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Assessment of Fresh Water Resources for Effective Crop Planning in South Andaman District

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ABSTRACT

The rainfall data for 40 yr from 1978 to 2017 of the rainfed tropical islands of South Andaman district of Andaman and Nicobar group of islands were analyzed to find out the weekly effective rainfall. Weekly and monthly effective runoff was calculated by following the US Soil Conservation Service - Curve Number (SCS-CN) method. The value of weekly effective rainfall and monthly effective runoff at different level of probabilities was obtained with the help of 'FLOOD' software. The sum of effective rainfalls of standard meteorological weeks from 18th to 48th gives the value of fresh water resource availability during *kharif* season and the same value at 80 percent level of probability was estimated to be 2.07 X105 ha.m. The sum of expected runoff of every month resulted due to the effective rainfall gives the water resource availability during rabi season and its value at 80 percent level of probability was found to be 4.8 X 103 ha.m. All these information will immensely help the farmers, policy makers, planners and researchers to prepare a comprehensive crop action plan for the South Andaman district to make the agriculture profitable and sustainable.

Key Words: Curve number, Effective rainfall, Fresh water resources, Storage capacity, Tropical islands

INTRODUCTION

Small islands are prevalent in the humid tropical regions of the world. Most are part of developing countries and have scarce natural landbased resources. In particular, the water resources of small islands are often very limited. Many islands have no surface water resources and rely on limited groundwater resources in the form of thin freshwater lenses. The exposure of islands makes them particularly vulnerable to natural disasters such as cyclones, floods and droughts. In our country the union territory of Andaman and Nicobar archipelago comprises of 556 small and big tropical islands covering an area of 8,249 sq km with a coastline of 1,962 km between 92-94° E longitude and 6-14° N latitude in the Bay of Bengal. The northern group of islands form the Andaman Islands, while the southern group of islands form the Nicobar Islands, which is separated by 10o channel. The North Andaman, Middle Andaman and South Andaman islands occupy major land mass. The Andaman and Nicobar group of islands fall under hot humid to per humid island eco-region designated as Agro-Ecological Region 21 (Ambast, 2011). The tropical ecosystem of the A&N Islands is very unique having diverse species with wide range of genetic diversity in varying density. High rainfall, extremely humid climate, undulating terrain and backwater creeks are very conducive for diversification of flora and fauna. Evergreen and littoral forests, mangroves and coral reefs are important components of the existing ecosystems prevailing in the islands.

These islands receive an average annual rainfall of about 3080 mm. About 95 percent of annual rainfall is received during May-December, of which,

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nearly 75 percent is lost as runoff to the sea due to undulated terrains and steep slopes (Srivastava and Ambast, 2009). The islands have a width of 15 to 40 km east to west and the slopes are from centre to either towards east or west, due to which, the length of drainage line to the sea is short. Because of this, there is only one perennial river Kalpong in North Andaman island. Thus the actual water availability is much less and islands face severe problem of water scarcity even for drinking water. The availability of groundwater in these islands is also limited as the total replenishable ground water resource is only 0.326 b.cu.m/yr though it is located in the high rainfall zone (Velmurugan and Ambast, 2011). The islands have become a major tourist destination not only for the national but also international tourists. In order to support the tourist driven economy of the islands, the emphasis should be given on production of adequate perishable items in these islands rather than transporting from the mainland. However, the irrigation potential created is just 3 per cent and actual irrigated area is about 1 percent (Srivastava and Ambast, 2009). Therefore, the focus of water resource development should be on irrigation of crops apart from drinking water demand. As the rainwater is the only source of the fresh water available in these islands, its assessment, harvesting, storage and recycling is the most important strategy for water resources development and management. In the present study, an attempt has been made to assess the availability of freshwater resources of South Andaman district for effective crop production during kharif and rabi season.

MATERIALS AND METHODS

The South Andaman district is located in the southern part of the Andaman group of island and is a hot per humid island eco-region in the Bay of Bengal. The district is a group of ten inhabited islands with three numbers of tehsils and 99 revenue villages covering a total of 310.6 thousand ha. The smallest and the biggest inhabited islands are the Flat Bay island (9.36 sq km) and South Andaman island (1347.97 sq km), respectively. Since pre-historic times, these Islands have been the home of aboriginal tribes namely, the Great Andamanese, Jarawa, Onge & Sentineles, all of Negrito Origin. Major portion of population is of settlers from the mainland. The economy of South Andaman district is primarily based upon agriculture, forestry and fishery, (Anon, 2011a). Agriculture during the monsoon is largely affected by the heavy rainfall that occurred during the months of May to July and October to December in the calendar year. In this period, farmers are not able to cultivate any crop other than paddy in the low-lying areas and during the post monsoon months the crops are affected by the severe water scarcity (Nanda *et al*, 2018). For effective assessment of water resources of these islands, various data related to land uses and climate parameters were collected from available published reports of District Statistical Hand Book of Andaman and Nicobar Islands, Directorate of Economics and Statistics, Andaman and Nicobar Administration, (Anon, 2011b), Division of Natural Resources Management, ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair, National Initiative on Climate Resilient Agriculture (NICRA), Port Blair centre and Indian Meteorological Department, Kolkata.

Estimation of fresh water resource potential in Kharif season

a. Calculation of expected week wise rainfall at different probabilities

For *kharif* season, the weekly rainfall data from 18th to 48th standard meteorological week (30th April to 26th November) for the period of 1978 to 2017 were considered and analyzed using the different probability distribution functions and the best fit probability distributions were determined. Applying it, expected week wise rainfall at different probabilities was estimated. The above computations were made with the help of the software 'FLOOD' (Flood frequency analysis software developed by Indian Institute of Technology, Kharagpur).

b. Calculation of expected week wise runoff

Expected runoff during each standard meteorological week was calculated by following the US Soil Conservation Service - Curve Number (SCS-CN) method. It was based on the recharge capacity, which was determined by antecedent moisture conditions (AMC) and physical characteristics of the area. At first, the curve number (CN) for the district was calculated based upon the area weighted value of different curve numbers of respective categories of land use and land cover. Values of curve numbers were determined as per the land use conditions, treatment or crop cultivation practice, hydrologic conditions and hydrologic soil groups. Thereafter, storage capacity (S) was determined by using Equation (1).

$$S=(25400/CN)-254 \quad (1)$$

where,

S = Storage capacity, mm and CN = Weighted Curve Number

The storage capacity as determined above was used to determine the surface runoff of the area as given in Equation (2).

$$Q=(P-0.2S)^2/((P+0.8S) \quad (2)$$

where,

Q = Surface run off, mm and P = Rainfall, mm

c. Calculation of effective rainfall and total water availability

The week wise effective rainfall for the area was calculated using Equation (3).

$$P_e = P - Q$$

The water availability during kharif season (W_{kharif}) in ha.m was obtained by using Equation (4) as stated below.

$$W_{kharif} = (\sum P_e) \times A$$

where,

$\sum P_e$ = Sum of effective rainfalls of standard meterological weeks from 18 to 48, m

A= Total cultivated area, ha

d. Estimation of water resource potential in rabi season

For rabi season, runoff yield from individual rainfall events from 1978 to 2017 was determined using US Soil Conservation Service - Curve Number (SCS-CN) method as described in Equations (1) and (2). These monthly runoff data were analyzed with different probability functions and the best fit probability distributions were determined. In this case the monthly runoff data were analysed against the weekly runoff data for better data handling in the 'FLOOD' software. Expected month wise run off at different probabilities were estimated. The above calculations were made with the help of software 'FLOOD'. The total water availability in ha.m during rabi season (Wrabi) was obtained by using Equation (5).

$$W_{rabi} = (\sum R) \times A$$

where,

$\sum R$ = Sum of expected runoff obtained from different rainfall events starting from January to December, m

A= Total cultivated area, ha

RESULTS AND DISCUSSION

Calculation of expected rainfall in *kharif* season

Using the different probability distribution functions, weekly rainfall data of kharif season for the period from 1978 to 2017 were analyzed and the best fit probability distributions for each week were determined (Table 1) and applying it, expected week wise rainfall at different probabilities were estimated and presented in Fig 1.

Calculation of expected runoff in *kharif* season

Expected runoff during each standard meteorological week is calculated following equations 1 and 2. The weighted curve number (CN) for the district was calculated based on the area weighted value of different curve numbers of respective categories of land cover as presented in Table 2. The values of CN apply to antecedent

Table 1. Week wise best fit probability distribution of rainfall.

SME*	Best fit distribution	SME*	Best fit distribution	SME*	Best fit distribution
18	Log pearson	29	Extreme value Type III	39	Pearson
19	Log pearson	30	Pearson	40	Weibull
20	Gumbel EV1 (Extreme value maximum)	31	Gumbel EV1 (Extreme value maximum)	41	Log normal (2 parameter)
21	Gumbel EV1 (Extreme value maximum)	32	Generalized Pareto	42	Exponential
22	Gamma	33	Extreme value Type III	43	Generalized extreme value
23	Generalized extreme value	34	Log pearson	44	Log pearson
24	Gamma	35	Generalized Pareto	45	Gamma
25	Weibull	36	Log normal (2 parameter)	46	Generalized extreme value
26	Exponential	37	Weibull	47	Gamma
27	Normal	38	Log pearson	48	Weibull
28	Normal				

***SME = Standard Meteorological Week**

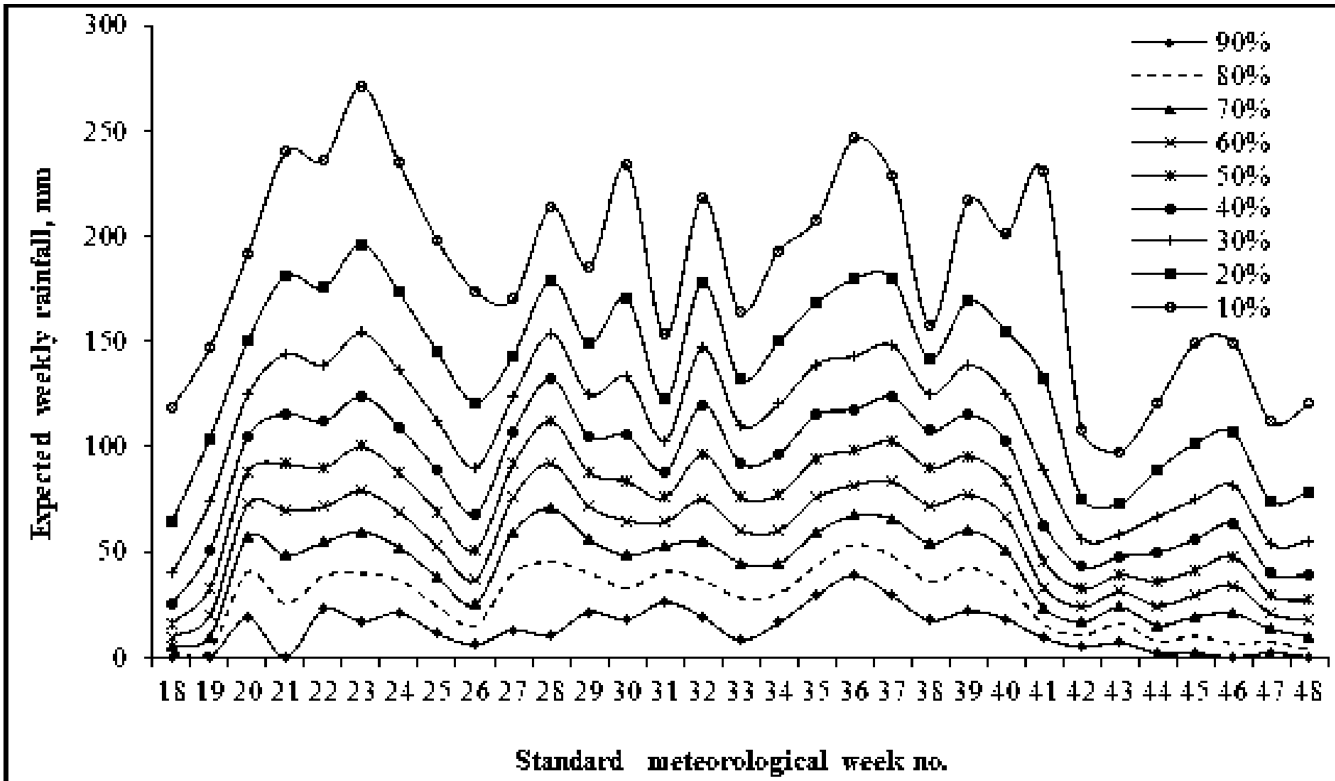

Fig 1. Expected Weekly Rainfall at different probability level for kharif season

rainfall condition II which is considered as an average value. The hydrologic soil group for the district is assumed as Group D due to the high runoff potential and salinity affected soil.

Table 2. Weighted curve no. for the district South Andaman.

Sr. No.	Land Use	Area (ha)	Curve No.
1	Forest Area	267294.00	77.00
2	Cropped Area	7141.04	91.00
3	Uncultivated fallow land	6007.46	94.00
Weighted Curve No.			77.72

(Source : Murty, 1985)

Using the value of weighted CN, storage capacity (S) was determined by using Equation (1) and then runoff was calculated using Equation (2).

Water availability in *kharif* season

Effective rainfall during each week was calculated as the difference between the expected rainfall and the expected runoff during the week. The total sum of the effective rainfall at 80 percent probability level for each week of the *kharif* season is the total water available during the *kharif* season (Naik, 2016). Total water available during *kharif* season at 80 percent probability level was estimated to be 2.07 X105 ha.m.

Table 2. Month wise best fit probability distributions of runoff.

Month	Best fit distribution (chi-square value is minimum)
January	Normal
February	Log normal
March	Weibull
April	Log normal 3 parameter
May	Weibull
June	Log pearson
July	Generalized pareto
August	Pearson
September	Extreme value Type III
October	Log normal
November	Gumbel Extreme value maximum
December	Weibull

Water availability in rabi season

Month wise surface run off due to rainfall was estimated by using Equation (1) and (2). Applying different probability distribution functions by software 'FLOOD', month wise run off for the period from 1978 to 2017 was analyzed and the best fit probability distributions were determined (Table 2). Applying it, expected month wise runoff at different probability levels were estimated and presented in Fig 2.

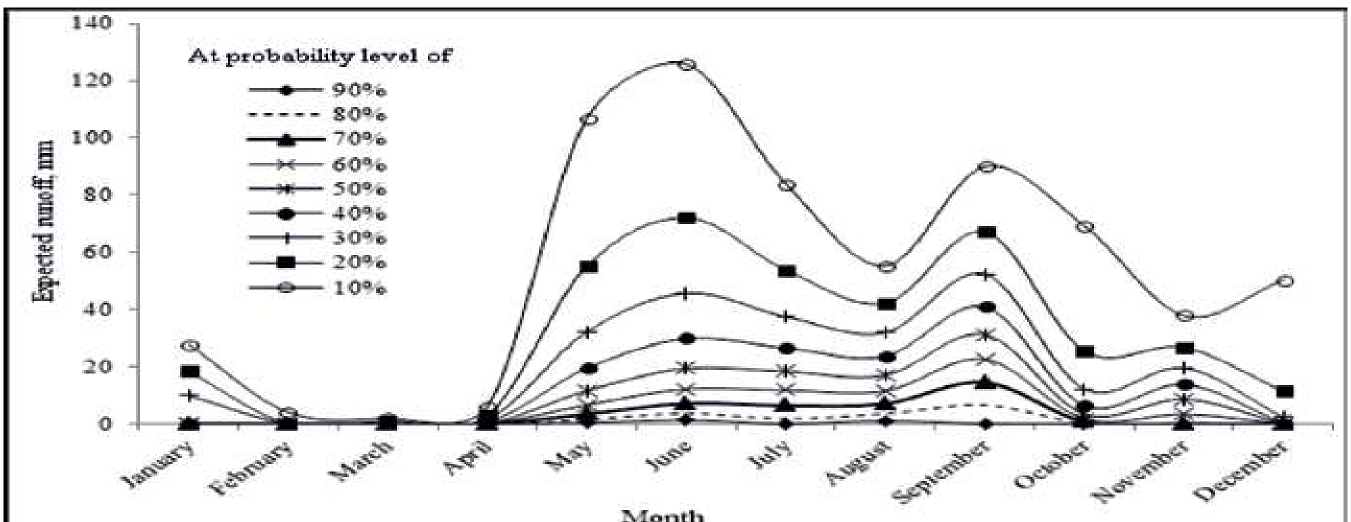

Fig 2. Expected month wise runoff at different probability levels

Expected runoff at 80 percent probability level is considered for estimation of total expected runoff resulted from the area (Naik, 2016). Total yearly surface run off at 80 percent probability level was estimated to be 4.8 X 103 ha.m.

CONCLUSION

The volume of fresh water resources available during *kharif* and *rabi* season for South Andaman district was estimated as 2.07 X105 ha.m and 4.8 X 103 ha.m, respectively for 80 percent level of probability. Due to non availability of ground water resources in these islands, this volume of fresh water will carter the need of both crop water requirement and domestic uses. Hence proper harvesting and storage of these fresh water resources is of utmost important to have an effective crop planning to make the agriculture profitable and sustainable in these group of tropical islands.

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