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Determination of Crop Water Requirement to Design of Irrigation Canal for Rikhey Village

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***Abstract*--- Bhutan being a mountainous country, the possibility of constructing an efficient irrigation system is less and most of the places do not have sufficient water for the cultivation of crops. There is limited research done to design the irrigation canal as many irrigation systems across the country has failed. The limitation can be covered with Geo-technical approach in designing the irrigation system. Richey village under Dewathang gewog, Samdrup Jongkhar was identified to have irrigation water shortage for planting the main crops i.e. rice and maize. Crop water requirement was determined with the application of CROPWAT. Maps were created using ArcGIS 10.4.1. Stream and contour map were used to locate the sources, three locations were identified namely Marthang, Lamsarong and the water harvest area. The alignment of the canal was produced using contour and slope maps and then compared where the water harvest area was found to be most suitable area as source for the study area. The calculated water amount for harvesting was 4,827,259.32m3. Finally, the irrigation canal was designed from the discharge and slope obtained from the CROPWAT 8.0 and ArcGIS respectively as per the standards of IS 4745-1968.**

***Keywords*--- Crop Water Requirement, CropWat, Irrigation, Small Farm Reservoir**

I. INTRODUCTION

Approximately 62 % of Bhutan's population resides in rural parts of the country. The rural-urban migration has been observed since 2016, with decline in rural population from 530,679 to 452,178, which is approximately 14.79% decline rate in the span of three years. The farmers face major challenges and constraints due to inadequate irrigation services and human-wildlife conflicts which lead them to migrate or leave their farmlands fallow. Bhutan cultivates 85,090MT of rice annually from 53,055 acres of farmlands. According to Agriculture-Statistics-2016, about 6.2% of the 163,001 households has been reported to experience food insufficiency. In the year 2018, agriculture sector contributed approximately 17% of Gross Domestic Product (GDP). With the increasing rate of rural-urban migration increases the food self- sufficiency. In the year 2018, rice import amounted to Nu. 1.267B and Nu. 2.69B worth of vegetables. It is observed that 10% of total migration is caused due to inadequate irrigation water supply for farming and unproductive land [1].

According to survey conducted in 2016 by experts from Asian Development Bank, concluded that about 29% of irrigation canal doesn't meet the demand of crops in farmlands [2]. It is found that, out of 7.8% of arable land in Bhutan, only 2.93% is under cultivation. Approximately 700 acres of paddy fields have been damaged due to rapid urbanization, building roads, townships and buildings and about 6345 acres of paddy fields been left fallow. It is determined that if 6345 acres of paddy fields could be cultivated, it would harvest approximately 10,323.315 metric tonnes of rice [3].

In the late 1960 with the 2nd Five Year Plans, the government of Bhutan launched the irrigation development plans with initiation of large-scale irrigation projects through donor assistance from Asian Development Bank [4]. These projects are now successfully utilized by the farmer communities.

Cultivated land in Bhutan is broadly categorized into two types: *Kamzhing* and *Chhuzhing*. *Kamzhing* is a sloping, unbounded terrace where rainfed crops like maize, potato, millet, buckwheat, and orchards are grown. *Chhuzhing* is a leveled, bonded terrace where summer paddy is grown as the main staple crop. *Chhuzhing* can be irrigated or rain-fed. Paddy (rice) is the most important and preferred staple crop in Bhutan. As a result, production of paddy is also synonymous with food security, and has become an important national goal. The need of irrigation channel is found at *Rikhey* village under Dewathang Gewog located at 26o51'12''N and 91o30'57''E. The total Cultivable Commanded Area (C.C.A) of *Rikhey* village is about 400 acres. The various crops grown are paddy, maize, potatoes, ginger and chilies, but they are mainly focused on paddy and maize with their total CCA of 400 acres (100 acers and 300 acres respectively). With future plans for extension in the cultivating land, they are facing shortage

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in irrigation water..

II. METHODOLOGY

A. Literature Review

The crop water productivity with small farm reservoir was conducted in Karanganyar, Indonesia. The runoff water from catchment area is collected in the reservoir with the size of 10m length, 3m width and 2m depth. The study showed water in SFR is sufficient for both growing season but SFR was not efficient enough because the water loss was greater than the total water usage for irrigation. The loss of water is due to evaporation, seepage and percolation. Tropical vegetation plantation will be recommended to prevent the loss of water it around the SFR [1].

Four parameters are determined using CropWat i.e. evapotranspiration, crop water requirements and crop irrigation scheme irrigation [2]. Due to aridity and drought there is scarcity of water for the agriculture purposes. Crop irrigation scheme will enable the farmers are agricultural officer to plan and manage efficient farming. Parameters like temperature, actual vapor pressure, saturation vapor pressure, wind speed are required for accurately measuring the crop water requirement [3].

This study concludes that water productivity of similar crops at farm and scheme were similar. The water productivity of the reservoir was low and it can be improved in study sites by improving the agronomic practices and good irrigation water management [4].

The water loss can be minimized by using proper regulation of irrigated water using the water distribution method [5]. Irrigation methods involving partial boarder strip causes 50% water loses than irrigation technique with the pipe distribution system [9].

B. Methodology

CropWat 8.0 is used for determining the Crop Water Requirement using climatic data, crop data and soil data. The average climate data (temperature, humidity, sun, wind and rain) of Samdrup Jongkhar used from the World Weather Online. ArcGIS was used to produce maps of the study area which was further used for selecting the source. Then a canal was designed using the standards of IS 4745 1968 for lined canal.

III. ANALYSIS AND RESULT

Precipitation deficit of the crops in each month is calculated as given in table-1. From it the requirement of the irrigation water is interpreted.

Table.1: Computation of Irrigation Requirements

	Precipitation			Net scheme	Irrigated area (% of total	Irr.req. for actual area
	Rice	Maiz	Maize-			
Jan	0	0	9.5	0.03	75	0.04
Feb	0	0	0	0	0	0
Mar	0	0	0	0	0	0
Apr	0	15.7	0	0.05	75	0.06
Ma	273.8	48.8	0	0.39	100	0.39
Jun	3.4	0	0	0	25	0.01
Jul	7.2	0	0	0.01	25	0.03
Aug	14.7	0	0	0.01	25	0.06
Sep	0	0	3.1	0.01	75	0.01
Oct	0	0	13.4	0.04	75	0.05
Nov	0	0	90.1	0.26	75	0.35
Dec	0	0	68.5	0.19	75	0.26

Table.2: Computation of Catchment Rainwater Harvest

Month	Eff. rain (m)	Area of catchment area (m2)	Vol. collected (m3)
January	0.0106	1664400	17642.64
February	0.0278	1664400	46270.32
March	0.0736	1664400	122499.84
April	0.2248	1664400	374157.12
May	0.3424	1664400	569890.56
June	0.6762	1664400	1125467.28
July	0.6197	1664400	1031428.68
August	0.4467	1664400	743487.48
September	0.3465	1664400	576714.6
October	0.1126	1664400	187411.44
November	0.0143	1664400	23800.92
December	0.0051	1664400	8488.44
Total			**4827259.32**

[1]. Calculation of design discharge

The maximum Irrigation requirement is on May month:
= 0.39 (liters/seconds)/hectors Total Area = 400 acres
= 400 x 0.404686
= 161.874 hectors
Discharge = 0.39 x 161.874
= 63.13 liters/second
= 0.0631 cu.m/S Q = 0.0631 /S
Therefore, the design discharge for the study area is equal to 0.0631 /S.

The contour, streamflow and source location of the study area was created (shown in figure 1). On analyzing there identified sources, Marthang's elevation was found to be 49m below the study area. The distance from the study area was longest from Marthang followed by Lamsarong

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and finally by the water harvesting area. Taking all the things into account and to be more economical the water harvest area was selected as the source for the designing of canal.

[2]. Computation of rainwater harvest from the catchment area

From the water harvest area, **4827259.32m^3** of water can be collected as shown in the Table 2. The collected water was enough for the current irrigation practices in the study area and also fulfils the demand in the extension of the cultivable land.

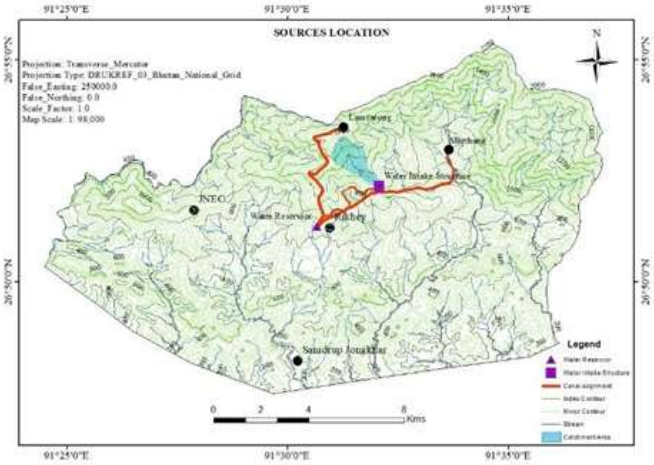

Fig..1: Map showing the source and alignment of canal

IV. DESIGN OF IRRIGATION CANAL

The Collecting water from the above mention watershed is minimum, therefore design the canal. Design was based on the Lined Trapezoidal shaped Channel (IS 4745 1968). Using the following parameters.

Discharge, Q = 0.0631 cumecs Slope, S = 1:13.4

Rugosity coefficient, N = 0.017 Limiting Velocity, V = 2 m/S Mean Hydraulic Depth, R = 0.4m

The canal of depth 0.35m including free board and base width 0.56m was obtained.

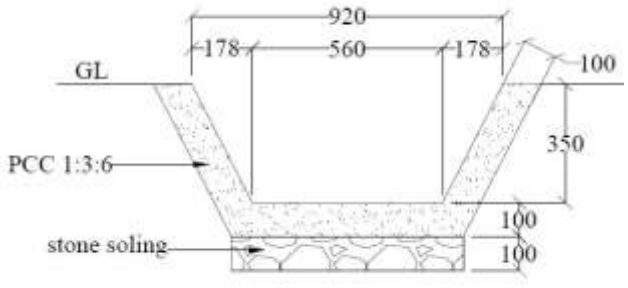

Fig.2: Cross-section of canal (dimensions are in mm)

V. CONCLUSION

The map works were done using the software ArcGIS 10.4.1 version. The maps produced to study the location and feasibility are the slope map, contour map, watershed for selecting the source of irrigation. Three locations Marthang, Lamsarong and water harvest area was obtained initially but while comparing their feasibility, the water harvesting area was found to be the most feasible and economical source for the designing of canal. The catchment area was extracted and using the rainfall data, **4827259.32m^3** of water was estimated to be used. The discharge from the CROPWAT 8.0 software was used to design the canal as per the standard of IS: 4745-1968. The canal of side-slope 0.5:1, base width 0.56 m and depth including the free board of 0.35 m was obtained. It was estimated to cost around **Nu. 3736618.13.**

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