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Sustainable Water Resource Management

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Abstract:

Kurseong sub-division consists of numerous smaller streams but they hardly have any water during non-monsoon period, hence local people suffer from acute shortage of water during dry period. To counter this situation, successful implementation of big scale rainwater harvesting system and simultaneously capturing excess surface water through various micro irrigation arrangements can be done. Sustainable water resource management can be done through Water harvesting Tanks, Check Dams etc. Micro irrigation structures are being constructed for capturing surface run-off as well as fruitful utilisation of reserved water for irrigation and other purpose. Reduction in the quality and quantity of tea production is very much influenced by rainfall pattern, so, increase in water holding capacities in various water bodies will help in supplementary irrigation during dry season. But during monsoon, the river Mahanadi and jhoras receive huge quantity of rainwater, but the basin is unable to hold back water due to steep slope and excessive deforestation most of the rainwater is wasted. Availability of water throughout the year through sustainable water resource management will help the local habitats for their required activities. Total rainfall of Kurseong during Nov'18 to Oct'19 was around 10200 mm. Population density of Kurseong is around 5646 per Sq. Km. Through study it has been observed that by the implementation of roof-top rainwater harvesting system in the study area around 35% of required water can be harvested. Sustainable water resource management is very much essential for growth and development of Kurseong hill area.

Keywords*-: Kurseong, Rainwater Harvesting, Water Resource Management, Sustainable, Rainfall*

I. INTRODUCTION

The situation is true indeed in Kurseong hill areas, where people suffer from acute water shortage during dry season despite high rainfall.

Topographically the region is mountainous with valleys, gorges formed by streams and their tributaries [23]. The average altitude of the watershed area is ranging from 300 meters to 2000 meter approximately. Along the basin area rugged terrain and Pedi plain has developed by the existing streams [1].

The climate condition of this region shows a wide variation. The mean annual temperature varies from 14^0C to 23^0C, while the annual rainfall also shows a huge difference between monsoon and non-monsoon period. The average annual rainfall has been estimated to be about 3791 mm, based on long-term average data of 13 rainfall recording stations situated within the catchment area [22]. The rate of mean monthly evaporation loss is also dependent on the mean monthly rainfall and temperature data. This study reveals that the northern part, which is the southern slope of the Mahaldiram range, shows minimum evaporation loss, which has been estimated to be about 10% of the rainfall during monsoon months and 19% of the total rainfall [2].

II. Objective

- Assessment of the rainfall status in and around the study area throughout a year in different seasons to get a comprehensive idea about the quantity of downpour in the area
- Study the present status of the available water resources in and around Kurseong hill area

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- Analysis of the impact of water as a natural resource on the socio-economic life of the local people
- Assessment of the problems related to water scarcity in the study area
- Identify the scope of alternate methods for water conservation, like rainwater harvesting system

III. Materials and Methods

Kurseong is basically mountainous in nature, with valleys formed by two-major rivers – Balason and Mahanadi. Shiva Khola, Jogi Khola etc are some of the important tributaries of Mahanadi [20]. Darjeeling district is covering an area of about 3149 Square Kilometer, which is divided into four sub-divisions, namely Darjeeling, Kalimpong, Kurseong & Siliguri. Kurseong sub-division is comprised of two blocks – Mirik and Kurseong and it lies between $26^0$37" to 27^0 N latitudes and from $88^0$12" to $88^0$30" E longitude [21]. The river Mahanadi has its source near Mahaldiram dome at an elevation of 2200 meter near Chimli and from there it flows south-south-eastward after receiving a few right and left bank tributaries. The whole area is also termed as upper part of Mahananda basin [3]. The present study of water resource management is carried out in Mahanadi River Basin, which is formed by Mahanadi and its tributaries.

Sampling techniques

Physiographies of the study area have been determined. Visiting different villages to find out local jhoras and their utilization has been done as the method of collecting primary data. Participatory Rural Appraisal (PRA) has been conducted. Problems related to the water resources have been identified. Secondary data have been collected from the relevant libraries, official sources and from Survey of India Topographical sheet 78 B/5. Problems related to water scarcity; landslides have been determined. The pattern of rainfall and run-off distribution has been correlated. Alternative method for the management of water resources has been assessed and suggested [4].

IV. Results

The following table (Table 1) depicts distribution of rainfall in different month starting from November 2018 till October 2019 in Kurseong sub-division to show the variation in rainfall pattern in the study area.

Table - 1

Month	No. of Rainy Days	Amount of Rainfall in m.m.
November 2018	5	10.7
December 2018	6	15.1
January 2019	6	19.2
February 2019	13	106.5
March 2019	18	409.8
April 2019	29	1388.7
May 2019	31	1645.8
June 2019	30	2096.8
July 2019	31	1729.9
August 2019	31	1148.1
September 2019	30	1120.2
October 2019	25	452.9

Severe winter is not observed in Kurseong and except the monsoon, calm, quiet and a healthy climate prevails throughout the year. During monsoon, heavy downpour is the significant feature which is also ideal for the growth of white orchids (*Coelogynae crystata*) found in significant number in the hill area for which Kurseong got its name from the Nepali word 'Kharsang' meaning 'Land of White Orchid' [5]. The month of June received the highest amount of rainfall. It is clear from the above table that, in the month of April, June, May, July, September and August, the quantity of rainfall is higher. In other words, these selected locations get maximum amount of rainfall throughout the year. Among these, in the month of June, Dow Hill and Long View gets highest amount of rainfall, confirming the huge downpour in these regions. But this huge amount of rainwater is lost as there is no arrangement or method available at present to preserve water for future use. Hence, proper water management plan is required [19].

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V. Discussion

Problems

In the watershed area the most significant problems related to water is shortage of water. Under the whole Kurseong sub-division, numerous smaller streams, locally known as jhoras exist, but they hardly have any water during non-monsoon period [18]. So, the people of Kurseong suffer from acute shortage of water during dry period and must purchase water at a very high cost. This indirectly affects the socio-economic status of the people of the basin area [6].

On the contrary, during monsoon period the river Mahanadi and those smaller jhoras receive huge quantity of rainwater, significant use of which cannot be made, because primarily the Mahanadi basin is unable to hold back water due to steep slope and excessive deforestation, the result of which is that, most of the rainwater goes down the slope and give rise to the severe soil erosion instead of solving the water scarcity problem. Secondly, there is no proper system, either natural or manmade, in place to preserve the huge downpour for use in future [7].

Generally, the people of this area suffer from two types of problems. One is the problem of drinking water and another is the problem of irrigational water [17]. At this stage it is necessary to take some action regarding the efficient utilization of water, so that proper developmental plan can be undertaken for sustainable socio-economic status of the people [8].

Rainwater Harvesting & Water Resource Management

Based on the detailed fieldwork and analysis of the problem of the watershed area it was noticed that the principal problem of this area is scarcity of domestic water especially during summer [24]. The next major problem is the scarcity of irrigational water followed by low productivity. A management plan for the identified problems has been proposed for mitigating these problems [9].

Roof top rainwater harvesting structures are proposed for mitigation of drinking water scarcity. In case of roof top rainwater harvesting, the rainwater is collected from roof of the building and stored in a reservoir for beneficial use during dry months [10].

Rainwater Harvesting Methodologies

1. Land based Rainwater Harvesting
2. Roof Top Rainwater Harvesting
3. Watershed based Rainwater harvesting

For Urban & Industrial Environment

Roof & Land based RWH

a) Public, Private, Office & Industrial buildings [11]

b) Pavements, Lawns, Gardens & other open spaces

Importance:

- To full-fill water crisis in the hilly area
- To reduce the run-off & thereby soil erosion
- To enhance ground water recharging and control long-term decline of water level
- To avoid overflow of water on the roads

Advantage

- Solution to the water scarcity problem
- To utilize the rainfall run-off, which is going to sewer or drain
- Rainwater after first shower is soft, organic matter free and pure from bacteriological point of view [13]
- Structural modifications regarding rainwater harvesting is economically viable, simple and eco-friendly

Rainwater Harvesting Storage facility and Capacity

Rooftop rainwater harvesting diverts the rainwater falling on the roof by an outlet pipe to store for future use or to recharge it into the aquifer. The roof may be constructed with suitable roofing material like PVC sheets, tiles or concrete slabs etc. [12]

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Roof yield

Rooftop rainwater harvesting has been suggested here as a part of management plan which would help us in assessing the total yield of water from the system. Maximum yield from a rainwater catchment is directly proportional to

- Surface area of catchment
- Runoff factor
- Amount of rainfall

Now, the meteorological factors affecting runoff are mainly -

1. Rainfall intensity
2. Rainfall duration
3. Rainfall quantity
4. Type of precipitation, e.g. snow/rain/sleet
5. Overall distribution of rainfall
6. Wind direction
7. Antecedent precipitation

So, if we get the total quantum of available rainwater in the Kurseong and the area of the rooftop then it will be easy for us to calculate the availability of total yield based on following formulae [14].

Therefore,

$$\text{Yield} = \frac{\text{Run-off factor} \times \text{Area} \times \text{rainfall in mm}}{1000} = m^3 \text{ yield / month}$$

General values for run-off factor for different catchment areas

1. ***Bare Ground = 0.10 - 0.20***
2. ***Paved area = 0.50 – 0.85***
3. ***Roof top = 0.75 – 0.95***
4. ***Green area = 0.05 – 0.10***

Calculations:

Total rainfall of Kurseong during the time period from Nov'18 to Oct'19 = 10200 mm.

Total area of Kurseong Municipality = 7.5 sq.km (Approximately)

Population = 42346 (As per 2011 Census)

Density of Kurseong (M) = 5646 per Sq.Km.

If the roof area is 100 Sq. meters

Run-off factor = 0.95 =1

Then, Roof yield

$$\text{Yield} = \frac{100m^2 \times 10200 \text{ mm} \times 1}{1000} = 1020 \text{ } m^3 \text{ yield / year}$$

1020 m^3 / yr for a single house having roof top area of 100 m^2

Considering 4 person per family, total number of houses = 5646 / 4 = 1412 per sq. Km.

Taking 50% of these houses would be able to harvest, the number becomes = 1412 x 50% = 706 per sq. Km

Therefore, the total yield would be = (706 x 1020) m^3 /yr

= 720,120 m^3 / yr

= 720120 ltr / yr per sq. Km.

For a family of 4, amount of water to be used is 8 liters per day.

So, for a year the amount would be = 8 x 365 = 2920 liters

Hence, for 706 families the amount = 2920 x 706 = 2,061,520 liters

So, by roof-top rainwater harvesting [(720120 x 100) / 2061520] = 34.931% = 35% of required water can be harvested.

If this much amount of water can be managed through roof top rainwater harvesting, then it will be a great relief for local people and this harvested water can be utilized for domestic purposes including drinking, washing, bathing etc. [15].

There might be other methods of water harvesting applied in this area, in the form of canal harvesting which can be further utilized in agricultural fields for crop production, cinchona plantation etc. [16]

VI. Conclusion

The water resource management policy should consider the effect of economic development on the practice of water as exploitation of natural resources strongly linked with technological developments as

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well as with capital accumulation and income and should be accounted for in planning.

Sustainable growth and poverty reduction can be solved through proper water resource management and development and that must be the goal of administrative authorities in Kurseong hill area.

The people suffer from acute shortage of domestic water especially during summer when there is hardly any water available in the local jhoras. Another major problem of this area is lack of irrigation water. As a result, crop productivity of this area is very less. On the other hand, heavy rainfall during the rainy season washed away the soil of the upslope area and lead to the problem of several hazards like flood, landslides etc., which is not desirable to us. So, as a part of our study it is our duty to recommend some mitigative measures with which the people may overcome such problems.

A study of the available water resource of the concerned area has been carried out as a part of Watershed management. This study has considered the presence of total water resource in the river Mahanadi, the availability of the water during monsoon and non-monsoon period. This study has revealed several problems that the local people have to face.

To get rid of the problems arising from scarcity of water, some positive steps can be taken, like:

1. Arrangements of domestic water through rainwater harvesting system
2. Checking soil erosion by proper land use management and engineering guidance
3. Continuous afforestation programme

Good quality with more space area and clean rooftop will provide cleaner, more pure and better quantity of rainwater. This water will also be adequate to support vehicle washing, gardening, cleaning and other secondary usage. Rainwater harvesting should be implemented in a large scale throughout Kurseong hill area from eco-tourism point of view and for the benefit of the local people. Tea estates, hotels, resorts should take the initiative for conservation of this precious resource.

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