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SELECTION OF SUITABLE SITES FOR SMALL HYDROPOWER PLANTS USING GEO-SPATIAL TECHNOLOGY

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1. ABSTRACT

Water is the most valuable and limited natural resource. This the basic need for all the organisms on the earth. It is required for the agriculture, industrial development and for the power generation. During several years many studies have been published papers on small hydropower plant that did on large extent. The objective of this study is to review different methodology used for generating the power by using runoff. The electricity generated from the small hydropower plants can be used for the nearby villages and towns. The selection of suitable sites for the small hydropower plants can be done by using Remote sensing and GIS. The most important thing is the availability of water. Soil type, Topography, Land use and land cover, slope, rainfall data, contour are the parameters required for selecting the suitable site. The selection of small hydropower plants can be done by using the satellite data and other data sources. The different methods used for runoff calculation and selection of suitable sites are discussed in this review paper.

2. INTRODUCTION

Now-a-days the non-renewable source of energy is depleting very fast, which focused on renewable source of energy. Solar energy, wind power energy and hydropower plants are considered as renewable source. Hydropower is one of the most common renewable sources abundantly available in the hilly region(Patil, Shirkol, & Joshi, 2013). Hydro power plant is a clean, renewable and non-polluting source which have higher efficiency showing relating to operational feasibility and economic superiority over the generation of electricity(M. P. Sharma, 2007). Small hydropower projects (SHPs) are normally run-off-the-river schemes with no storage of water. The globally accepted classification for hydro is in terms of power output, but the norms vary from country to country. In India a hydro power plant of capacity lower than 15 MW is termed ‘small hydro’(Das & Paul, 2006). The classification of hydropower plants depends on the installed capacity.

1. Micro hydropower plants (0.1 MW)

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2. Mini hydropower plants (2 MW)
3. Small hydropower plants (<15 MW)
4. Large hydropower plants (>15 MW)

Table no 1: hydropower capacity applications for small-scale categories.

Hydropower category	Capacity in power output	Potential hydropower use either as a single source or in a hybrid configuration with other renewable energies.
Pico	Up to 20KW	10KW network to supply a new domestic dwellings .
Micro	20 KW to 100 KW	100KW network to supply small community with commercial/ manufacturing enterprises.
Mini	100KW to 1MW	1MW plant can offset about 150000 tons of CO_2 annually and will provide about 1000 suburban households with reliable electricity supply.
Small	1MW to 10 MW	1 MW to 10MW network-electrical distributions will be at medium voltage ranging from 11 to 33 KV and transformers are normally needed; the generation must be synchronised with the grid frequency.(typically 50 to 60 hertz)

In India, a hydro power plant of capacity lower than 15 MW is termed 'small hydro' power plant (Das & Paul, 2006). Small hydropower plant is classified according to the availability of water as run-off (Singal, 2009).

The following are the methods used the researchers for calculating the runoff and type of the soil are soil conservation service (SCS) and curve number(CN), soil water assessment tool(SWAT), Geo-spatial information system, decision support system, analytical hierarchy process, Hydrological modelling.

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3. Application of Remote sensing and GIS

GIS is a computer based system dealing with the geographic data or maps for capturing and processing spatial data of geographic nature and used input, storage, manipulation and display of geological data. Remote sensing can be defined as the observation of targets from distance without physical contact(Sayeed, Hasan, Hasnat, & Kumar, 2017).

GIS gives suitable alternatives for systematic management of large and complex database. The best advantage of using remotely sensed data for hydrological modelling and monitoring its capacity to generate information in spatial and temporal domain is the ability to reduce time, labour and money which are useful in making quick decisions for sustainable water resource management (Tiwari & Shukla, 2015).

Remote sensing and GIS plays a vital role in in the field of land and water resource.one of the greatest advantage of using Remote sensing data for natural resource management its capacity to generate the information in spatial and temporal domain, which is very crucial for successful model analysis, prediction and validation(Sciences, 2017) .

Remote sensing and GIS techniques play an important role in solving human needs and natural problems. Remote sensing deals that each object has its own spectral signature that facilitate its distinction from other objects. GIS has a capacity to link the spatial data and non spatial data to give better decision making(Al-Awadhi, Al-Shukili, & Al-Amri, 2011).

Remote sensing is the widest sense is concerned with detecting and recording the electromagnetic waves from the selected areas in the field of view of the sensor instruments. It is a practice of getting information about earth's land and water resource using images getting from an overhead perspective, electromagnetic radiation in one or more regions of the electromagnetic spectrum reflected from the earth's surface.

GIS is a computer programme, which is used to collect, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular purpose. GIS primarily deals with the geographic data to be analysed, manipulated and managed in the organised manners thought the computers to solve the real world. GIS operation requires Geographic data and computer system(Patra, 2010).

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One of the basic method used in the field work is space information in a selected area. These space information contains topography, land use, climatic changes and socio economic changes. GIS and Remote sensing are the useful methods for collecting and analysing the above information.(BAUMGARTNER & APFL, 1996).

4. Methodology for the identification of suitable sites

4.1 GIS and hydrological modelling technique

The small hydropower plants are developed from the ancient periods. Instead minute energy control from the water source, its participation to over all energy is still low. This is proof from some of the energy statistics. The total contribution of hydropower has been calculated as 6.15% of the overall world energy mix. The total energy from the hydropower is wasted is only 25% of the economically potential with its concentration mostly in industrialised country. In India it has been reported as 16.6% of total energy have been represented as 25% of the country's demand. In north-eastern part of India, only 2% of overall energy has been wasted so far. Compared to the other energy source, the development of hydropower plant has also been slow (during 1990-2005). Hydropower growth is 43% against 67% of thermal power and 73.8% for wind.

With benefits of modern calculations tools like remote sensing, GIS and hydrological modelling are used for the identification of suitable sites. The practical representation of: (i) existing terrain(ii) complex hydrological phenomenon(iii) climatic changes are now possible with the development of spatial data and modelling techniques. Hydrological modelling are simply the representation of hydrological cycle. These model is based on both mathematical and statistical concepts which is possible to integrate all physical events leading to better simulation of physical world using GIS and hydrological modelling. GIS and remote sensing tools has been used for identifying the hydropower energy in recent times.

There are number of benefits for GIS integrated procedure depends on the hydrological modelling, some of the limitations are explained below. It requires large amount of data including land use, soil and climatic changes has been major limitation of hydrological modelling.

The following objectives has been considered for the identification of suitable sites for the development of small hydropower plants.

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(i) Identification of suitable sites by using GIS, remote sensing and hydrological modelling technique.

(ii) To find the spatial and temporally available water source using hydrological modelling technique.

(iii) To calculate theoretical hydropower energy in the study watershed integrating results of spatial analysis and modelling simulation.

To identify the suitable site, the DEM data and stream network is required. The DEM data tells about the terrain features of the study area and interpolating of contour at 20m interval from survey of India at 1:50000 scale. The stream network was also extracted from the SOI toposheets at 1:50000. The ordering of the stream network is done by using strahler method. For the assessment of flow rate, the SWAT2000 hydrological model was used. Basically SWAT model is a long term, physically based, continuous simulation watershed model developed to quantify the impact of land management practices in large complex catchments. It has a capacity of simulating runoff, percolation return flow, erosion, nutrient loading, pesticide fate and transport, irrigation, ground water flow, channel transmission losses, pond and reservoir storage, channel routing, field drainage, plant water use and other supporting process from small, medium and large watersheds. It can be applied for large un-gauged rural watershed with more than 100 number of sub water sheds. SWAT model can divide the watershed into sub basins which allows accounting of land use and soil properties impact on hydrology again divides into small units called hydrologic response units (HRU). The application of SWAT2000 requires some specific data for simulation of flow rates. These data can be divided into spatial thematic map and discrete data at specific locations. Spatial thematic map includes: (i) Digital Elevation Model (DEM), (ii) stream network data, (iii)land map use and(iv) soil map. The input data corresponding to discrete location include: (i) climatic data and (ii) discharge data.

The disadvantage of this method is to overcome by using latest modelling tools. However, such modelling models approach requires large number of data DEM, soil properties, land use data and metrological data. Here SWAT2000 is used for the hilly watershed areas situated in North east India using the available data to assess the water resource and the hydropower potential (Kusre, Baruah, Bordoloi, & Patra, 2010).

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The ability to identify renewable energy resources is of paramount importance in reducing fossil fuel dependency and addressing climate change. The Rapid Hydropower Assessment Model (RHAM) uses a Geographic Information System (GIS) to identify hydroelectric power opportunities. Using a Digital Elevation Model (OEM) and regional hydrologic data, RHAM calculates the amount of hydroelectric power available on all streams in a study area, screening out sites within parks and environmentally sensitive areas, and estimates project costs. RHAM can also assess the suitability of hydroelectric development in a given area, taking into account economic, environmental and social factors, and can assess storage hydro and clustered developments (

4.2 Geo-spatial information system

Construction of small hydropower plants are the most important resource which helps to fulfil energy demand. In the whole world 70% of the site are exit where small hydropower plants can be constructed. Location of sites for selecting the sites for small hydropower plant can be done by different methodologies and different ways. Geo-spatial information system is the one of the method for selecting the suitable sites. In Korea, are blessed with plentiful of potential dam sites. Geo-spatial information system is used for identification of suitable site. The analysis for suitable site the following steps: (a) preparation of spatial data, (b) spatial analysis to create searching points,(c) making criteria and adding weights, (d) overlay analysis, (e) calculating total scores with relative weights, (f) selecting sites location by total score.

The methodology is divided into the following steps:

a) Initial processing

Initial hydrological assessment of study area.

b) Initial processing of data Initial hydrological assessment of area of interest'

c) Definition of criteria maps and calculating their weights.

Selecting the sites and their assessment as well as calculating the storage capacity.

First, the watershed assessment was done by using ArcGIS. In multiple criteria analysis, for the dam construction, in literature review various people have proposed different factors like flow characteristics, indices of flow as well as human disruptions, flood frequencies, peak average and annual discharge. In a addition to that the different terrain parameters like elevation, slope stability and geology is the basic criteria for the dam construction as well as economic viability.

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There was a problem occurred with the stream which a linear series of selected pixels of flow creates the problem in the weighted overlay tool for computing the dam zones furthermore high flow is on tertiary steams so floe accumulation map was used as an alternative of stream order map. The Strahler method is virtual as it takes the small tributaries and make them as order 1 i.e., initial and increases their order when two same order streams meet each other and resulting the stream is numbered as 2.

The next criteria war TRI is the first criteria factor for the management of watershed as well as depends in various factors like gravity and water flow in the catchment area and mostly incorporated in the modelling in flow paths of the rivers runoff. For effective planning of dam construction the rainfall and discharge data should be of past 30 years.(S, 2016).

For location examination of the SHP can be describe as the process of test for identifying sites that are deemed to have lesser obstacles to the projects and are more beneficial at the initial stages of the development. Considering that location analysis is to be carried at the initial stages, regional to use the existing geographical and hydrological data in order to reduce the cost and time. Here for locating the suitable sites Geo-spatial information system is used. GSIS has recently started for locating analysis which is accurate at the initial stage of SHP planning. GIS is a operating system of software, hardware and GIS database which required qualified manpower, comprehensively and systematically collects, stores search for and compute difficult spatial information. Previously the methodology used for selecting the site is done by onsite and manual work. For selecting accurate site for SHP the GSIS method is used. This methodology is used for selecting the alternative site than selecting the suitable site. By applying the new methodology, a large area can be accurately survey within short period of time. The spatial data is required for creating streaming network grid and the other data is used for overlay analysis. Spatial analysis is specially used for creating stream network grid from DEM of the study area. The stream network grid map is used for searching SHP locations. The searching process sequentially advance from an upward cell to a neighbouring downward grid cell. Therefore each cell can perform as for the searching point in location analysis. The stream network grid is used for the selection site. After creating the searching points the criteria for location analysis and their relative weights are determined. In the location criteria the hydrologic, topographic and eco-environmental factors are used to grade each searching points are included to evaluate accurate location from the eq.1. As the natural head have been calculated in multiple numbers according to the

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water length by a searching point, we need to find the representative values. From the eq.2 s_i is calculated for n number of points, it is divided by the maximum value for standardization. Thus this method is used for selecting a few locations among the many searching points.

$$P^h_i = w_n * S_1 / \text{Max}(S_1, S_2, S_{3,\ldots\ldots}) * 100 \quad \ldots\ldots\text{eq.1}$$

$$S_i = \sum_{j=1}^{m} \left(\frac{\frac{hf}{\text{lf}}}{m}\right) \; (i = 1,2,\ldots\ldots,n) \; (j = 1,2,\ldots\ldots,n) \quad \ldots\ldots\text{eq.2}$$

The dam wider ratio can be limited to the land use item of the land cover map include residential district, industries, commercial areas, recreation facilities, traffic areas and public facilities.

It is critical that SHP maintains a stable stream flow, need to perform a flow duration through long term runoff data or a long term runoff simulation for an ungauged basins. It is difficult to conduct this type of analysis on number of points at the location analysis stage. Assuming that precipitation characteristics of the area are not significantly different spatially, larger area contributing area will coincide with more stable and continuous stream flow. Here we set the runoff contributing areas hydrologic factor in this study. From the eq.3 the runoff for the particular area can be calculated. The runoff contributing area can be estimated as

$$P^a_i = w^a * a_1 / \text{Max}(a_1, a_2, \ldots.., a_n) * 100 \quad \ldots\ldots\ldots\ldots\text{eq.3}$$

$$i = 1,2,\ldots..n$$

The sites generated from the GSIS is considered as alternatives for the final decision. There are so many factors which effect the site suitability like economic efficiency, site accessibility and the electric grid connections were not taken into account. Here the total process of site analysis by creating a system model while accurate of the result were enhanced. This functionally will enhance the feasibility and reliability of the decision making process for SHP development location analysis. (Yi, Lee, & Shim, 2010).

Water shortage, energy crisis and natural misfortunes are the glitches which reduce the efficacy of agricultural ecosystems especially in Pakistan where these are more frequent besides being intense. Accordingly, the agricultural water resources, food security and country's economy are at risk. To address this, we have used geospatial techniques incorporating ASTER Global DEM, geological map, rainfall data, discharge data, Landsat 5

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image of Swat valley in order to assess the viability of selected sites. The sites have been studied via GIS tools, hydrological investigation and multi parametric analysis for their potentialities of collecting and securing the rain water; regulating floods by storing the surplus water bulks by check dams and developing them for power generation. Thus, there is necessity of active hydrological developments to estimate the flooded area using advanced and multifarious GIS and remote sensing approaches so that the sites could be developed for harnessing those sites for agricultural and energy drives (Saima, Zeshan, & Rida 2016).

4.3 Soil conservation service (SCS) and Curve number(CN)

Identifying the suitable site for small hydel in the inaccessible mountainous area is a tremendous task. This paper deals about the selection of suitable site for the small hydel in the mountainous region by using GIS and Remote sensing. In this paper the soil conservation service (SCS) curve number (CN) method have been utilized for calculating the monthly average runoff. The distributed curve number technique has been used in this work. SCS CN methods has been used for calculating the monthly average runoff for the selected sites. It increases our energy security and is ideal for meeting the peak demand. Small hydropower plant is normally run-off-the river scheme with no storage of water. The globally accepted classification for hydropower is in terms of power output, but the norms vary from country to country. In India the capacity of hydropower plant less than 15 MW is termed as ‘small hydro’.

The basic methodology contains as follows:

I. Identifying of sites in the watershed having suitable elevation for small hydro using GIS.
II. Calculating of available water flow in the selected site.

a) Calculation of base flow: This has been done by actual measurement of the flow at accessible points at various watershed in the same region and having similar characteristics. The following parameters are used to find the base flow of any watershed in the region:

(i) Number of pixels draining at the point where observation has been taken.

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(ii) Average slope of the sub-watershed whose measurement has been done.

(iii)Quantity flow as measured at actual sites of the sub-watershed.

b) Run-off calculation: Run-off of the selected site has been calculated by using distributed CN method

c) Total flow: The total flow of the selected site is the sum of the run-off and base flow.

d) Calculation of the power generation can be calculating using the formula:

Generating capacity : P =9.81*Q*H*E …………..eq.4

Where P = Power in kw

Q = Discharge available in m3/sec

H = Net head in mt

E = Overall unit efficiency (85% to 90%)

Identifying the suitable sites in the mountainous area can be very difficult task. GIS with its spatial and three dimensional capabilities can be successfully used for this purpose. While selecting the suitable sites for small hydel, it is the one of the most necessities the cost should be low. By using the eq.4 the amount of power generated can be calculated. This methodology can reduce the cost to a great extent and hence improve the cost benefit ratio of such an installation (Das & Paul, 2006).

Rainfall and runoff are great sufficient amount to recharge the ground water in the watershed. Additional sources of recharge include the seepage canals, tanks, streams and functional irrigation. Hydrological and hydro metrological data are important for assessing of water availability for planning and design of artificial recharge structures. Runoff in a watershed is affected by the geomorphological factors, especially land use changes affects runoff volume and runoff rate significantly. The SCS-CN method is used to calculate volume of runoff from the land surface meets river and stream. The land use and land cover map is obtained from the satellite image LISS III, topo sheets form survey of India, soil and texture type was collected from survey of India. Digital elevation model is derived from USGs web site and Rainfall data is collected from PWD Dharmapuri. By studying the satellite image find out the land use and land cover of both type of land. To find out the soil type convert them into hydrological soil type A, B,C,D according to the infiltration capacity of soils. Superimpose the land use map on the hydrologic map obtained each soil group with polygon,

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finally area of each polygon is calculated and the curve number is assigned for each polygon based on the standards of SCS method. The curve number is assigned for each drainage basin of area-weighting calculated from the land-use soil group polygon within the drainage basin boundaries. The Soil conservation service Curve number approach is frequently used to calculate direct runoff from watershed using the eq.5. The infiltration losses are combined with surface storage by the relation of

$$Q = (P-I_a)2 ⁄ P-I_a+s \quad \text{.........eq.5}$$

Where, Q is the gathered runoff in mm,

P is the rainfall depth in mm,

I_a is the initial abstractions in mm and storage capacity, interception and infiltration prior to runoff in the watershed.

The empirical relation was developed for the terms I_a , the empirical relation is given by I_a=0.3s

For Indian conditions the form S in the potential maximum is related by S = (25400 /CN)-254

Where, CN –curve number which can be taken from SCS handbook of hydrology (NEH-4), section-4

Now the equation can be written as:

$$Q = (P - 0.3S)2/(P + 0.07S) \quad \text{.............eq.6}$$

The SCS curve number is purpose of the capacity of soils to allow infiltration of water with respect to land use/land cover and antecedent soil moisture condition. Based on the U.S SCS soils are distributed into four hydrological soils A,B,C,D with respect to the runoff and final infiltration. Therefore the direct runoff for the particular area can be calculated from the given eq.6

The soil map is traced in ArcGIS software by using registration topographic maps. Various soils are digitized up to the boundaries and each polygon representing many soils classes were assigned and various colour for recognition. The hydrological soils are divided into A,B,C,D are classified soils in the watershed. The soil A indicates low runoff potential, high infiltration rate. The soil B indicates moderate infiltration, moderate well drained to well drained. Soil C indicates pointed to moderate fine to moderate rough texture, moderate water transmission. Soil D group indicates slow infiltration and possible high runoff.

SCS and curve number methods is efficient method which consumes less time and facility to handle extensive data set as well as lager environment area to identify site selection of artificial recharge structures (Satheeshkumar, Venkateswaran, & Kannan, 2017).

4.4 Geo-spatial technology

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Identification of suitable sites for small scale hydropower plant by using Geo-spatial technology and SWAT model. Catchment boundary id delineated using DEM and SWAT MODEL. By using the DEM the flow direction map is generated. The direction of flow is determined by finding the direction of steepest descent from each cell. Flow accumulation is created using the flow direction map. The flow accumulation function calculates accumulated flow, as the accumulated weights of all cells flowing into each down slope cell in the output raster. In the present work the flow accumulation ranged from 0 to 470716 in terms of cells. Identification of suitable site can be done by using DEM and flow accumulation map. Aspect map was also considered while identifying the location of site. SWAT model set up for the catchment to simulate the flow for the entire catchment.

SWAT model has been used to study the spatial and temporal variations in steam-flow. The SWAT model was tested mainly on monthly and annual basis for predicting runoff and sediment yield. The SWAT model has also been validated on Indian watershed, on basis of daily and monthly run-off and sediment yields.

The output power for a system is computed based on the equation proposed by the U.S. Department of energy. Multiply net head by flow divided by 10. Which will yield the systems output in watts(W).

Power Output for Sub-Catchment 77

Power Output= net head [(feet) x flow (gpm)]/10 = W.

Power Output = (50 x 22507.45)/10 = 1125.37 KW

Power Output at the outlet of Catchment:

Power Output = (70 x 31066.63)/10 = 2174.66 KW

With the power output for the sub-catchment 77 and the output at the outlet of catchment, it can be proposed, Micro hydropower plant.

In past, the small hydropower plants resources has been carried out by using the maps and onsite survey which consumes time and cost to a great extent. In this study is able precisely survey large area within short period of time. By using the applications Geo-spatial technology the identification of suitable sites for small hydropower plants can overcome the difficulties faced in the traditional methods (Patil et al., 2013).

4.5 Decision support system

This study tells about the method Decision Support System (DSS) which is a computer –based planning. DSS is designed and implemented to ease and focus of regional energy planning is being shifted speed up the use of environmental analysis and towards

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environmental analysis and towards renewable sources and energy conservation technique. Spatial DSS (SDSS) refers to the systems which related to the GIS technology. GIS gives an important source of tools and techniques, which can usefully be incorporated in a DSS, which utilize of geographic or spatial data.

Energy from hydropower plant is a clean, renewable source which helps to serve national environmental and energy policy objectives. The energy from hydropower plants can be obtained from freely falling water, either from river and streams downwards to the sea or lake and dams along the river flow due to the gravity. The energy from the flowing water is known as kinetic energy. The kinetic energy from the flowing water which helps to drive the turbine to generate electricity. The amount of kinetic energy stored in the water depends on the volume of water and the velocity of water. Large scale hydropower plants causes environmental issues, social issues and complex technical problems. Due to this, the focus has shifted to micro, mini and small hydropower plants. Small hydropower plants are mostly based on run-off-rivers with no storage of water and one of the most cost effective. The small hydropower plants are better when compared to the large hydropower plants.

The electricity from the hydropower plant which is feasible all over the world, which is estimated at 14,370 TWh/Year and which is equal to 100% of today's global electrical demand. The economically feasible proportion of this is considered to be 8080 TWh/Year. Karnataka has a capability of developing 7500MW of hydroelectric project, of which just 2755MW constituting around 36.75% of energy has been exploited.

In this paper, the relationship between runoff and precipitation is determined by using regression analysis and calculated by using the eq.7 is given based on the field data and the by using ruoff the catchment area the yield can be calculated using the eq.8. Empirical relation between variable runoff and precipitation is given by

$$R= 0.849*P*30.5 \quad \text{.........eq.7}$$

Where R- Runoff

P- Rainfall in cm.

A rational approach is used to find the yield of a catchment area by assuming a runoff co-efficient

$$Yield=C*A*P \quad \text{...eq.8}$$

Where C - co-efficient of runoff

A- catchment area

P- Rainfall

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The value of C varies depends on soil, geology, vegetation. From 0.1 to 0.2 (heavy forest), 0.2 to 0.3 (sandy soil), 0.3 to 0.4 (cultivated absorbent soil),0.4 to 0.6 (cultivated or covered with vegetation), 0.6 to 0.8 (slightly permeable, bare), 0.8 to 1.0 (rocky and impermeable).

For calculating the hydropower potential requires both exact value and time variability of flow head using the eq.9. Power is calculated based on flow data and head height.

P= 9.81*Average (flow data) * Average (head height) ………eq.9

E=P*t*n*f ……..eq.10

Where

P- Power in KW

t- Operating time in hours

n- Efficiency of the turbine generator assembly

f- co-efficient for seasonal flow variation for river run of river installation.

The DSS method is a user friendly, which gives user with all the needs to calculate hydropower energy at different sites with different conditions for Micro, Mini and small hydropower plants. From the power consumed and time the energy can be calculated using the eq.10. The frame work is designed in such a way, that user provides with helpful tips and context sensitive options(Ramachandra, Kumar Jha, Vamsee Krishna, & Shruthi, 2004)

4.6 AHP and GIS for Decision making system

The selection of site for the construction of dam in the Northwest china. Northwest china has been proved as one of the highest water pressure in a global scale. The yearly precipitation in Northwest china varies from 40 to 600mm, while the yearly evaporation reaches a high point at 1500-3000mm. To overcome this type of problems, one of the major solution is to construct the dam which helps to store the water and generates the electricity. Here, the selection of site is done by using Analytical hierarchy process (AHP) which is the most feasible and simplest but very efficient method for solving multi attribute decision making (MADM) problems. Multi decisions are sometimes very difficult in the real world due to the difficulties of reality. One of the most efficient methods which is possible solutions is multi criteria decision making which refers to making decisions in the presence of multi criteria that usually conflict each other. By using MCDM, the complex problems are divided into smaller parts which help to understand and make judgment on. There is no unified

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method can be followed step-wise. Instead, big different methods are proposed for MCDM. Analytical hierarchy method is one of the most used methods.

Geographical information systems (GIS) provide the decision-maker with a powerful set of tools for the manipulation and analysis of spatial information. The functionality of GIS is, however, limited to certain deterministic analyses in key application areas such as spatial search. The integration of multi-criteria evaluation (MCE) techniques with GIS is forwarded as providing the user with the means to evaluate various alternatives on the basis of multiple and conflicting criteria and objectives. An example application based on the search for suitable sites for the disposal of radioactive waste in the UK using the Arc/Info GIS is included. The potential use of a combined GIS-MCE approach in the development of spatial decision support systems is considered (Stephen J. Carver.1991).

Small hydropower projects (SHP) are emerging as solution for sustainable, eco-friendly, long term and costeffective water or renewable energy resource for future. Selecting the appropriate small hydropower project site and its parameters in which to invest is a critical task involving different factors as each project is unique and site specific. Hence such decision-making can be viewed as a multi-criteria optimization problem with correlating criteria and alternatives. This task should take into consideration several conflicting aspects because of the increasing complexity of the socio-political, technological, environmental and economic factors. Traditional single criteria decision-making approaches cannot handle the complexity of such systems. Multi-criteria optimization or MCDA or MCDM methods may provide a better and flexible tool to evaluate applicability of multi-criteria optimization to decision makers during the small hydropower project site selection. To the best of the author's knowledge these novel approaches for application of multicriteria optimization in small hydropower site selection are absent in renewable energy or water resource or fluid mechanics literature due to its assessment complexity (Adhikary , Roy, 2015).

Analytical hierarchy method is one of the easy and efficient decision making method as well as one of the most useful method in MCDM. Most of the publications from 2000-2014 used AHP method in MCDM. Both intangible and tangible problems can be measured with absolute scales by utilizing AHP. The procedure of AHP is divided into three types which is considered to find the objectives, criteria and alternatives.

Geographic Information System (GIS) and tools or multi-criteria decision making (MCDM) methods in order to obtain the evaluation of the optimal placement of photovoltaic solar power plants. The combination GIS-MCDM generates an excellent analysis tool that allows for the creation of an extensive cartographic and alphanumeric database that will later be used

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by multi-criteria methodologies to simplify problems to solve and promote the use of multiple criteria. In GIS two types of criteria will be reflected: constraints or restrictive criteria, and weighting criteria or factors.Weighting criteria or factors will be those which, according to the objective to be reached, influence the ability to solve a concrete alternative. The choice of such criteria is marked by the influence presented to the overall goal; in this case they will be location, geomorphological, environmental and climatic criteria. Through the use of MCDM the criteria or factors mentioned will be weighted in order to evaluate potential sites to locate a solar plant. Analysis and calculation of the weights of these factors will be conducted using Analytic Hierarchy Process (AHP) (Watson, Hudson, 2015).

The application of AHP in GIS has been operated since beginning of 21st century. The integration of AHP with GIS gives an efficient and user friendly which helps to solve complex problems with the combination of decision making support method and tools with powerful ability of mass data computation, visualization and mapping. The implementation of AHP in ArcGIS, which is most used method. It is utilized to know definition of objectives, identification of criteria, data collection and pre-process, digitization of criteria and convert all data into raster data, classification of raster datasets, creation of preference matrix, determination of criteria weights according to calculation preference matrix, weight summation of criteria raster data as results.

ArcGIS is used for processing data including the DEM, soil, geological layer, land cover, precipitation and products from these datasets. Drainage network gives the necessary runoff water for dam construction, different levels of drainage network provides runoff water with relation of streams are upper streams tributaries and downwards main streams. Precipitation is the main source of runoff source. Precipitation has positive influence for the dam construction. Slope is one of the main functions for constructing dams. High degree of slope has higher risk of natural disasters like landslides and gives more pressure on the construction of dams. Soli type can determine the texture of the soil, infiltration capacity which helps for constructing the dam. Geological layer which helps to find the rock type. Suitability of the selection of site is calculated as weighted summation of different layers in the ArcGIS RASTER Algebra tool. The above data will be used for selecting suitable site for constructing the dam.(Dai, 2016).

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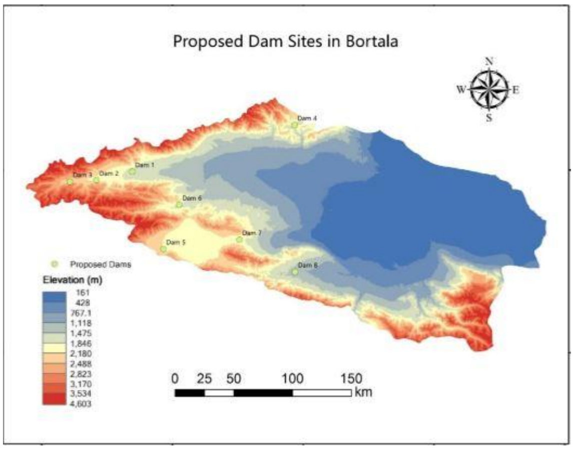

Fig.no 1: proposed dam sites in Bortla

Here 8 sites are located area with highly elevation distributed from 1180m to 2342m. All dam are located in or near to the moutainous area where proper valley shaped and highly precipitate are exist.

4.7 Hydro potential assessment tool

Reservoir, runoff and hydro kinetic are important but the present system assessing small scale run-off- river resource potential all over the world. The study focus on small scale run-off-river because there is a need for tool that has all over the world applicability to the site these project and model how climate may changes impacts on the future performance. We selected this method because run-off-system are the most depends on the natural things like stream flow which are important in the developing regions. Hydro-kinetics are based on the natural flows but often installed in the agricultural canals or in the reservoir based hydropower infrastructure.

SWAT is a hydrological model by USGS, in conjunction with Geological information system model which helps to find the watershed locations within India suitable for generation of hydropower plants. The first disadvantage of this model is not distributed fully and initially it is to assess non-point pollution source. As alternate uniform grid cell, SWAT model utilises the hydrological response units which have uniform properties are related to the small hydro power plant infrastructure. SWAT model which does not able to resolve the study domain at a sufficient spatial scale for identifying small runoff river hydropower energy instead these are depends on the local elevation gradient.

Hydrospot tool is able to find runoff river and selected sites but requires uses to

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supply their own gridded streamflow time series, which cannot be done in hydrospot. Due to this, implementing the data for new regions would essentially requires conducting new climate, hydrology and hydropower studies using region specific tools.

HPAT is set of integrated model written in matlab which has ability of modelling runoff river hydro potential at each grid cell in a study domain. HPAT model which is implemented for existing hydropower infrastructure or over a large area explore which region have high hydropower resource energy. It requires the DEM data with 1km spatial resolution. In many regions runoff river hydropower is mixture of both rain and snowmelt.

HPAT model is used to find the more potential locations within the site for development of small runoff river hydropower resource and to quantify impacts on hydropower resource energy due to climatic changes(Mosier, Sharp, & Hill, 2016).

5. Analyse the factors effecting the development of hydro power projects in hydro regions of India

Hydropower plant is considered as non-polluting source of energy. The hydropower plants are considered according to the capacity and which helps to increase availability of the power. This type of power plants are considered for fulfil the peak demand as well as basic power demand of the particular area. The small hydropower plants which have a long life and helps in saving the environment from the effect of non-renewable sources. More than 80% of hydropower plants of our country are distributed among 4 Himalayan states that are Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Arunachal Pradesh. In India hydropower plants with the capacity of 25 MW are considered as small hydropower plants. The total SHP capacity in India is about 19,749MW from 6747 identified sites. About 34.8% lies in the Himalayan regions. These small hydropower plants are based on run of the river schemes. The central Government is providing financial support to areas with hydro rich states and also to the private sectors for developing this sector. Central ministry is giving helps the site surveys in addition the investigation, preparation of the detailed project report f SHP and special training is giving by the Alternate Hydro Centre(AHEC). Small hydropower plants are not experience with the deforestation, large area requirement and development of large dams when compared with the large power plants. These type of plants have the capacity to meet the power requirement of remote areas.

In the research article we have taken case study of Jammu and Kashmir which is located in the north western Himalayan region of India. This is having huge amount of power plants in terms of small hydropower plants and large power plants. The Jammu and Kashmir

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is having huge hydel capacity which, when exploited totally, will give a strong boost to the development of its economy. The total capacity of the Jammu and Kashmir is 20,000 MW of which around 16,475 MW have been identified. During winter, the flow will be minimum due to the snow results in power shortage. To fulfil the demand the state government rely on the purchase power from north grid. The 18^{th} all India power survey has depicted an increase in maximum power demand of Jammu and Kashmir from 1706 MW during 2004-2005 to 4217MW during 2021-2022. The development of SHP in Jammu and Kashmir is slow. Lack of the private sectors in the state is the one of the region for the low establishment of the projects. Special motivating forces are additionally given by the state government to the private gatherings for the establishment of undertakings up to25 MW in Jammu and Kashmir. The state government additionally sets up discrete divisions which will handle the establishment of micro/mini scale and small hydro power projects hydro extends inside the state. The local people are excited to have such type of power plants which provides job opportunities and reduces the power demand. This type of projects plays a major role for the development of remote locations(A. K. Sharma & Thakur, 2016).

5.1 Design Considerations of Micro-Hydro- Electric power plant

The micro hydropower plant which is designed to be run-off –river because it requires small amount of water or no reservoir for generating the power. For generating the power water should be in motion. When the water is falling by the force of gravity, its potential energy converts into kinetic energy. This kinetic energy of the flowing water changes into blades in the hydraulic turbines. This form of energy converts into mechanical energy. The turbine starts rotating when the energy changes into mechanical energy. According to the international energy agency, the first hydraulic systems are developed in 1880's. The large scale hydropower plants provide about 16% of the electricity in the world. This kind of hydropower plants requires large amount of land, dams, flood control and often creates environmental problem. The micro hydropower plants are alternative source for production of electricity. This type of hydropower plants can generate 5 – 100 kilowatt energy when they constructed on the streams or river. The difference between the small hydropower plant (up to 10 MW) and the micro hydropower plant (up to 100KW) reveals that causing difficulties in implementation. The micro- hydro powers plants are low cost, small seized and generate electricity for small community.

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Micro hydro powers are generally constructed on the rivers or streams. As the micro hydropower plants are built on the rivers, the water flow capacity of the turbines can be determining by using the flow duration curve of the river.

For measuring the discharge of the water several methods are available. The velocity-area method is a conventional method for medium size to large size rivers, including the cross sectional area of the mean velocity of the water flow through it(Nasir, 2014).

5.2 Environmental factors

The clearance is given by Ministry of Environment and forest, Govt. of India. The project cost is up to 1000 million Indian rupees. It is mandatory for developing projects in reserve forest area which required considerable time. Some trees are cut which required for constructing the project, developer should plant more plants to take of ecological balance (Singal, 2009)

In India, the SHP with an outlay of less than 1000 million are allowed from the environmental clearance from MoEF but required all clearance from the state government. In India and china, the capacity of SHP is up to 25 MW and in Sweden up to 1.5. However, the capacity of 10 MW is generally agreed worldwide. In India, the classification of SHP is based on the capacity; Micro hydro: 100KW, Mini hydro: 101-2000 and SHP:2001-2005 kW. The SHP has low ecological problems but advances made are not properly harmonised with environmental protection. Environmental management plans have been worked with financial estimates to the mitigation measures (M. P. Sharma, 2007)

Power is the backbone for the country. If a country has their source to generate the power at competitive price in that case the people of the country get the benefits in terms of development in their social and economic life. So, it is necessary to find the factors which effects the SHP especially in western India region. The SHP have long life and helps in protecting the local environment from the negative effect of fossil fuels (A. K. Sharma & Thakur, 2016)

The main benefit of SHP is its economically friendly design. Diversion power plant are considered as green power which reduce carbon emission and the environmental impact of fossil fuel energy production. They also produce less economic waste and pollution than other type of power plants. Runoff river plants is aimed for maintaining natural ecosystem. It has been said that increase in hydropower in India will reduce the burning of wood as fuel. This idea supports the theory that SHP will reduce deforestation and decrease the green house emission. Silt deposition and sediments are removed to protect turbines blade (Spicer, 2014)

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6. Conclusion

The study involves the selecting the suitable sites for small hydropower plants. In the earlier, small hydropower plant is carried by using the map, which requires more time and cost. This paper tells about the ability of selecting the suitable site by utilising the different methods in Remote Sensing and GIS. The Geo-spatial technology is the one of the method in GIS which is used to identify the suitable sites for the development of the small hydropower plant. This method can be done within the short period of time and economical. This method can be used in the hilly areas or mountainous region. The main aim is to utilise the runoff water, because it requires very little or no reservoir in to power to turbine for the production of electricity. For generating the hydropower, the water should be in flowing motion. Geospatial technology will be used for the selection of the site for the development of the hydropower plant.

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