	2.29	0.04	2.29
Mattigatta	0.83	40.03	0.69	34.66
Hasehalla	0.19	10.75	0.24	13.49

1	2	3	4	5
Bili halla	0.161	9.14	0.196	11.09
Hirehalla	0.69	34.6	0.64	32.61
Togse halla	0.49	26.1	0.48	25.64
Shivganga falls	0.96	43.83	0.76	37.23
Pattanada halla	0.18	10.2	0.20	11.3
Sonda River	0.19	10.75	0.20	11.3

Catchment Shape : The shape of Boosangeri catchment is short and wide (fan shape), while Muregar, Mattigatta, Shivganga catchments are elongated.

Stream Flow Measurement and Compuation of Power (kW) : Stream gauging carried out as explained in methodology using current meter every month. Stream discharge ranges from 1.12 cum/see (in the month of August) to 0.015 cum/sec (in the month of February) for Boosangeri stream. In the case of Muregar range is from 1.395 to 0.026 cum/sec. The hydraulic power computed for these streams on monthly basis is listed in Table – 3. This indicates that streams of these kinds are seasonal. Power generated during June-sept. is sufficient to meet the energy needs of the nearby villages for agro proceesing and domestic lighting etc. (Fig. 1 & 2).

Rational Method : As an alternative study, monthly yield is derived by assuming a runoff coefficient of 0.25, and hence power is estimated that could be harvested from the streams. This is listed in Table – 4. Comparison of Table – 3 and 4, shows that power computed by rational methods compares with the power computed by gauging streams namely Boosangeri and Muregar. This comparative assessment by both direct and indirect methods, would help in assessing potential of remaining ungauged streams in this region.

Fig. 1 Estimated power in Muregar & Boosangeri (based on field experiments)

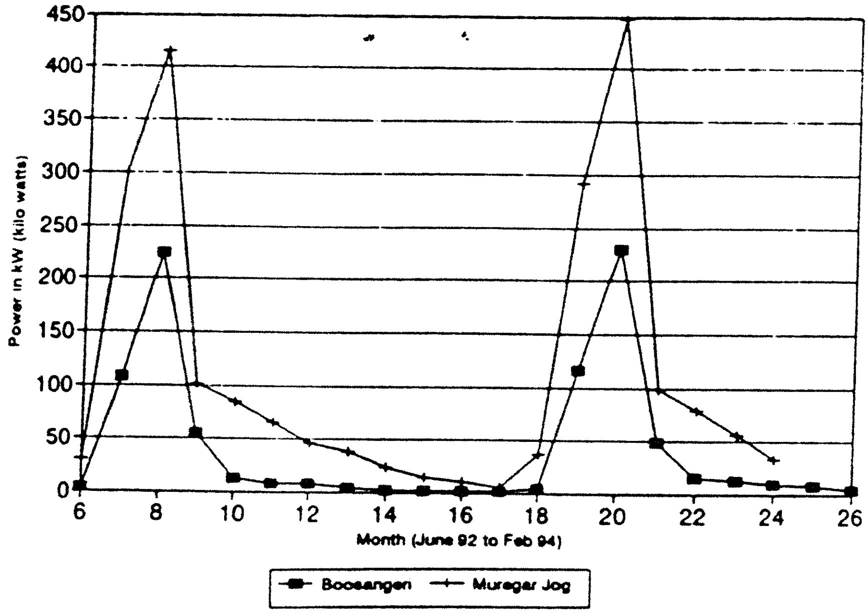

Fig. 2 Estimated power in Muregar & Boosangeri Jog (Rational method)

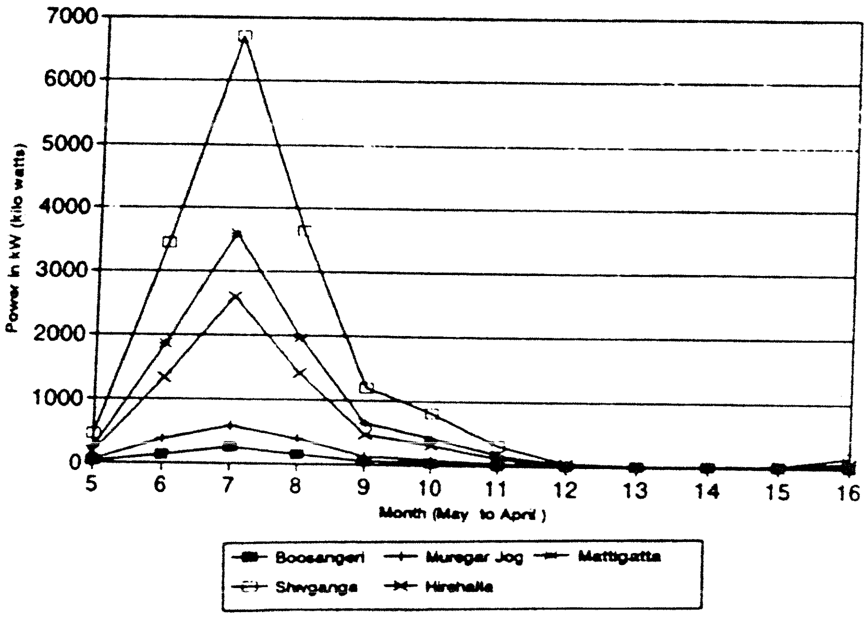

Table – 3

ESTIMATED POWER (MONTH WISE) IN BOOSANGERI STREAM AND MUREGAR JOG

		Based on field measurements Boosangeri	Muregor
6	12 June 1992	2.94	30.09
7	12 July 1992	108.31	300.12
8	12 August 1992	224.99	414.78
9	12 September	55.09	101.85
10	12 October	12.14	84.76
11	12 November	8.27	65.42
12	12 December	7.6	45.65
13	12 January	4.19	38.54
14	12 February	2.68	23.37
15	12 March 1993	1.72	14.56
16	12 April 1993	1.6	10.75
17	12 May 1993	1.49	5.23
18	12 June 1993	4.19	36.92
19	12 July 1993	116.45	292.12
20	12 August 1993	230	447.48
21	12 September	48.72	99.47
22	12 October	15.12	79.45
23	12 November	12.54	56.33
24	12 December	9.41	32.61
25	12 January	7.65	30.06
26	12 February	4.44	23.04

Table – 4

RATIONAL METHOD WITH THE KNOWLEDGE OF CATCHMENT AREA, PRECIPITATION (100 Years)

		Boosangeri	Muregar	Mattigatta	Shivganga	Hirehalla
5	May 1992	17.50	48.02	242.23	450.45	174.96
6	June	138.38	379.69	1853.68	3447.02	1338.85
7	July	260.19	576.83	3601.43	6697.07	2601.19
8	August	141.70	388.82	1961.39	3647.32	1416.64
9	September	48.23	132.33	646.04	1201.35	466.61
10	October	31.17	85.52	431.42	802.22	311.59
11	November	12.73	34.92	170.48	317.02	123.13
12	December	1.85	5.08	25.63	47.66	18.51
13	January 1993	0.24	0.65	3.29	6.11	2.37
14	February	0.24	0.73	3.34	6.22	2.42
15	March	1.04	2.86	14.41	26.80	10.41
16	April 1993	6.67	17.08	83.41	155.10	60.24

CONCLUSIONS :

This study highlights the possibility of harnessing hydel potential in ecologically sound way to suit the requirements of the region. Sirsi, Siddapur, Yellapur taluks of Uttara Kannada District being located in a hilly terrain amidst evergreen forests with large number of streams ideally suitable for micro/mini/small hydel plants. Monthly stream gauging at Muregar and Boosangeri has revealed that mini hydel plants could be set up at these sites. Stream at Muregar is perennial, during summer with a flow of about 0.26 m3/sec power of the order 10-20 kW could be generated. While during seasons power of 300-400 kW could be harnessed.

Computations of discharge on empirical basis/rational method based on precipitation history of last 100 years and power calculated is in conformity with the power calculations done based on stream gauging. This method may be used for calculations of power in ungauged streams in these taluks. These exercise provides insight to the regional requirement through integrated approaches like harnessing hydel power in decentralised way during seasons and meeting lean season requirement through solar or other thermal options.

APPENDIX

Definitions :

Catchment Area : Catchment Area is the area above a specific point on a stream from which water drains towards the stream. Catchment boundaries are located by using the contour lines on a topographical map. Boundaries are drawn by following the ridge tops which appear on topo maps as down hill pointing V-shaped crenulations. The boundary should be perpendicular to the contour lines it intersects. The tops of mountain are often marked as dots on a map, and the location of roads which follow ridges are other clues. Catchment area can be measured directly form the marked maps using planimeter or (b) superimposing a grid of squares or a dot grid over a map and then counting the number of squares or the number of dots which fall within the catchment *area*. Stream flow and ecology are both affected by catchment conditions. Changes in stream discharge and sediment loading caused by the modification of the catchment are reflected in variations in the rate of sediment transport, channel shape and stream pattern. Responses to a change may be immediate, delayed or dependent upon a critical factor reaching a threshold level.

Stream Length : Stream length will influence the amount of stream habitat area in a catchment. The lengths of a streams also affect the travel time of water in a drainage system and availability of sediment for transport. Opisometers (map wheels) which measure distance as they roll across a map are used to measure stream length.

The longitudinal Profile : The longitudinal profile of a stream describes the way in which the stream's elevation changes over distance. The x-axis represents the distance along a stream as measured from some outfall point such as a stream junction, a lake, or an ocean.

Perennial Streams : Perennial streams are those which flow year-round. They are primarily effluent, and consist of base flow during dry periods.

Intermittent Streams : Intermittent streams are those which flow for only certain times of the year, when they receive water from springs and runoff. Depending on the season they are either influent or effluent. During dry years they may cease to flow entirely or they may be reduced to a series of separate pools.

Euphermal Streams : Euphermal streams are influent, having channels which are above the water table at all times.

Gross Head : Difference in level form the upper surface of the water at the highest usable point to the lower level of its use by the turbine.

Mean Catchment Slope : The slope of the catchment will influence surface runoff rates and is related to drainage density and basin relief.

$$S_b = \frac{(\text{Elevation at } 0.85\ L) - (\text{Elevation at } 0.10\ L)}{0.75L}$$

Mean Stream Slope : is given by —

$$S_c = \frac{(\text{Elevation at Source} - \text{Elevation at mouth})}{\text{Length of Stream}}$$

Net Head : Equivalent to the gross head less the hydraulic losses in the different elements conveying the water to the turbine.

CLASSIFICATION OF HYDEL PLANTS

1. Systems based on power and head : Mini/Micro/Small Hydel Plants

	Power (kW)	Low Head	Medium	High Head
Micro	up to 50	< 15	15–50	> 50
Mini	50-500	< 20	20–100	> 100
Small	500-5000	< 25	25–130	> 130

Note : Head is in metres

The upper and lower head and output limits adopted for any classification are indicative only.

2. According to intake :

Run of river (lateral intake from a main water course) with reservoir or dam

3. According to its regulation :

Adjustable flow which may be either manual or automatic.

Constant load, whether because of the actual nature of the load or through dissipation of excess energy.

4. According to its links to the grid :

Isolated plants

Plants connected to small electric grids

Plants connected to major zonal or national networks

5. According to technological concepts :

Plants using conventional technology : This implies quality civil engineering works for the intake, canal and forebays : silt basin at the intake, steel piping, expensive electro- mechanical equipment constructed to strict material and manufacturing criteria and fully instrumented switchboards.

Plants using non-conventional technology : They often use intakes from existing irrigation canals which are improved, the forebay installed in line on the canal and incorporating the silt basin, electro-mechanical equipment designed and constructed with technologies appropriate to the level of industrial development of the country and the availability of local materials, standardised equipment and modular switchboards with minimum instrumentation.

6. Classifications of basins and sub basins :

Based on a study of geographic and topographical maps a preliminary approximations are to be carried out. It includes the approximate determination of the hydrographic and physical parameters of the basins and sub basins of the region either on the basis of measurements and studies which have been carried out or by inference from mathematical models. Overall evaluation studies of the resources in the region to be carried out covers the studies of ecology, hydrology, geology, geomorphology and the availability of aggregates.

CRITERIA FOR SITE SELECTION

The choice of site is to be based on a close interaction between the various conditions like the pattern of the stream, the integrity of the site works, environmental integration. It is necessary to establish the inventory of energy demand in various sectors and assessment of various other sources like Isolar, biomass, wind etc. Various factors involved in estimating hydro potential are : (1) the head (2) hydrological pattern : defined from measurements or form interrelationships between effective rain and discharge. (3) usage of water, upstream of the intake to determine the flow which is available, and downstream to determine the effects of diverting the water from present and furture uses. (4) Distance from the intake to the power station and from the power station to the consumer site. (5) Size of the scheme involved and evaluation of their stability depending on various lithological, morphological and topographical conditions.

EQUIPMENTS REQUIRED FOR FEASIBILITY STUDY

(1). A spirit level or dumpy level, (2), Plumb line with about 15 m string, (3).

Graduated poles (in cms) 2 meters length, (4). 50 m length tape, (5). Current meters with accessories, (6), 50 m length nylon rope and 2 pegs, (7). Stop watch.

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