Soil and Water Conserving Ability of Shola Forests: a Case Study from Wayanad Forest Division, Kerala

Thomas P Thomas and ***S. Sankar***

Kerala Forest Research Institute, Peechi, Kerala, India
E-mail: thomas@kfri.org

Abstract: A short-term investigation was carried out in one of the shola regions in South Wayanad, namely Chembra to estimate runoff from two adjacent shola-grassland catchments which differed in morphometry and extent of shola forests. The first catchment (C_1) was larger (1.52km^2) and steeper (65% slope) with longer than broader shape compared to the second catchment (C_2) with 0.79 km^2 area and 50% slope and thus was more conducive to runoff and soil erosion. But it was blessed with greater coverage of 0.61 km^2 (40.13%) of shola forest. The second catchment had a shola cover of 0.27 km^2 (34.17%). Streamflow (runoff) was quantified by velocity-area method along with stage level recorder to obtain stage of flow.

Runoff from C_1 amounted to 1056.6 mm(63.1%) while that from C_2 amounted to 1,133.17 mm (67.7%). Runoff coefficient was higher in C_2 in all the months showing that it could not retain as much water as C_1 in any of the seasons. The climate, soil and type of vegetation in these catchments were similar; the morphometry and shola coverage alone differed. Drainage density did not vary much but form factor, circularity ratio and elongation ratio were higher in the second catchment, which shows that C_1 is comparatively more prone to runoff and erosion. But the study revealed the contrary-runoff percentage was lesser in this catchment while sediment load did not differ between catchments. This effect can be attributed to the extent of shola forest which is more in the first catchment. The microclimate and the soil properties within the shola have been found to be very conducive to retention of water and is reflected in the soil moisture status in different seasons. Thus it was concluded within the limits of a single water year observation that shola forests do play a positive role in maintaining the water courses in the high ranges of Kerala Western ghats.

1 Introduction

The term “shola”, derived from Tamil “Cholai” meaning stream as well as shade (Swarupanandan *et al.*, 1998) later on became synonymous with both mountain streams and the forests associated with mountain streams. No better word could have been thought of because these forests and streams are inseparable and each owes existence to the presence of the other. They occur together in the mountain folds and depressions where there is abundant moisture and hold soil and water most efficiently on very steep slopes. The location of these Tropical Montane Forests (Meher Homji, 1965) in the high ranges of the Western Ghats above 1,500 m altitude also adds to their water conserving efficiency due to low evapo-transpiration demand.

2 Study area and methods

2.1 Study area

The study was carried out at Chembra Peak area in Meppadi Forest Range of South Wayanad Forest Division. The area receives mean annual rainfall of 2,000 mm. The maximum day temperature goes upto 38℃ during the hot summer and the minimum drops to 10℃ during the cold winter.

2.2 Methods

The following methods were used to characterise the watershed and measure the rainfall, runoff and sediment yield. Stream morphometry was characterised by studying stream order (Strahler, 1957), drainage density (Strahler, 1957), from factor (Horton, 1945), Circularity ratio (Miller, 1953) and elongation ratio (Schumm, 1956). Rainfall was measured with the help of standard rain gauge. Runoff was quantified using velocity-area method, stage of flow being obtained from stage graphs of stage level recorders. Water samples collected twice daily were used to obtain sediment yield.

3 Results and discussion

Data collected on morphometry, climate, soil, runoff and sediment yield are described below:

3.1 Catchment morphometry

The morphometric properties of the two catchments C_1 and C_2 are presented below. The stream of order 3 in C_1 had a length of 1.889 k.m. and the stream in C_2 of order 2 was 0.9887 km long. Both the hilly watersheds had northern aspects and started from 1,150 m asl altitude. Catchment, C_1 went up to 1,860 m asl with an average slope of 65% while catchment, C_2 had maximum altitude of 1,800 m asl only and it was less steep also with 50% slope on an average C_1 had an area of 1.52 km^2, drainage density of 1.243 km/km^2, form factor of 0.426, circularity ratio of 0.6759 and elongation ratio of 0.7366 while C_2 had corresponding values of 0.79 km^2, 1.252 km/km^2, 0.808, 0.808 and 1.0147 for area, drainage density, form factor, circularity ratio and elongation ratio respectively.

3.2 Rainfall

Rainfall pattern at the site is described below. Rain occurred in all the months except January and February 2000 during the study period June 1999 to September 2000 and most of it fell during the South West monsoon period of June-August as is the normal pattern in Kerala State. July was the month with maximum rainfall. Most of the rain (83.65%) fell during June-August 1999 when we take into consideration the water year June 1999 — May 2000. North East monsoon period comes next with 12.11% as its contribution. All the other months together provided only 2.65 percent. The month of July 1999 had 28 rainy days giving 656.7 mm rainfall while July 2000 could contribute even higher quantity (720.3) though the number of rainy days were only twenty five. Maximum rainfall of 73 mm was recorded on 9th July in the year 1999 and 96 mm rain fell on 12th July 2000. There were 54 days with more than 10mm rainfall in the water year June 1999 — May 2000 and 115 such days when the whole study period is taken into account. Thus it can be seen that rainfall was concentrated in the months of June, July and August and intense rains occurred in 54 days in the water year.

3.3 Soil moisture

Soil moisture measured in the surface soilo showed that soil moisture didn't fluctuate much between months in a particular season. Soil moisture values of 32% — 34% on an average was recorded during the S.W. monsoon, 29.30% during the N.E. Monsoon, 28.29% during the winter and 13.6% during the summer. The grassland could not retain as much soil moisture as the shola especially during the non monsoon days. The values during the corresponding seasons were 30%—31%, 22%—26%, 12%—14% and 6%—7%.

3.4 Soil

Soils of shola characterised by studying profiles as well as several surface samples are presented below (Table 1). The morphology reveals that the shola soil is deep (>150cm) with abundant litter cover.

It is dark reddish brown in colour throughout, though the surface horizons are darker than those below. Very friable, loose, crumb structure was found in the top soil while the sub soil horizons had loose massive structure. Roots were found to be present even beyond 100 cm depth, though most of the roots were concentrated within the top 40 cm section. It was sandy loam in texture with very low bulk density (1.0g· cm^{-3}), high porosity (56.5%) and water holding capacity (60%) in the top layers.

3.5 Shola soil profile and properties

Shola forest, 1,600 m asl, steep slope, full canopy cover, thick litter cover, well drained, no rocks, few stones.

0 cm — 10 cm Dark reddish brown (5 YR 2.5/2) loose, friable, crumb structure, abundant roots.
10 cm — 20 cm Dark reddish brown (5 YR 3/2) loose, friable, crumb structure, abundant roots.
20 cm — 28 cm Dark reddish brown (5 YR 3/3) loose friable, granular structure, plentiful roots.
28 cm — 40 cm Dark reddish brown (5 YR 3/3) loose, massive, plentiful roots.
40 cm — 70 cm Dark reddish brown (5 YR 3/4) loose, massive, few roots.
70 cm — 110 cm Dark reddish brown (5 YR 3/4) loose, massive, few roots.
> 110 cm Dark reddish brown (5 YR 3/4) loose, massive few roots.

Table 1 Soil physical properties

Soil depth cm	Gravel	Sand	Silt	Clay	B.D	P.D	Po	MWHC
	%				g· cm^{-3}		%	
0—10	1	76	9	15	1.0	2.3	56.5	60
10—20	1	78	9	13	1.0	2.3	56.5	60
20—28	14	77	9	14	1.05	2.3	54.3	57
28—40	17	78	10	12	1.10	2.35	53.2	53
40—70	7	78	8	14	1.05	2.3	54.3	53
70—110	21	76	9	15	1.10	2.35	53.2	53
> 110	0.7	77	11	12	1.10	2.35	53.2	52

3.6 Runoff

Runoff from the two shola catchments are depicted in Table 2. It can be seen that during the water year 1999—2000, 1,606,059 m^3 water flowed down the stream draining the first catchment (C_1) and 895,242 m^3 water through the stream in the second catchment (C_2). Runoff was concentrated in the S.W. monsoon season. A quantity of 1,449,016 m^3 ran off from C_1 while the runoff from C_2 amounted to 812,294 m^3 during this season. These were 90.62% and 90.7% respectively of the total runoff. Maximum runoff occurred during the month of July corresponding to maximum rainfall. Contribution during this month alone was 45.4% and 45.7% of the total runoff from the catchments C_1 and C_2 respectively. Runoff tapered down to 3,520 m^3 and 1,393 m^3 in the month of May.

Runoff coefficient, an index of runoff - rainfall relationship was seen to be above 0.5 during the S.W. monsoon season showing that more than half the rainfall ran off the catchments (Table 3). In July with highest rainfall, the runoff coefficient was more than 0.70 and in September the values rose to 1.37 in C_1 and 1.43 in C_2. This means that runoff was greater than rainfall in this particular month. All other months had lower than 0.5 values with the lowest value of around 0.1 in the month of May. Similar pattern was repeated in the S.W. monsoon of the next water year also.

3.7 Sediment yield

Measurable amounts of sediments were present in stream water only during the months of June and July when the streams overflow its banks. Water was clear during all other months. In the month June

1999, 0.021 kg/m^3 was the sediment load in the stream from catchment C_1, while that through the stream from C_2 was 0.020 kg/m^3. The sediment load was 0.019 kg/m^3 and 0.017 kg/m^3 respectively from C_1 and C_2 during the next month. The corresponding figures during June and July 2000 were, 0.018, 0.018, 0.019 and 0.018 respectively. It can be inferred that on an average 0.1431 t/ha soil is being lost from C_1 and 0.1448 t/ha from C_2 annually.

Table 2 Runoff from the catchments

Year	Month	Runoff(m^3) C_1	C_2
1999	June	367,080	206,032
	July	728,384	408,825
	August	298,680	167,654
	September	54,872	29,783
	October	72,656	40,029
	November	33,744	17,617
	December	19,912	9,954
2000	January	7,904	3,871
	February	5,016	2,449
	March	8,168	4,620
	April	6,123	3,015
	May	3,520	1,393
	June	353,248	198,290
	July	821,712	458,674
	August	271,016	153,497
	September	61,104	33,022
Total runoff during the water year		1,606,059	895,242

Table 3 Rainfall-runoff relationship

Year	Month	Rainfall (mm)	Runoff (mm) C_1	C_2	Runoff coefficient C_1	C_2
1999	June	416.4	241.5	260.8	0.58	0.63
	July	656.7	479.2	517.5	0.73	0.79
	August	327.2	196.5	212.2	0.60	0.65
	September	26.4	36.1	37.7	1.37	1.43
	October	123.5	47.8	50.67	0.39	0.41
	November	74.2	22.2	22.3	0.30	0.30
	December	5.1	13.1	12.6	2.6	2.5
2000	January	-	5.2	4.9	-	-
	February	-	3.3	3.1	-	-
	March	14.8	5.4	5.8	0.36	0.39
	April	12	4.0	3.8	0.33	0.32
	May	17.6	2.3	1.8	0.13	0.10
	June	421.1	212.4	251.0	0.55	0.60
	July	720.3	540.6	580.6	0.75	0.81
	August	353.2	178.3	194.3	0.50	0.55
	September	34.5	40.2	41.8	1.16	1.21
Total during water year June 1999 — May 2000		1,673.9	1,056.6	1,133.17		

The results obtained are indicatory of the role of shola forests in maintaining watercourses in the highranges of the Western Ghats. The study area located at Chembra was hilly with steep slopes and received a total of 1,673.9 mm rainfall in the water year June 1999 — May 2000 most of which was concentrated (85%) in the South West monsoon season. The total runoff could be seen to be 63.1% of the total rainfall in C_1 and 67.7% in C_2. The runoff coefficient was always higher in C2 showing that it could not retain as much water as C_1 in any of the rainy months. Runoff coefficient values greater than unity recorded in the month of September shows that discharge exceeded rainfall, in both C_1 and C_2.

The shola-grassland catchments being adjacent did not differ in climate, micro climate soil and type of vegetation. The only notable differences were with respect to slope and proportion of shola forest. The catchment C_1 was steeper with greater percentage of shola area (40.13%) compared to catchment C_2 which had 34.17% under shola species. Drainage density did not differ much between the catchments while the form factor, circularity ratio and elongation ratio were more in the case of C_2. This shows that C_1 was more long than broad and also that it was more conical with steeper side slopes. These features render it more liable to runoff losses. But still runoff percentage has been found to be comparatively lower from this catchment. The sediment load did not differ much between the two catchments. The only reason that can be deduced is the impact of shola forest which efficiently conserve soil and water. The soil moisture status within shola lends credence to this view. Soil moisture status during various months of the water year in the shola compared to grassland showed that during the non monsoon months shola soil holds much more water than the grassland. These facts explain the efficiency of catchment C_1 in reducing run off in spite of its morphological weaknesses.

Both the catchments, though small in extent has been found to feed the streams originating from them through out the year. And the shola forests can be seen to be mainly behind this benevolence. Thus it can be concluded that shola forests are capable of giving birth to and maintaining streams in the high ranges, though this conclusion arrived at from a single year study has to be supported by further detailed long term studies.

4 Conclusion

Hydrological data collected from two adjacent shola-grassland catchments at Chembra in South Wayanad revealed the importance of shola forest in conserving water and thus maintaining the streams perennial. The first catchment prone to easy runoff compared to the second by virtue of its morphometry was found on the contrary to contain runoff more efficiently which could only be attributed to the role of larger shola forest cover in that catchment.

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