INDIAN NATIONAL COMMITTEE ON SURFACE WATER (INCSW-CWC)

UID	KL-2006-106
Type (State whether final or draft report)	Final Report
Name of R&D Scheme	STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGHLAND KERALA
Name of PI & Co-PI	Dr Celine George &Dr George Abe
Institute Address	Centre for Water Resources Development and Management, Kunnamangalam P. O., Kozhikode, Kerala, Pin - 673571
Circulation(State whether Open for public or not)	Open
Month & Year of Report Submission	February 2021

Central Water Commission
E-Mail: incsw-cwc@nic.in

Final Report
No.SC/MMK/R-133/21

STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGHLAND KERALA

Funded by :

INDIAN NATIONAL COMMITTEE ON HYDROLOGY (INCOH)

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
KUNNAMANGALAM, KOZHIKODE – 673 571

FEBRUARY 2021

EXECUTIVE SUMMARY

The project entitled "Study on Hydrology of Small Watersheds of Highland Kerala" was sanctioned to CWRDM vide letter no.23/47/2006-R&D/207-217dated January 23, 2006, by INCOH, MoWR, Government of India. The duration of the project was three years and the total sanctioned budget was Rs 13.0 lakhs. As per the request of the investigator the period of the project was extended up to August 2010.

Seven small sub-watersheds in the Erattayar watershed in highland Kerala has been considered in this study. Erattayar Panchayath forms a part of the Periyar river basin, which flows through Idukki, the high-range district of Central Kerala. Erattayar watershed is having an area of 64.6sq.km. and lies between 77° 01' 00" and 77° 10' 00" E longitude and 9° 45' 30" and 9° 51'00" N latitude. The average slope is 18.33%. The entire watershed is having mixed cultivation with seasonal crops like tapioca, plantain and other plantation crops like coffee, pepper, coconut, arecanut, etc. Few patches of cardamom cultivation are also found in the watershed.

The sub-watersheds selected are (a) Thankamani with area 0.48sq.km and stream order 1, (b) Kamakshy with area 1.38sq.km and stream order 2, (c) 8^{th} mile with area 2.05sq.km and stream order 3, (d) Vazhavara with area 3.7sq.km and stream order 3, (e) Idinjamala with area 4.3sq.km and stream order 3, (f) Parakkadavu with area 7.98 and stream order 4 and (g) Nalumukku with area 22.8sq.km and stream order 5. Geomorphological analysis was carried out for the sub watersheds. It is observed that Kamakshy, Vazhavara and Idinjamala is elongated and 8^{th} mile less elongated and Parakadavu is oval in shape. As the area of the sub watershed increases the discharge observed is also seen increasing except for Idinjamala. Idinjamala is observed to be very elongated with very less relief ratio.

A meteorological yard for observing daily rainfall, temperature, humidity, wind speed, etc. was installed at Thankamani. Another raingauge was installed at Pathammile. Soil samples were

collected bi-weekly from each sub-watersheds and water levels observed from four selected open wells. Staff gauges were installed at the seven sub-watersheds for observingdaily water levels. Bi-weekly velocity measurements were made and stage-discharge curve plotted for the seven sub-watersheds. Streamflow data collection at Thankamani and Nalumukku were obstructed several times due to flash floods/ debris flow/ river sand mining. For the other five stations data was collected continuously during the project period.

During the project period, the average annual rainfall received in the watershed is 2634mm with 58% during the south-west monsoon (June –August), 28% during the north-east monsoon (September-December). and remaining during the dry months (January-May). The annual average rainy day is 145. Comparing this data with the long term data of a nearby station, Chinnarwhich is maintained by the State Water Resources Department, there is variation in total rainfall (3452mm) but the similarity is observed in percentage contribution (58%, 26% and 16% seasonally) and rainy days (142). The maximum temperature observed is 34°C and the minimum is 11°C. The monthly average potential evapotranspiration has been observed to vary from 2.75mm/day in July to 4.34mm/day in March. The average monthly discharge values were computed for the five locations. An infiltration study was conducted at one location and the infiltration rate was found to be 60cm/hr initially and becomes constant at 8cm/hr in the sandy loam soil with a moisture content of 23.4%. The average soil moisture variation is observed to be 16.5% in January to 26.9% in August. A sediment rating curve has been developed for the watershed at Nalumukku.

AVSWAT model was attempted to simulate streamflow for the selected watersheds. Based on the comments from the experts the report was revised. AVSWAT model couldn't be re-run with the same version as it is not workable in the new system and userface. Hence the newest version ArcSWAT was executed with the data collected. The rainfall, other climate data, soil moisture, evapotranspiration data,etc were taken as the input data for the model in addition to the DEM, soil, and land use data as thematic layers. ASTER DEM was downloaded from the internet and Soil map and soil details collected from Soil Survey Organisation. Land use map was collected from the Land Use Board. Two years of data were taken for calibrating the model. The most sensitive parameter in predicting the streamflow values was arrived for each station by using

SWAT CUP software. The model was calibrated and validated for the prediction of flow at four stream gauging stations, Idinjamala, Vazhavara, 8th mile, and Parakkadavu. The calibrated model was also validated with the data for the four stations for 2009 and forKamakshy station. SWAT 2012 is found to be good in predicting mean monthly flows in the Erattayar watershed, with good accuracy.

The average annual water yield per unit area for the sub watersheds obtained from the model simulation is 1400.71mm for Kamakshy, 2902.2mm for 8th mile, 1253.21mm for Vazhavara, 484.15mm for Idinjamala and 2032.04mm for Parakadavu sub watersheds. For the less elongated sub watershed (8th mile) the yield per unit area is observed to be high. As the watershed area increases yield per unit area decreases.

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CONTENTS

I.Title of the scheme: Study on hydrology of small watersheds of highland kerala

II.Name and addresses of the PI and other investigators:

Principal investigator : Dr Celine George, Principal Scientist& Head, CWRDM Sub Centre, Manimalakunnu, Oliyappuram P. O., Koothattukulam, Ernakulam, Kerala -686662.

Co-Principal investigator : Dr George Abe, Chief Scientist& Head, Sub Centre, Kottayam, Kerala.

Co-investigators : Sri E. G. Soman, Technical Officer and Sri K. I. Jose, Technical Officer

III. Name and address of the institute : Centre for Water Resources Development and Management (CWRDM), Kunnamangalam P. O., Kozhikode-673 571, Kerala.

IV. Financial details:

i) Sanctioned cost : Rs 13,00,000/- (Rupees Thirteen Lakhs only)

ii) Details of Grant-in-Aid sanctioned :

S.No.	**Subhead**	**Amount (Rs)**
1	Salary (2 nos JRF/SRF @Rs8000/- per month for 1st and 2nd year and @Rs 9000/- per month for 3rd year)	6,00,000
2	Travel Expenditure	1,60,000
3	Infrastructure/Equipment	1,12,000
4	Experimental charges	1,60,000
	Total	10,32,000
5	Contigency	51,600
6	Overhead charges	2,16,720
	Grand Total	13,00,320
	Say	**13,00,000**

iii) Amount released: Rs 10,83,000/- (Rupees Ten Lakhs Eighty Three Thousand only)

iv) Expenditure:

Year	Opening Balance	Grant Received	Total	Expenditure	End Balance
2005-06	Nil	296,000.00	296,000.00	Nil	296,000.00
2006-07	296,000.00	Nil	296,000.00	245,509.00	50,491.00
2007-08	50,491.00	250,000.00	300,491.00	312,784.50	-12,293.50
2008-09	-12,293.50	429,000.00	416,706.50	319,812.00	96,894.50
2009-10	96,894.50	108,000.00	204,894.00	193,833.00	11,061.50
2010-11	11,061.50	Nil	11,061.50	Nil	11,061.50

Sub-Head	Total Expenditure
Salary	619,466.00
Travel Expenditure	158,144.00
Infrastructure/Equipment	117,746.00
Experimental charges	176,582.50
Total	1,071,938.50

(v) Unspent balance (if any) and return of unspent balance:

i) unspent amount: Rs 11,061.50

ii) refund done by DD no. 760726 dated 18.09.2020 in favour of PAO, MoWR to Member Secretary, INCSW Sectt, Ist Floor, Wing-IV, West Block-1, R. K. Puram, New Delhi-110066.

V. Utilization Certificate

UTILISATION CERTIFICATE

Utilisation certificate for the period : 1 April 2005 to 31 March 2006

Title of the project : Study on hydrology of small watersheds of high land Kerala.

Name of the Institution : Centre for water Resources Development and Management, Calicut, Kerala.

Principal Investigator : Celine George

Ministry of Water Resources letter reference sanctioning the project : 23/47/2006-R&D/207-217, Dt: 23-01-2006

Head of account as given in the original sanction letter: 2701.80.00.004.05.01.31 Major & Medium Irrigation - General Research -R&D Programme – Contribution /Grant – Grant- in-Aid of the Budget (Plan) of MoWR during 2005-2006

Financial Year to which the UC Pertains : 2005-2006

	Reference (MoWR letter and date)	Amount (in lakhs Rs.)
Amount brought forward from the financial year 2004-2005	NA	NA
Amount received during the financial year 2005-2006	23/47/2006-R&D/218-229,Dt: 23-01-2006	296000.00
Total amount that was available for expenditure during the financial year 2005-2006	-	296000.00
Actual expenditure incurred during the financial year 2005-2006	-	Nil
Balance amount available on 1st April 2006	-	296000.00

Certified that :

1. The information given above is correct.
2. The amount remaining unutilized at the end of the financial year is carried forward for utilization during the next year ie. 2006-2007

Signature of the Principal Investigator with date

Officer-in-charge CWRDM Sub Centre Mannalakunnu

Signature of the Registrar/ Accounts Officer with date

DEPUTY REGISTRAR (ACCOUNTS) CWRDM, Kozhikode - 673 571

Signature of the Head of the Institute with date

Executive Director Centre for Water Resources Development and Management Kozhikode

UTILISATION CERTIFICATE

Utilisation certificate for the period : 1 April 2006 to 31 March 2007

Title of the project : Study on hydrology of small watersheds of high land Kerala.

Name of the Institution : Centre for water Resources Development and Management, Calicut, Kerala.

Principal Investigator : Celine George

Ministry of Water Resources letter reference sanctioning the project : 23/47/2006-R&D/207-217, Dt: 23-01-2006

Head of account as given in the original sanction letter: 2701.80.00.004.05.01.31 Major & Medium Irrigation - General Research -R&D Programme – Contribution /Grant – Grant- in-Aid of the Budget (Plan) of MoWR during 2005-2006

Financial Year to which the UC Pertains : 2006-2007

	Reference (MoWR letter and date)	Amount (in lakhs Rs.)
Amount brought forward from the financial year 2005-2006	NA	296000.00
Amount received during the financial year 2006-2007	-	Nil
Total amount that was available for expenditure during the financial year 2006-2007	-	296000.00
Actual expenditure incurred during the financial year 2006-2007	-	245509.00
Balance amount available on 1st April 2007	-	50491.00

1. Certified that the information given above is correct.
2. The balance of Rs.50491/- remaining unutilized at the end of the year is carried forward for utilization during the next year ie. 2007-2008.

celine george

Signature of the Principal Investigator with date

Officer-in-charge
CWRDM Sub Centre
Manimalakunnu

Signature of the Registrar/ Accounts Officer with date

Signature of the Head of the Institute with date

Executive Director
Centre for Water Resources Development and Management
Kozhikode

CENTRE FOR
WATER
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DEVELOPMENT AND
MANAGEMENT

CWRDM

An Institution of the Kerala State Council for Science, Technology and Environment, Government of Kerala

Calicut
11-01-08

UTILISATION CERTIFICATE

Certified that a sum of Rs. Nil was received as fund for the Project – Study on hydrology of small watersheds of high land - Kerala, funded by INCOH, undertaken by the Centre for Water Resources Development and Management, Calicut, Kerala, and a sum of Rs. 296000/- (Rupees Two lakhs ninety six thousand only) was brought forward as previous year balance and that a sum of Rs.245509/- (Rupees Two lakhs forty five thousand five hundred and nine only) has been utilized during the period 2006-2007 for the purpose for which it was granted.

For Centre for Water Resources Development and Management

Deputy Registrar (Accounts)

Executive Director

For S. Suresh Babu Associates
Chartered Accountants

S. Suresh Babu B Sc. FCA

Ph: 91-495-2351800, 2351801, 2355374 Fax : 91-495-2357827, 2357151 Website : www.cwrdm.org

Utilisation Certificate

Utilisation Certificate for the financial year	***2007 – 2008***
Title of the Project/Scheme	***Study on Hydrology of Small Watersheds of Highland Kerala.***
Name of the Institution	***Centre for Water Resources Development and Management (CWRDM), Calicut, Kerala***
Principal Investigator	***Celine George***
Ministry of Water Resources letter reference sanctioning the project	**23/47/2006-R&D/207-217, Dt: 23.01.2006**
Head of account as given in the original sanction letter	**2701.80.00.004.05.01.31 Major & Medium Irrigation – General Research – R&D Programme – Contribution/Grant – Grant-in-aid of the Budget (Plan) of MoWR during 2005-06**
Financial Year to which the UC pertains (Hereinafter Referred to as the ***UC Financial Year***)	***2007 – 2008***

	Reference (MoWR letter and date)	Amount
Amount brought forward from the previous financial year	NA	50,491.00
Amount received during the *UC Financial Year*	-	2,50,000.00
Total amount that was available for expenditure during the *UC Financial Year*	-	3,00,491.00
Actual expenditure incurred during the *UC Financial Year*	-	3,12,784.50
Balance amount available at the end of *UC Financial Year*	-	-12,293.50

Certified that :

1. The information given above is correct.
2. An amount of Rs. 12,293.50 is overspent during the financial year 2007-08.

Signature of Principal Investigator
Date 13.05.08

Signature of Registrar/ Accounts Officer with date
DEPUTY REGISTRAR (ACCOUNTS)
CWRDM, Kozhikode - 673 571

Signature of Head of the Institute
Director
Centre for Water Resources Development and Management
Kozhikode

CENTRE FOR
WATER
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DEVELOPMENT AND
MANAGEMENT

CWRDM

An Institution of the Kerala State Council for Science, Technology and Environment, Government of Kerala

Calicut
05-12-08

UTILISATION CERTIFICATE

Certified that a sum of Rs.250000/- (Rupees Two lakhs fifty thousand only) was received as fund for the project 'Study on hydrology of small watersheds of highland Kerala' funded by INCOH, undertaken by the Centre for Water resources Development and Management, Calicut, Kerala, and a sum of Rs.50491/- was brought forward as previous year balance and that a sum of Rs.312784/50 (Rupees Three lakhs twelve thousand seven hundred and eighty four and paise fifty only) has been utilized during the financial year 2007-2008, for the purpose for which it was granted.

For Centre for Water resources Development and Management

Deputy Registrar (Accounts)

Executive Director

Executive Director
Centre for Water Resources Development and Management
Kozhikode

For Jayakumar, George & Associates
Chartered Accountants

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
Kunnamangalam, Kozhikode.

INCOH– STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGH LAND KERALA

Receipts and payments Account for the period from 01-04-2007 to 31-03-2008.

Receipts	Amount Rs.	Payments	Amount Rs.
Opening Balance	50491.00	Salary	172822.00
Fund	250000.00	Travel	46621.00
		Experimental charges	44709.50
		Equipment	48632.00
Balance	12293.50		
	312784.50		312784.50

Deputy Registrar(Accounts) Executive Director Chartered Accountant

Executive Director
Centre for Water Resources
Development and Management
Kozhikode

Utilisation Certificate

Utilisation Certificate for the financial year : 2008-09

Title of the Project/Scheme : Study on Hydrology of Small Watersheds of Highland Kerala

Name of the Institution : Centre for Water Resources Development and Management

Principal Investigator : Mrs Celine George

Ministry of Water Resources letter reference sanctioning the project : 23/47/2006-R&D/207-217, Dt:23-01-2006.

Head of account as given in the original sanction letter : 2701.80.00.004.05.01.31 Major & Medium Irrigation – General Research – R&D Programme – Contribution/ Grant – Grant-in-Aid of the Budget (Plan) of MoWR during 2005-2006.

Financial Year to which the UC pertains : 2008-09

	Reference (MoWR letter and date)	Amount (Rs)
Amount brought forward from the financial year (2007-08)	NA	*Nil
Amount received during the *UC Financial Year (2008-09)*	Order No.23/47/2006-R&D/6892-6901 Date 8-10-2008	429000.00
Total amount that was available for expenditure during the *UC Financial Year*	-	429000.00
Actual expenditure incurred during the *UC Financial Year 2008-09*	-	319812.00
Balance amount available at the end of *UC Financial Year 2008-09*	-	96894.50

*Rs 12293/50 spent in excess as on 31-3-2008.

Certified that :

1. The information given above is correct.
2. The balance of Rs. 96894.50 remaining unutilized at the end of the year is carried forward for utilization during the next year i.e. 2009-10.

celine george
Signature of Principal Investigator
Date 29.04.09

Signature of Registrar/ Accounts Officer
with date 4/5/09

Signature of Head of the Institute
with date

Executive Director
Centre for Water Resources Development and Management
Kozhikode

CENTRE FOR
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DEVELOPMENT AND
MANAGEMENT

CWRDM

An Institution of the Kerala State Council for Science, Technology and Environment, Government of Kerala

UTILISATION CERTIFICATE

Certified that a sum of Rs.429000/- (Rupees Four lakhs twenty nine thousand only) was received as fund for the project 'Study on hydrology of small watersheds of highland Kerala' funded by INCOH, undertaken by the Centre for Water resources Development and Management, Calicut, Kerala, and a sum of Rs.Nil was brought forward as previous year balance and that a sum of Rs.319812/- (Rupees Three lakhs nineteen thousand eight hundred and twelve only) has been utilized during the financial year 2008-2009, for the purpose for which it was granted.

For Centre for Water resources Development and Management

Deputy Registrar (Accounts)

Executive Director

Executive Director
Centre for Water Resources
Development and Management
Kozhikode

For Jayakumar, George & Associates
Chartered Accountants

Calicut
Date:

Ph: 91-495-2351800, 2351801 Fax : 91-495-2357827, 2351808 Website : www.cwrdm.org
KUNNAMANGALAM, KOZHIKODE, PIN - 673 571 KERALA (INDIA)

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
Kunnamangalam, Kozhikode.

INCOH– STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGH LAND KERALA

Receipts and payments Account for the period from 01-04-2008 to 31-03-2009.

Receipts	Amount Rs.	Payments	Amount Rs.
Fund	429000.00	Opening Balance	12293.50
		Salary	196698.00
		Travel	32653.00
		Experimental charges	48087.00
		Equipment	42374.00
		Balance	96894.50
	429000.00		429000.00

Deputy Registrar(Accounts) Executive Director Chartered Accountant

Executive Director
Centre for Water Resources
Development and Management
Kozhikode

Utilisation Certificate

Utilisation Certificate for the financial year : 2009-10

Title of the Project/Scheme : Study on Hydrology of Small Watersheds of Highland Kerala

Name of the Institution : Centre for Water Resources Development and Management

Principal Investigator : Mrs Celine George

Ministry of Water Resources letter reference sanctioning the project : 23/47/2006-R&D/207-217, Dt:23-01-2006.

Head of account as given in the original sanction letter : 2701.80.00.004.05.01.31 Major & Medium Irrigation – General Research – R&D Programme – Contribution/ Grant – Grant-in-Aid of the Budget (Plan) of MoWR during 2005-2006.

Financial Year to which the UC pertains : 2009-10

	Reference (MoWR letter and date)	Amount (Rs)
Amount brought forward from the financial year (2008-09)	NA	96894.50
Amount received during the *UC Financial Year (2009-10)*	Order No. 23/47/2006-R&D/ 1699-170 dt. 24-09-2009	108000.00
Total amount that was available for expenditure during the *UC Financial Year*	-	204894.50
Actual expenditure incurred during the *UC Financial Year 2009-10*	-	193833.00
Balance amount available at the end of *UC Financial Year 2009-10*	-	11061.50

Certified that :

1. The information given above is correct.
2. The balance of Rs. 11,061.50 remaining unutilized at the end of December 2009.

Celine George

Signature of Principal Investigator
Date 10.03.2010

Signature of Registrar/ Accounts Officer with date

DEPUTY REGISTRAR (ACCOUNTS)
CWRDM, Kozhikode - 673 571

Signature of Head of the Institute with date

EXECUTIVE DIRECTOR
CWRDM
Kunnamangalam P.O.
Kozhikode - 673 571, Kerala

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
Kunnamangalam, Kozhikode.

INCOH- STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGH LAND KERALA

Receipts and Payments Account for the period from 01.04.2009 to 31.03.2010

Receipts	Amount Rs.	Payments	Amount Rs.
Opening Balance	96894.50	Salary	109200.00
Fund	108000.00	Travel	33739.00
		Experimental Charges	50894.00
		Balance	11061.50
	2,04,894.50		2,04,894.50

Deputy Registrar (Accounts) | Executive Director | Chartered Accountant

Executive Director
Centre for Water Resources
Development and Management
Kozhikode

UTILISATION CERTIFICATE

Utilisation certificate for the period : 1 April 2010 to 31 March 2011

Title of the project : Study on Hydrology of Small Watersheds of Highland Kerala

Name of the Institution : Centre for water Resources Development and Management, Calicut, Kerala.

Principal Investigator : Mrs. Celine George

Ministry of Water Resources letter reference sanctioning the project: No.23/47/2006-R&D/207-217 Dated: 23-01-2006

Head of account as given in the original sanction letter: 2701.80.004.05.01.Major & Medium Irrigation–General–Research–R&D Programme–Contribution/Grant–Grant-in-Aid of the Budget (Plan) of MoWR during 2005-2006

Financial Year to which the UC Pertains: 2010 - 2011

	Reference (MoWR letter and date)	Amount Rs.
Amount brought forward from the financial year 2009-2010	NA	11061.50
Amount received during the financial year 2010 - 2011	NA	Nil
Total amount that was available for expenditure during the financial year 2010-2011	-	11061.50
Actual expenditure incurred during the financial year 2010-2011	-	NIL
Balance amount available on 31st March 2011	-	11061.50

Certified that the information given above is correct.

celine george

Signature of the Principal Investigator with date

Signature of the Registrar/ Accounts Officer with date

Signature of the Head of the Institute with date

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
Kunnamangalam, Kozhikode.

INCOH- STUDY ON HYDROLOGY OF SMALL WATERSHEDS OF HIGH LAND KERALA

Receipts and Payments Account for the period from 01.04.2010 to 31.03.2011

Receipts	Amount Rs.	Payments	Amount Rs.
Opening Balance	11061.50		
		Balance	11061.50
	11061.50		11061.50

Principal Investigator

Assistant Registrar (Accounts)

Executive Director

Chartered Accountant

For M/S JAYAKUMAR GEORGE ASSOCIATES
CHARTERED ACCOUNTANTS, TRIVANDRUM
FRN 01[illegible]

CA JAYAKUMAR [illegible] B.Com, FCA
M.No. [illegible]58
Authorised Signatory

Calicut
Date:06.02.2012

VI. Statement of equipment purchased under the scheme

Statement of Equipment Purchased (GFR-19)

[See Government of India's Decision 7 (b) under Rule 148 (3)]
Assets Acquired Wholly or Substantially out of Government grants
Register maintained by grantee institution
Block Account maintained by Sanctioning Authorities

Name of Sanctioning Authority : **INCOH, MoWR, Govt of India**

Serial No	
Name of Grantee Institution	**CWRDM**
No. and date of sanction	**23/47/2006-R&D/207-217, Dt:23.01.2006**
Amount of the sanctioned grant	**Rs 13,00,000/-**
Brief purpose of the grant	**Project execution**
Whether any condition regarding the right of ownership of Government in the property or other assets acquired out of the grant was incorporated in the grant-in-aid sanction.	**Yes** **The assets/equipments acquired will remain the property of Govt of India**
Particulars of the assets actually Credited or acquired	**Scientific** **1. Electronic raingauge** **2. Rain module** **3. Pigmy current meter** **4. Wading rod current meter** **5. Developer for Sharp AR 5316 machine** **6. Inkjet printer** **7. Upgradation of WMS software**
Value of the Assets as on (Date)	**1. Rs 20,088/-** **2. 6552/-** **3. &4. 48,632/-** **5. Rs 4304/-** **6. Rs 2650/-** **7. Rs 35,420/-**
Purpose for which utilized at Present	**Item no.1 to 4 used in field data collection for Centre's other projects.** **Item 7 used for project analysis work.**

Encumbered or not	**No**
Reasons if encumbered	**N/A**
Disposed of or not	**Items 5 and 6**
Reasons and authority, if any, for disposal	**Not working**
Amount realized on disposal	**N/A**
Remarks	**The items/equipment in working conditionsisutilized for the Centre's project implementation.**

Principal Investigator

Head of the Department

EXECUTIVE DIRECTOR
CWRDM
Kunnamangalam P.O.
Kozhikode - 673 571, Kerala

CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT
Kunnamangalam.P.O
Calicut, Kerala

VII. Original objectives and methodology as in the sanctioned proposal

i) OBJECTIVES

The main objectives of the project are :

a. To identify the existing water resources of the watershed.

b. To compute water availability and water demand of the area.

c. To demarcate water-scarce areas.

d. To understand other water-related environmental problems.

e. To develop models relating hydrology and environmental factors.

ii) METHODOLOGY

As it is difficult to collect the data required for the study from the entire basin five small watersheds were selected within the basin. These small watersheds will be representing the whole River basin area.

Programme of work

a) Demarcating the watershed boundary
b) Conducting a detailed survey to identify different sources of water
c) Collecting meteorological data from appropriate offices
d) Installing rain/staff gauges at an appropriate position and monitoring data
e) Carrying daily observations on meteorological parameters
f) Recording the water table fluctuations and soil moisture variations
g) Preparing land use maps of the watersheds
h) Analysing the data to understand the relationship between hydrology and water-related problems
i) Developing models to understand and predict the water-related environmental problems

VIII. Any changes in the objectives during the operation of the scheme

Objectives 'a to e' combined and stated as below

- To evaluate the hydrological and hydro-environmental status of the study area.
- To develop models relating to River basin hydrology and environmental factors.

IX. All data collected and used in the analysis with sources of data.

Instrumentation was carried out to measure the following hydrologic and meteorological parameters *[Rainfall, Evaporation, Temperature, Humidity, and Streamflow]*

In addition periodic sampling/ field data collection was carried out to determine sediment movement, water table fluctuations and soil-moisture status.

Site Selection And Instrumentation

One meteorological yard was installed in the watershed, at Thankamany (Plate 1). The yard at Thankamany was instrumented with ordinary and automatic rain gauges, U S class A evaporation pan, Stevenson screen with maximum-minimum, dry and wet bulb and ordinary thermometers, wind vane and anemometer. In addition to this one non-recording rain gauge and an electronic rain gauge were installed at Pathammile (Plate 2).

Suitable sites were selected for stream gauging in the watershed for continuous observation of stage and discharge. The stations were located at Thankamany, Kamakshy, Parakadavu, 8th mile, Vazhavara, Idinjamala, and Nalumukku. Accessibility has been an important criterion in selecting the site and stream order were also considered while selecting the sites. A survey was conducted at each site and the river cross-sections were determined. Staff gauge painted and graduated in centimetres and metres, were installed in cement concrete foundations at the river bed and banks to read from zero to maximum expected flood levels at each gauging station.

Plate 1 Meteorological Yard Installed At Thankamany

A series of soil sampling stations were established to monitor the soil moisture variations concerning time and space. Few observation wells were selected based on the geography, topography, and geology throughout the basin to monitor the water table fluctuations in the watershed.

Velocity in the stream was measured with the help of a wading rod current meter (Plate 3). A double ring infiltrometer (Plate 4) was used for conducting the infiltration test.

Plate 2 Electronic Raingauge installed at Pathammile

Plate 3 Wading Rod Water Current Meter

Plate 4 Double Ring Infiltrometer

Data Collection Procedure

Rainfall data were collected from the two stations using non-recording and recording rain gauges. Daily evaporation was measured with the help of a class A evaporation pan from the meteorological yard at Thankamani. Dry and wet bulb, ordinary and maximum and minimum thermometers were installed as per standards to compute temperature fluctuations as well as humidity. Infiltration tests were conducted at Idinjamala. Constant infiltration rate has been determined by applying the best-fit equation for the observed data:

$$F = kt^x \quad (1)$$

where F is the cumulative infiltration, x and k are constants.

The sediment rating curve was plotted for the station after analyzing the suspended load in the collected samples and stream discharge. It is having the relationship:

$$S = kQ^n \quad (2)$$

where k and n are constants.

Groundwater storage was computed after observing the water level fluctuations in the selected wells.

Suitable formats were used for recording flow velocities, river stages, discharge, rainfall, evaporation, temperatures, wind speed, suspended sediment load, etc.

Staff gauges were installed at seven gauging stations and daily readings were taken. These readings were converted to discharge using the stage-discharge curve plotted for each location. For preparing the stage discharge curves the area of flow and the velocity were measured at all points where staff gauges were installed. For measuring the velocity current meter was used.

Field data collected and used in analysis is listed in Appendix-I.

X. Methodology actually followed :

Observations

Study Area :

The study area selected lies within the Erattayar watershed with an area of 64.6 km^2which situated between 09° 45’ 30” and 09° 51’ 00” N latitude and 77° 01’ 00” and 77° 10’ 00” E longitude (Fig.1). Erattayar watershed is a part of the Periyar river basinof Kerala State. The entire watershed lies in five panchayats namely,Mariapuram, Kamakshy, Erattayar, Kattappana, and Pampadumpara of the Idukki district. Considering the drainage pattern, contour lines and the accessibility to station points, the seven small sub watersheds in the Erattayar watershed were selected for the present work (details described in the analysis part).

Open wells are the major source of water both for drinking as well as for irrigation. About 50% of the population depends on well water for domestic purposes. The rest depends on public taps, ponds, canals and springs. 95 percent of the population reported water scarcity from December to May.

Physiography :

Erattayar watershed is mainly situated in the eastern highland region of Kerala State. The drainage map of the watershed along with the contour lines is given in Fig.2. The lowest most valley portion of the watershed is at 720 m above the mean sea level and the highest point is at 1270 m above the mean sea level. The average slope is 18.33%.

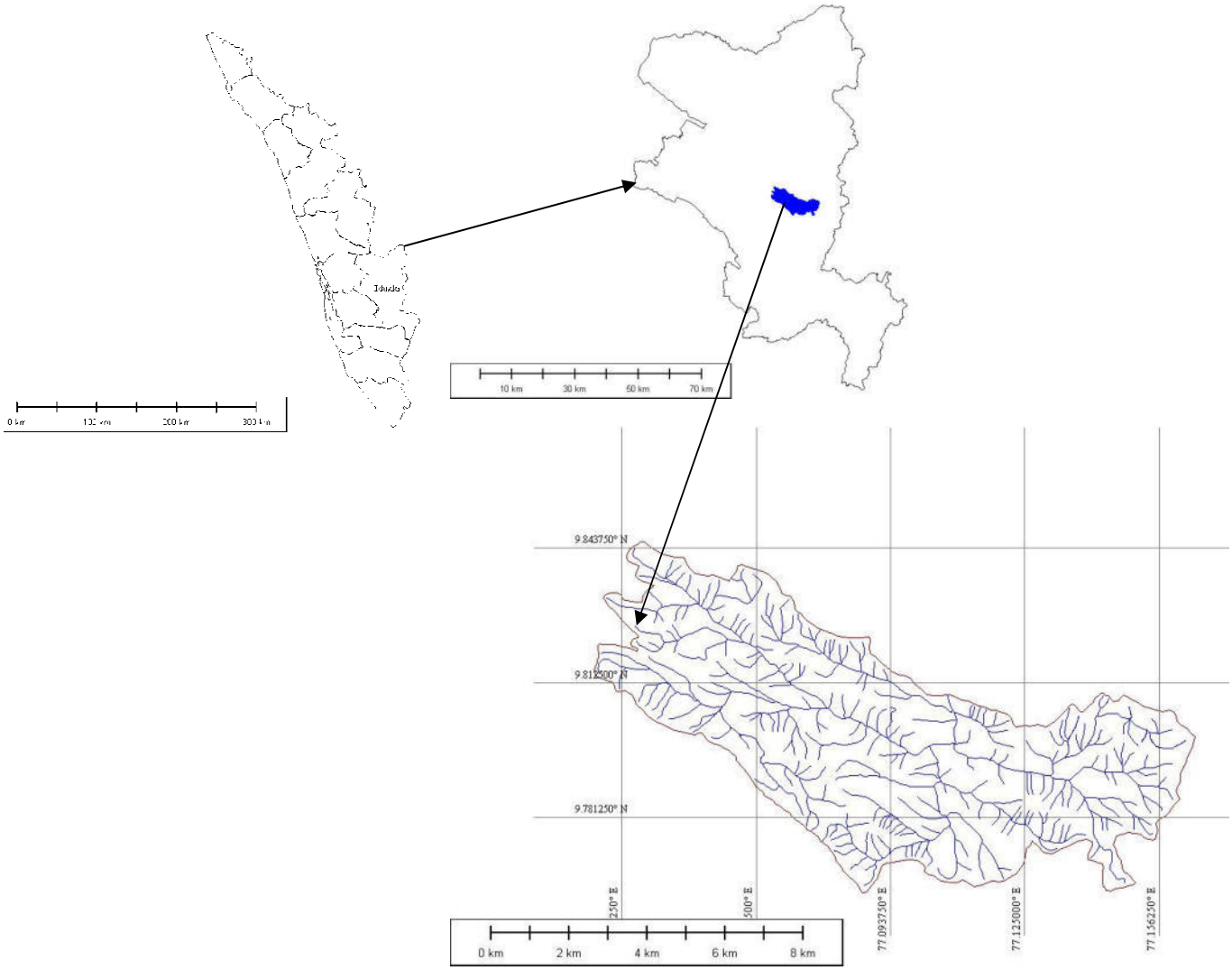

Figure 1 Location Map Of Erattayar Watershed

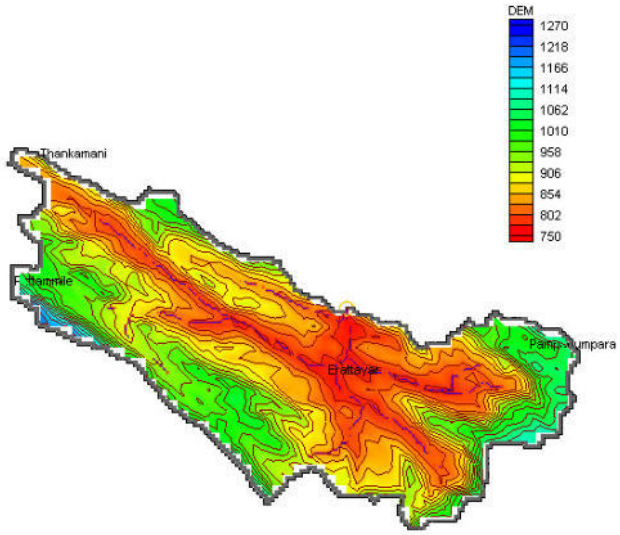

Figure 2 Contour Map Of Erattayar Watershed

Soils

Soil details for the study area were collected from the Soil Survey Organisation department of Kerala State. Venmany series, Thommankuthu series, and Pampadumpara series are the major soil groups identified in the watershed. Figure 3 shows the soil map (with below given details) of the watershed collected from Soil Survey Organization.

The venmany series are tentatively classified under clayey-skeletal, mixed, iso-hyperthermic, usticpalehumults. These are very deep well drained hill soils developed from gneissic parent material. Soils have reddish brown to red colour and clay loam to clay texture.

Thommankuthu series are classified under clayey-skeletal, mixed, isohyperthermic, usticpalehumults. They are very deep, well-drained hill soils developed from gneissic parent material. Soils are black to yellowish red with loam to clay texture.

Pampadumpara series are classified under clayey, mixed, thermic, typicpalehumults. They are very deep, well-drained hill soils developed from gneissic parent material. Soils have dark reddish-brown to yellowish red colour with silty clay to clay texture.

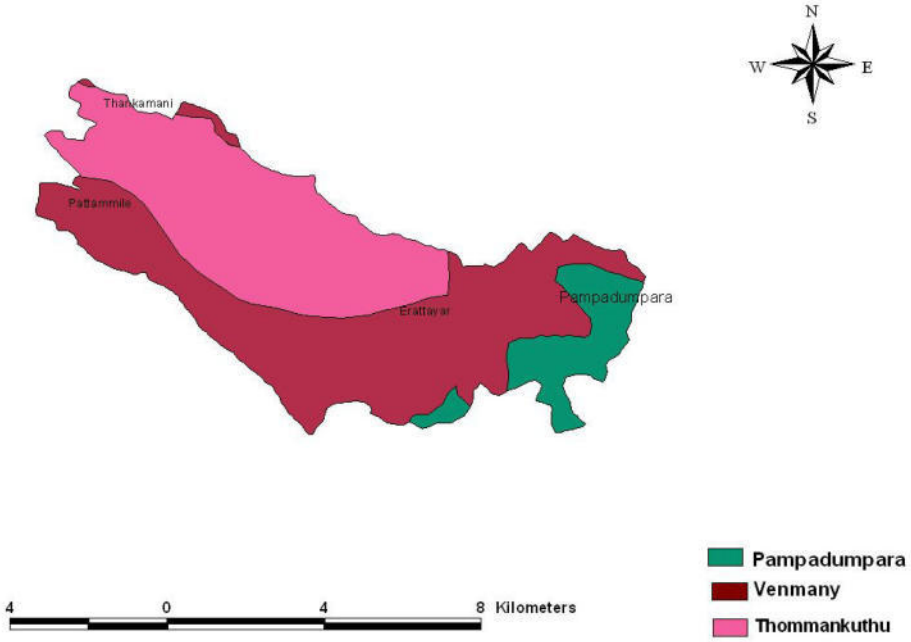

Figure 3 Soil Map Of Erattayar Watershed

Soil samples from 10 locations were collected and analyzed for its physico-chemical characteristics. The parameter values obtained are given in Table 1.

Table 1 Physico-chemical characteristics of the soil samples from Erattayar Watershed

Site No.	Sample Site	Latitude	Longitude	pH 1:10 (w/v)	EC 1:10 (w/v)µs/ cm	Organic Carbon (%)	Organic Matter (%)
1	Thankamany Yard	9.841	77.034	4.85	9.38	0.73	1.25
2	Thankamany	9.8476	77.0322	5.74	32.10	0.16	0.28
3	Kamakshy	9.8299	77.0446	5.07	23.40	0.89	1.53
4	Parakkadavu	9.8304	77.0533	5.10	12.65	0.81	1.40
5	Nalumukku	9.8166	77.0661	5.51	9.38	0.89	1.53
6	Idinjamala	9.8213	77.0848	4.67	25.90	0.24	0.42
7	IdinjamalaThodu	9.8160	77.0893	4.74	12.18	0.57	0.98
8	Vazhavara	9.7912	77.0760	5.17	22.90	1.00	1.75
9	8th Mile	9.8105	77.0353	4.95	11.68	0.98	1.68
10	Pathammile	9.8219	77.0275	4.10	22.70	1.47	2.53

Soils are found to be acidic in nature. Organic carbon as well as organic matter is very less in all the samples.

Climatological aspects

The average annual rainfall in the watershed during the observation period is 2634mm. On an average the watershed receives 58% of the total annual rainfall during the south-west monsoon (June-August), 28% during the north-east monsoon (September-December) and the remaining 14% during summer months (January-May). The maximum temperature that occurred in the watershed during the observed period is 34°C and the minimum temperature is 11°C. The average monthly temperature ranges from 21°C to 29°C.

Land-use

The land-use map of the Erattayar watershed collected from the Kerala Land Use Board is given in Figure 4. The entire area is having mixed cultivation with seasonal crops like tapioca, plantain,etc and other plantation crops like coffee, pepper, coconut, arecanut, etc. A few patches of cardamom cultivation are also found in the watershed.

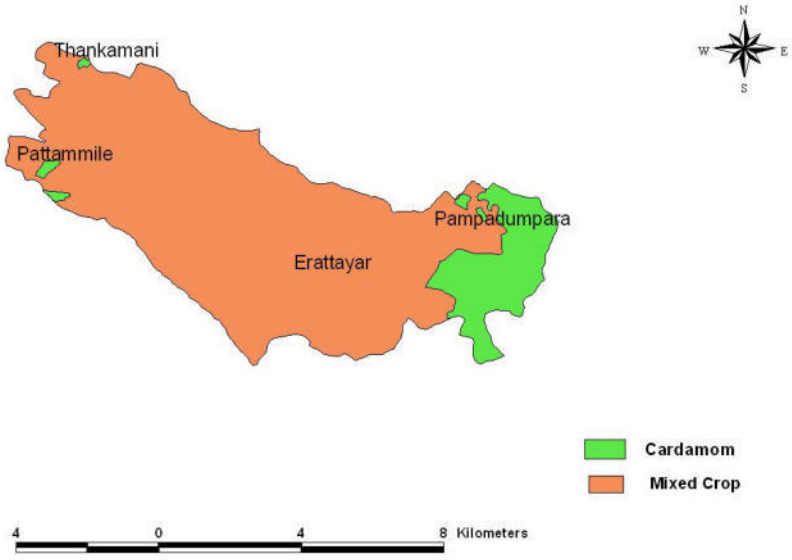

Figure 4 Landuse Map of Erattayar Watershed

Geomorphology of Erattayar watershed

The term geomorphologyrefers to the geometric aspects of the watershed, including length, drainage pattern, slope, and area. The description of the geometric aspects of a watershed in quantitative terms (the fundamental dimensions of length, time, and mass are used) is an important factor in hydrology. A classification of watersheds based on stream orders was introduced by Horton, which was later modified by Strahler (1952). There are certain laws governing stream numbers, stream length, basin area, and relief characteristics (Horton 1945, Morisawa 1968). Survey of India toposheets are the chief tools used for this kind of study. Any GIS package can be used for the linear and areal measurements.

Laws of Drainage Composition

The laws of drainage basin composition are given in Table 2. Morphometric analysis of small watersheds includes the quantitative measurement of the catchment characteristics and their expressions in numerical terms to evaluate the drainage system. Morphometric parameters like stream number, length, basin area, perimeter,etc can be found by direct measurement, whereas parameters such as bifurcation ratio, drainage density, basin relief, elongation ratio, etc can be computed.

An attempt has been made to study the laws of stream gradients and basin relief concerning the watershed. The parameters like drainage density, stream frequency and basin slope have also been studied. The Survey of India topo-sheets on a 1:50000 scale has been made use of to compute the morphometric parameters of the watershed.

Table 2 Laws of Drainage Composition

Law	Mathematical Expression	Particulars	Source
Stream Numbers	$N_u = R_b^{k-u}$	Nu - number of streams of given order 'u' R_b - bifurcation ratio-ratio of the number of streams of a given order 'u' to the number of streams of the next highest order k - highest order of streams in a given basin	Horton (1945)
Stream Length	$L_u = L_1 R_L^{u-1}$	L_u - average length of streams of order 'u' R_L - stream length ratio	Horton (1945)
Basin Areas	$A_u = A_1 R_a^{u-1}$	A_u - average area of basin of order 'u' R_a - area ratio	Horton (1945) Schumm(1956)
Stream Gradients	$S_u = S_1 R_s^{k-u}$	R_s - gradient ratio or slope ratio S_u - average slope of streams of order 'u'	Horton (1945) Morisawa(1968)
Basin Relief	$H_u = H_1 R_R^{u-1}$	Hu - average relief of basins of order 'u' R_R - basin relief ratio	Morisawa(1968)

Linear Aspects

Stream Order

The first step in basin morphology is the determination of stream orders. Stream ordering is the process of identification of the links in a stream network. The most widely used ordering scheme was developed by Strahler in which fingertip channels are specified as order one and where two first order tributaries join, a channel segment of second order is formed and so on. The number of stream segments of any given order will be fewer than that for the next lower order. The ratio of a number of segments of a given order Nu to the number of segments of the higher-order *Nu+1* is termed as bifurcation ratio, *Rb* :

$$R_b = \frac{N_u}{N_{u+1}} \tag{1}$$

Horton's law of stream numbers states that the number of stream segments of each order forms an inverse geometric sequence with an order number.

$$N_u = R_b^{(k-u)} \tag{2}$$

where k is the order of the trunk segment.

Stream Length

Horton's law of stream lengths states that the mean length of stream segments of each of the successive orders of a basin tends to approximate a direct geometric sequence in which first-order term is the average length of the segments of the first order. If the law of stream length is valid, a plot of the logarithm of stream length (ordinate) as a function of order (abscissa) should yield a set of points lying essentially along a straight line (Schumm 1956).

Mean channel length can be calculated by knowing total stream length and stream order :

$$\overline{L_u} = \frac{\sum_{i=1}^{N} L_u}{N_u} \tag{3}$$

Areal Aspects

The law of stream areas is similar to the law of stream lengths. The law relates the mean tributary area of streams of order u (A_u) to the mean drainage area of first order basins (A_1) and the stream area ratio (R_a).

$$A_u = \overline{A_1} R_a^{\,u-1} \tag{4}$$

where the stream area ratio is the average basin area of streams of one order to the average area of basins of the next lower order. The similarity in the above two equations reflects the high correlation that exists between watershed length and area.

Relation of Area to Discharge

An empirical relation between stream discharge and basin area is :

$$Q = JA^m \tag{5}$$

where Q and A are the discharge and drainage area, J and m are derived by fitting a regression line to the available data. The relationship between logarithmic discharge and area is linear from which J and m can be calculated.

Drainage Density

The drainage density (D) is the ratio of the total length of streams within a watershed to the total area of the watershed. Thus D has units of the reciprocal of length. A high value of drainage density would indicate a relatively high density of streams and thus a rapid storm response. Highly resistant or highly permeable subsoil material and dense vegetative cover form low drainage density (Chow 1964).

$$D = \frac{\sum_{i=1}^{k}\sum_{i=1}^{N} L_u}{A_u} \tag{6}$$

Stream Frequency

Horton introduced stream frequency or channel frequency, defined as the number of stream segments per unit area.

$$F = \frac{\sum_{i=1}^{k} N_u}{A_u} \tag{7}$$

Constant of Channel Maintenance

Schumm used the inverse of drainage density as a property termed as aconstant of channel maintenance given as

$$C = \frac{1}{D} = \frac{A_u}{\sum_{i=1}^{k}\sum_{i=1}^{N} L_u} \tag{8}$$

Slope Profile

This is an expression of the slope along a certain line. A profile to the scale gives an accurate picture of the landform along the given line.

Basin Shape

Watersheds have an infinite variety of shapes, and the shapes supposedly reflects the way that runoff will "bunch up" at the outlet. A number of watershed parameters have been developed to reflect basin shape. The following are a few typical parameters.

1. *Form factor* (R_f) :

$$R_f = \frac{A_u}{L_b^2} \tag{9}$$

where A_u is the basin area and L_b is the maximum basin length (km).

2. *Circularity ratio* (R_c) :

$$R_c = \frac{A_u}{A_p} \tag{10}$$

where A_p is the area of a circle that has the same perimeter as the basin.

3. *Elongation ration* (R_e) :

$$R_e = \frac{D}{L_b} \tag{11}$$

D is the diameter of the circle of basin area.

Watershed Relief

A number of parameters have been developed to reflect variations in watershed relief. The most common are the channel slope, the watershed slope and the hypsometric curve.

The channel slope is given by :

$$S_c = \frac{\Delta E}{L_c} \tag{12}$$

where ΔE, the relief is the difference in elevation between the points defining the upper and lower ends of the channel and L_c is the length of the channel between the two points. Maximum

relief within a given region of given boundary is the elevation difference between the highest and the lowest points. Maximum basin relief is the elevation difference between the mouth and the highest point on the basin perimeter.

Hypsometric Curve

The hypsometric curve is a description of the cumulative relationship between elevation and the area within the elevation intervals. The curve is plotted as elevation plotted as the ordinate and the area within the watershed above the elevation plotted as abscissa.

The determination of different stages of the basin development have been done following tentative boundaries suggested by Strahler, 1952 (table 3).

Table 3 The Tentative Boundaries Suggested For The Determination Of Different Stages In Hypsometric Analysis

Percentage	Stages of Watershed
Above 60%	Youth Stage [Inequilibrium]
35% to 60%	Mature Stage [Equilibrium]
Below 35%	Old Stage [Monaduock phase]

Analysis

Quantitative geomorphic studies in erattayar watershed

Linear Aspects

Considering the drainage pattern, contour lines, and the accessibility to station points, seven small sub-watersheds with different stream orders selected for the present study is given in figure 5 and details in table 4. The stream orders were identified following the system introduced by Horton and later modified by Strahler (1952). Higher stream order is associated with greater discharge and higher velocity. The total number of stream segments decreases with stream order. Any deviation indicates that the terrain is typified with high relief and/or moderately steep slopes, underlain by varying lithology and probable uplift across the basin.

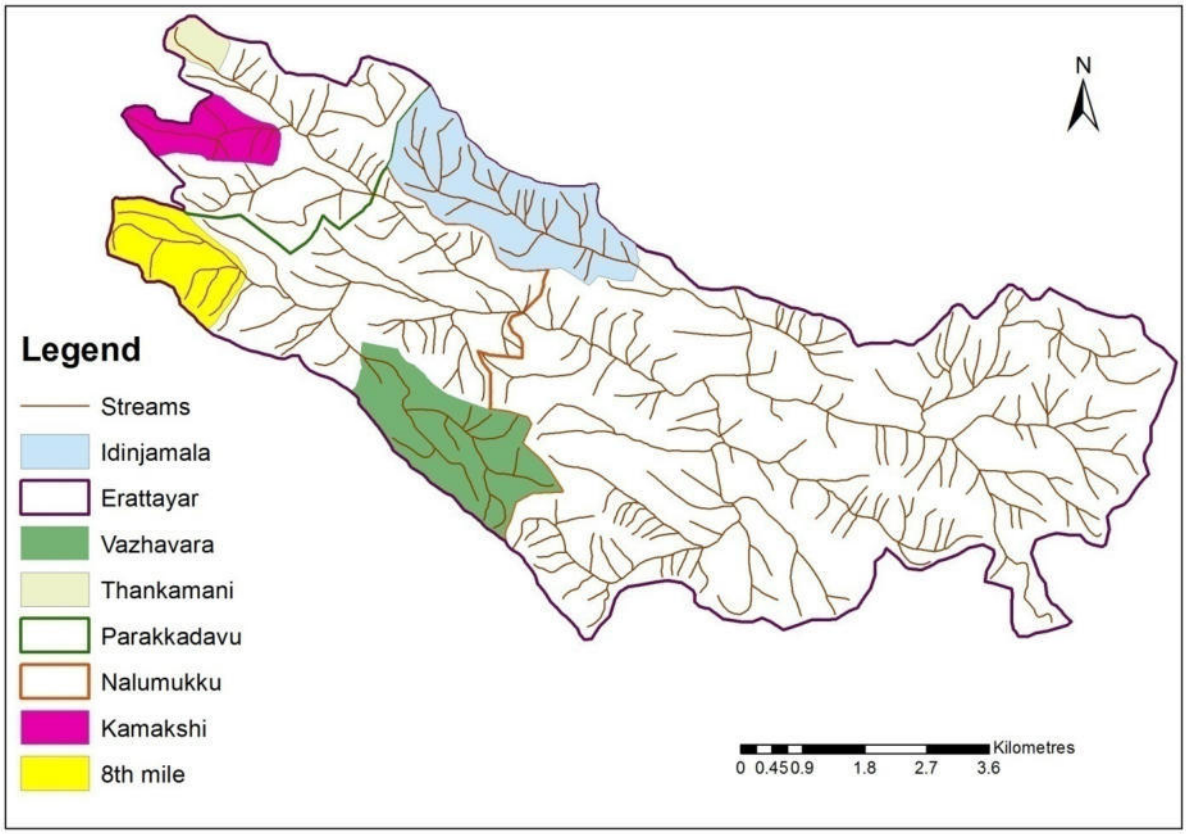

Figure 5 Drainage Map of Erattayar Watershed showing the selected sub watersheds

Table 4 Linear Aspects Of The Basin And Sub-Basins Of Erattayar Watershed

Basin/Sub-basin	Drainage Area A_u [km^2]	Latitude	Longitude	Perimeter P_b [km]	Order u	No.of Streams N_u	Stream Length L_u [km]	Bifurcation ratio R_b	Mean Length L_u	Length ratio	Max. Basin Length L_b [km]	Total No.of Streams $\sum N_u$	Total Stream Length $\sum L_u$ [km]
Erattayar	64.6	9.814	77.105	49.8	1	242	160.357	-	0.663	-	9.59	316	205.884
					2	52	27.924	4.65	0.537	0.810			
					3	14	8.894	3.71	0.635	1.183			
					4	5	7.699	2.80	1.540	2.424			
					5	2	0.998	2.50	0.499	0.324			
					6	1	0.012	2.00	0.012	0.024			
Thankamani	0.48	9.838	77.039	2.7	1	1	0.979	-	0.979	-	0.952	1	0.979
Kamakshy	1.38	9.830	77.047	5.89	1	6	3.343	-	0.557	-	2.26	7	4.259
					2	1	0.916	6.00	0.916	1.644			
8th mile	2.05	9.811	77.043	6.13	1	6	5.225	-	0.871	-	2.21	9	6.936
					2	2	1.543	3.00	0.772	0.886			
					3	1	0.168	2.00	0.168	0.218			
Vazhavara	3.7	9.801	77.058	9.28	1	11	6.561	-	0.596	-	3.51	15	10.605
					2	3	1.494	3.67	0.498	0.835			
					3	1	2.55	3.00	2.550	0.195			
Idinjamala	4.3	9.812	77.094	10.3	1	22	10.272	-	0.4669	-	3.87	29	15.178
					2	6	1.766	3.67	0.2943	0.630			
					3	1	3.14	6.00	3.14	0.094			
Parakadavu	7.98	9.822	77.060	15.1	1	31	17.395	-	0.5611	-	3.8	39	25.685
					2	5	6.258	6.20	1.2516	2.231			
					3	2	2.009	2.50	1.0045	0.803			
					4	1	0.0226	2.00	0.0226	0.022			
Nalumukku	22.8	9.806	77.079	29.8	1	81	47.6	-	0.5877	-	6.5	105	74.07
					2	16	13.218	5.06	0.8261	1.406			
					3	5	7.412	3.20	1.4824	1.794			
					4	2	5.8	2.50	2.9	1.956			
					5	1	0.0404	2.00	0.0404	0.014			

The logarithm of the number of streams (log Nu) plotted against stream order (u)is given in figure 6, which shows a linear relationship. Table 4 gives the linear aspects of the Erattayar watershed and its sub-watersheds. Figure 7 gives the linear relationship between the logarithm of length of streams (log Lu) and stream orders. Horton's law of stream numbers states that the number of stream segments of each order forms an inverse geometric sequence with the order number. While analyzing each sub watersheds separately, it is seen that a straight-line relationship is followed for watersheds except Idinjamala and Vazhavara for the Log Lu versus order u. It indicates that except for Idinjamala and Vazhavara watersheds the area has uniform underlying lithology and geologically there has been no probable uplift in the basin.

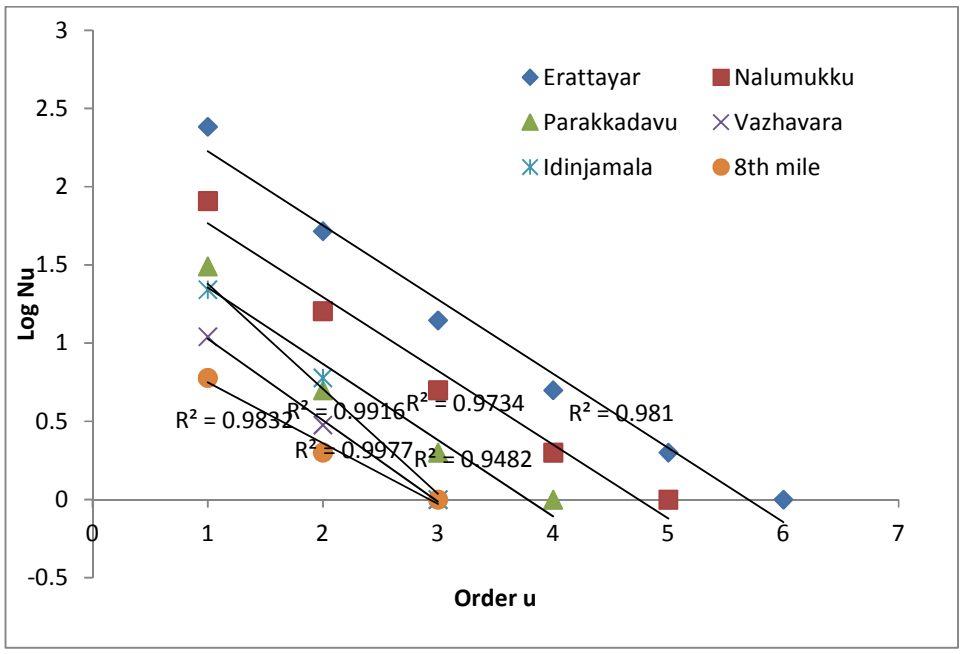

Figure 6 Order u vs Log number of streams (Log Nu) – Erattayar Watershed

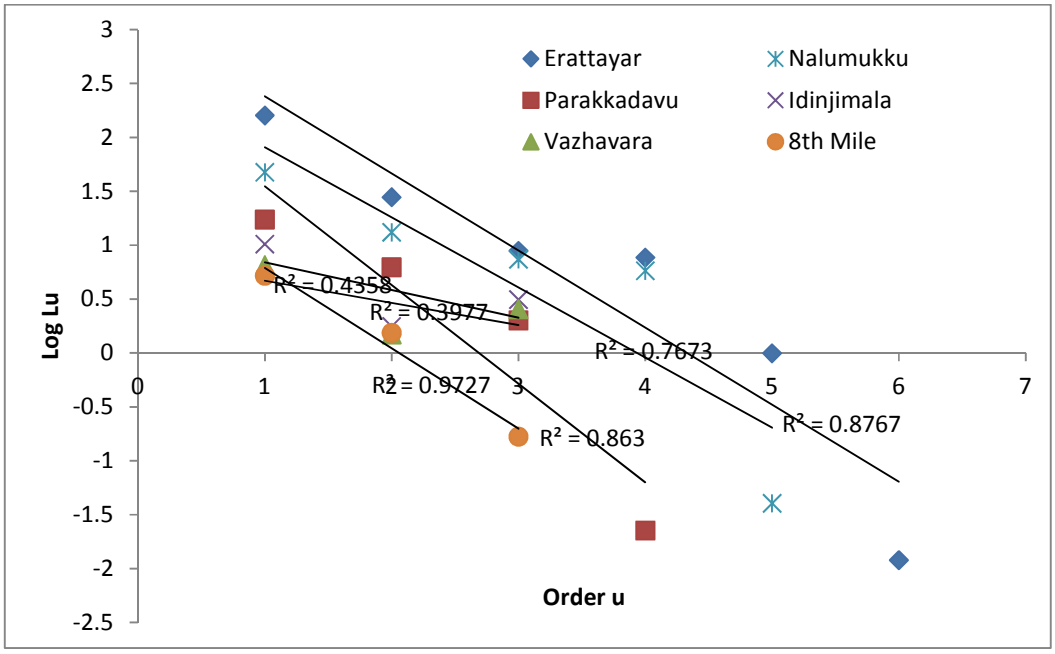

Figure 7 Order u vs Log length of streams (Log Lu) – Erattayar Watershed

Areal Aspects

Erattayar watershed and its sub-watersheds selected namely, Idinjamala, Nalumukku, Parakadavu, Vazhavara, 8th mile and Kamakshy were taken for studying the relationship between area and length. The logarithm of the area of each sub-basin is plotted against logarithm of stream length which shows a linear relationship, figure 8.

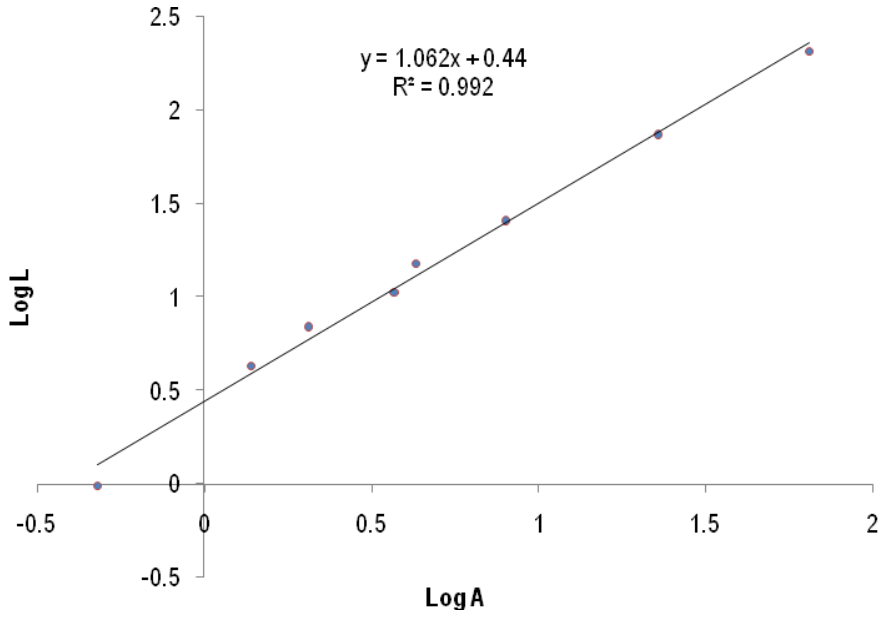

Figure 8 Area vs Stream Length of Erattayar Watershed

Drainage Density and Stream Frequency

The drainage density and stream frequencies of different sub-basins and the entire basin of Erattayar are given in table 5. Lesser the stream frequency longer the time to peak discharge because of low runoff rates due to a lesser number of streams. The travel time by water within the basin is controlled by Drainage Density. Generally, drainage density has a low valuein regions underlain with highly resistant permeable material with vegetative cover and low relief. High drainage density is observed in the regions of weak and impermeable subsurface material and sparse vegetation and mountainous relief. Drainage density above 2.5km/km^2 is considered to be a high value and less than 2.0 km/km^2 as a low value. Table 5 indicates that the entire watershed is having a high drainage density indicating that the watershed is having sparse vegetation and mountainous relief.

Basin Shape

The form factor (Rf), circularity ratio (Rc),and elongation ratio (Re) for the sub-basins and the entire Erattayar watershed is given in table 5. Basins with high Rf have high peak flows of

shorter duration, whereas elongated sub-watersheds with low Rf have low peak flow of longer duration. Erattayar, Thankamani, Parakkadavu, and Nalumukku have Rf indicating that they have developed into quite circular to a rectangular shape.Kamakshy, 8th mile, Vazhavara and Idinjamala with low Rf is more or less elongated with lower peak flows of longer duration. Rc is influenced by the length and frequency of stream, geological structures, land-use/land-cover, climate, relief and slope of the basin. The values of Re vary from 0.6 to 1.0 over a wide variety of climatic and geologic type. Values close to 1.0 are typical of the region of very low relief, whereas values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler inVenTe Chow, 1964). It can be grouped into three classes namely Circular (>0.9), Oval (0.9 – 0.8) and less elongated (<0.7). Table 5 shows that Re varies from 0.587 to 0.908, which says that majority of the area has high relief and steep ground slope.Rc is a significant ratio that indicates the dendritic stage of a watershed. Low, medium and high values of Rc indicate young, mature and old stages of the life cycle of the tributary watershed. Watershed morphology has profound impacts on the watershed hydrology.

Relief Ratio (Rh)

It indicates the overall steepness of a drainage basin and is an indicator of the intensity of erosion processes operating on the slope of the basin. Rh normally increases with decreasing drainage area and size (Gottschalk in VenTe Chow, 1964). The relief ratio of Erattayar sub-watersheds ranges between 0.05 to 0.173.

Constant Channel Maintenance (C)

The values of C for the study area vary from 0.283 to0.49. Thus the sub watersheds are under the influence of high structural disturbance, low permeability, steep to the very steep slope and high surface runoff.

Profile

The longitudinal profile along two sections are shown in figure 9 and 10.

Table 5. Areal And Relief Aspects Of The Basin And Sub-Basins Of Erattayar Watershed

Basin/Sub-basin	Drainage Area Au [km2]	Form Factor Rf	Circularity Ratio Rc	Elongation Ratio Re	Drainage Density D (per km)	Constant of Channel Maintenance C	Stream Frequency	Relief Ratio R
Erattayar	64.6	0.647	0.327	0.908	3.187	0.314	4.892	0.054
Thankamani	0.48	0.530	0.827	0.821	2.040	0.490	2.083	0.173
Kamakshy	1.38	0.270	0.500	0.587	3.086	0.324	5.072	0.124
8th mile	2.05	0.420	0.685	0.731	3.383	0.296	4.390	0.153
Vazhavara	3.7	0.300	0.540	0.619	2.866	0.349	4.054	0.050
Idinjamala	4.3	0.2871	0.509	0.605	3.530	0.283	6.744	0.065
Parakadavu	7.98	0.5526	0.440	0.839	3.219	0.311	4.887	0.079
Nalumukku	22.8	0.5396	0.322	0.829	3.249	0.308	4.605	0.082

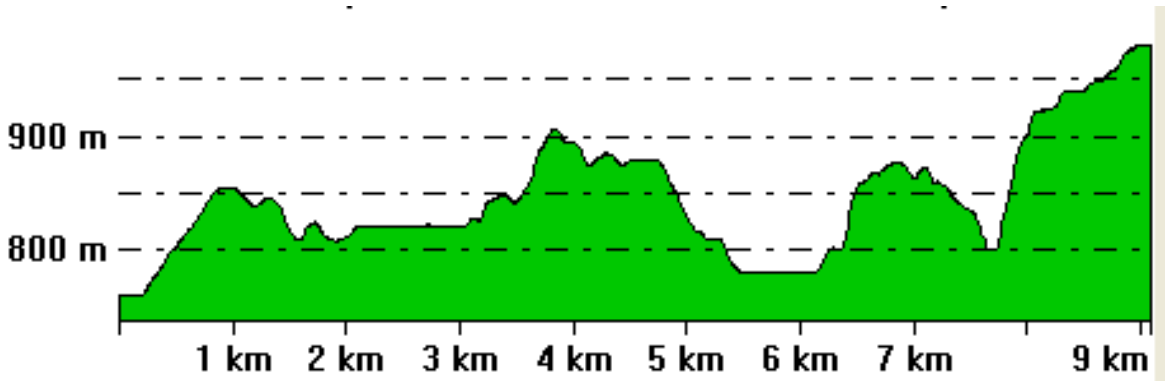

Figure 9 Longitudinal Profile Along Maximum Basin Length

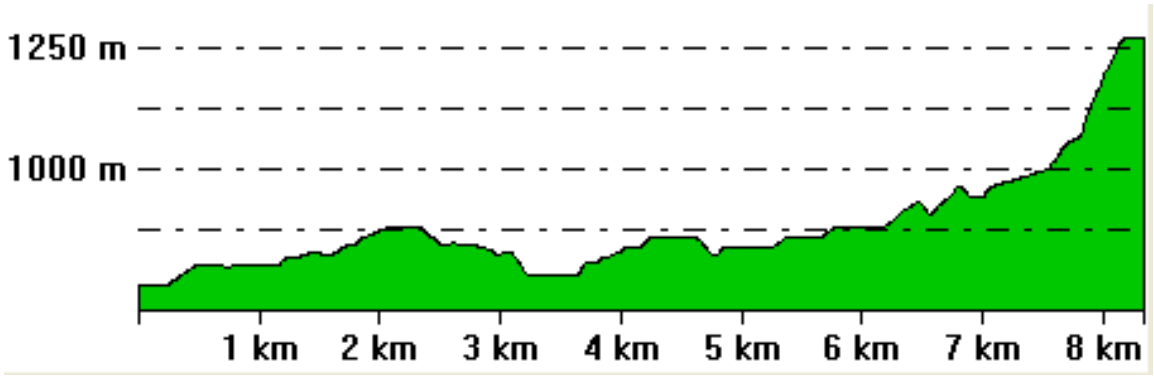

Figure 10 Longitudinal Profile From Highest Elevation Point To Outlet

HYDROLOGICAL STUDIES

ANALYSIS OF RAINFALL DATA

Rainfall Data

Daily rainfall data collected from Thankamani and Pathammile is used to arrive at the average rainfall of the Erattayar watershed. The average annual rainfall in Erattayar watershed is 2634 mm. About 58 percent of the rainfall in the watershed is received during the south-west monsoon [June-August], 28 percent during north-east [September-November] and the remaining 14 percent during the other six months [December-May], as is given in table 6. The vagaries of nature bring about the late onset of monsoon and early disappearance; these trends lead to drought conditions for short period during many a year. As indicated in the table rainfed cultivation is possible only during the monsoon period. It is realized that for the rest of the year irrigation is essential for seasonal crops and most the plantation crops. Figure 11 gives the monthly average rainfall in the Erattayar watershed.

Table 6 Monthly Rainfall in the Erattayar Watershed

MONTH	YEAR			Average
	2007	2008	2009	
Jan	0	9.5	6.26	5.3
Feb	15.8	58.85	5	26.6
Mar	0	161.15	109.7	90.3
Apr	188.3	79	101.1	122.8
May	122.9	28.35	112.6	88.0
Jun	411.5	392.8	416.3	406.9
Jul	828.4	597.8	605.15	677.1
Aug	318.25	650.05	362.25	443.5
Sep	425.2	270.235	284.75	326.7
Oct	333.1	323.55	192.5	283.1
Nov	97.9	88.25	201.2	129.1
Dec	67.8	9.1	24.2	33.7
Annual	**2809**	**2669**	**2421**	**2633**

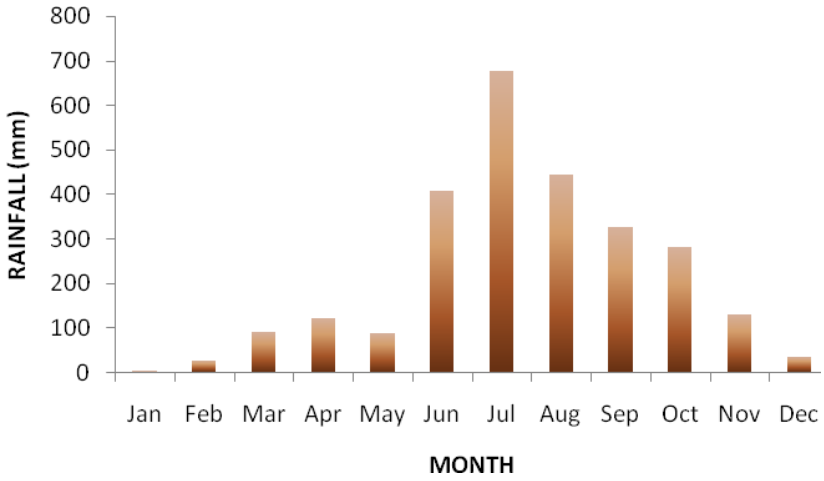

Figure 11 Monthly Rainfall in Erattayar Watershed

Estimation of Rainy Days

Data collected from Thankamani and Pathammile for three years were analyzed and the number of rainy days was estimated for Erattayar watershed. On average, the watershed has 145 rainy days per year. This information on rainy days is expected to be useful to ascertain the requirement of irrigation and the possibility of utilizing rainwater directly for agricultural purposes. The average number of rainy days per month for the watershed is given in Table 7.

Table 7 Average Number of Rainy Days Per Month – Erattayar Watershed

Month	Number of Rainy Days
January	1
February	1
March	8
April	4
May	8
June	22
July	28
August	26
September	19
October	15
November	10
December	3

ESTIMATION OF POTENTIAL EVAPOTRANSPIRATION

Estimation Techniques

Knowledge of evapotranspiration from a watershed is an essential requirement in planning and design of irrigation systems. There are numerous approaches for the estimation of potential evapotranspiration, none of which is generally applicable for all purposes. For all hydrologic studies concerned with water allocation, water balance studies, reservoir operations etc. information on potential evapotranspiration from the watershed is required.

Evapotranspiration is the process by which water present in water bodies, soil & vegetation, and plantation is converted into vapour state and returned to the atmosphere. It consists of evaporation loss (E) from water bodies and soil and transpiration loss (Tr) from vegetation and plantation (Gupta, 1989). The evapotranspiration losses (Et) (ie.,E+Tr) are important components in the hydrologic process and play a dominant role in long-term water balance in a watershed. Field observations of E or Tr or Et do not exist in plenty. Available records are often difficult to interpret because the methodology followed in collection of data is not often known fully. To overcome the difficulty, the estimation of potential evapotranspiration (PET) is extrapolated as a substitute for field observations. PET or potential evapotranspiration is the sum of maximum evaporation and transpiration rate that occur when water is available all around the year and vegetative cover is dense and climate condition is normal (Linsley et. al. 1988).

The PET loss is often interpreted as consumptive use to denote the loss of water by evapotranspiration in an irrigated agricultural field. Historically the concept of PET was first attributed by Thronthwaite (Thronthwaite et. al. 1944). The PET is an indication of optimum crop-water requirement. Most of the available formulas to estimate the PET in a region is empirical in nature and dependent on the known correlation between PET and one or more meteorological variables such as radiation, temperature, wind velocity, and vapour pressure difference. There are many practical as well as empirical methods in evaluating the values of potential evapotranspiration or PET. The methods can be listed as follows :

i) Water Budget determination

ii) Lysimeter determination

iii) Field plot determination

iv) Estimation from meteorological data

Several methods are available to predict PET using climatological data. The monthly potential evapotranspiration for the Erattayar watershed was computed using Thornwaite's method, Hargreaves Method and Penman Monteith Method.

Computational Methods

Thornwait's Approach

Thornwaite's equation is given by :

$$PET = 16\left(\frac{L}{12}\right)\left(\frac{N}{30}\right)\left(\frac{10T_a}{I}\right)^{\alpha} \quad (13)$$

where,

Ta is the average daily temperature of the month being calculated

N is the number of days in the month being calculated

L is the average day length of the month being calculated

$$\alpha = (6.75 \times 10^{-7})I^3 - (7.71 \times 10^{-5})I^2 + (1.79 \times 10^{-2})I + 0.49 \quad (14)$$

$$I = \sum_{i=1}^{n}\left(\frac{T_{ai}}{5}\right)^{1.514} \quad (15)$$

Hargreaves Equation

In the equation developed by Hargreaves the most important parameters are temperature and solar radiation. The simplied form of the equation is :

$$ETo = Ci(Tmed + 17.78)\,(Tmax - Tmin)0.5\,Ra \quad (16)$$

where,

Ra = water equivalent of extraterrestrial radiation in mm/day, Tmax, Tminand Tmedare the daily maximum, minimum and mean air temperatures (°C), respectively; Ci= 0.0023 is the empirical constant proposed by Hargreaves and Samani (1985)

Penman MonteithEquation

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (17)$$

where,

ET_o = Reference crop evapotranspiration in mm/day

R_n = Net radiation at the crop surface in MJm^{-2}/day

G = soil heat flux density in MJm^{-2}/day

T = mean daily temperature at 2m height in °C

u_2 = wind speed at 2m height in m/s

e_s= saturation vapour pressure in kPa

e_a = actual vapour pressure in kPa

$e_s - e_a$ = saturation vapour pressure deficit in kPa

Δ = slope vapour pressure curve in kPa $°C^{-1}$

γ = Psychrometric constant in kPa $°C^{-1}$

The computation for Penman Monteith method was done using the CROPWAT software of FAO.

Computation from Evaporation Pan Data

Evaporation pan data could be converted to evaporation from free water surface with pan coefficient to obtain PET in the absence of measured PET values. Different pan coefficients have been suggested for different locations. A coefficient of 0.8 has been adopted here for the Class A pan as per the FAO Irrigation and Drainage Paper No.24, Table 18.

The monthly potential evapotranspiration for the Erattayar watershed has been estimated using Thornwaite, Hargreaves and Penman-Monteith Methods. Figure 12 gives the monthly variations of PET obtained using the different methods. This was also computed from pan evaporation data collected from the Thankamani yard. Table 8 gives a comparison of the PET values obtained by Penman Monteith Method and the open pan method.

Table 8 Monthly Estimate of Potential Evapotranspiration in Erattayar Watershed

MONTH	Potential Evapotranspiration mm/day	
	Penman Monteith	Class A Pan
January	3.33	3.26
February	3.61	3.74
March	4.34	3.98
April	4.07	3.58
May	3.70	3.19
June	2.96	3.07
July	2.75	2.66
August	3.11	2.87
September	3.60	3.00
October	3.18	3.30
November	3.20	3.35
December	3.35	3.33

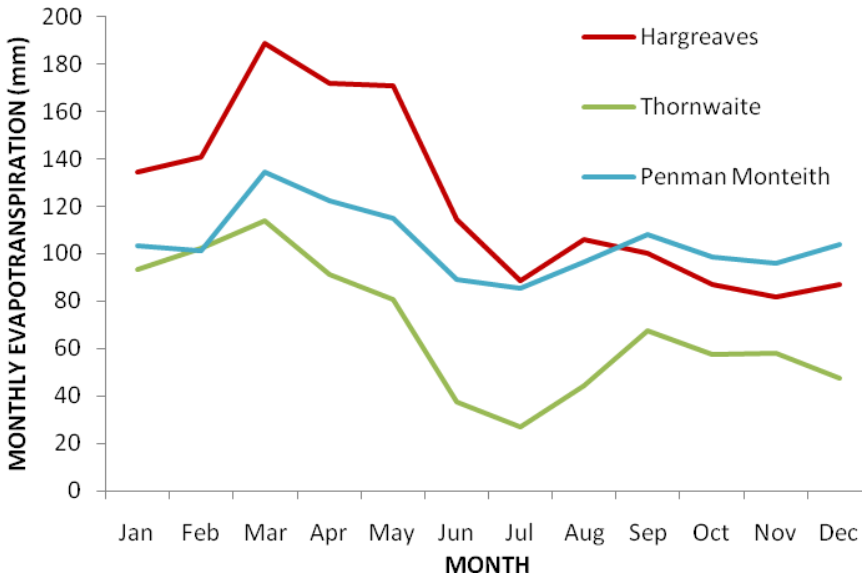

Figure 12 Monthly Evapotranspiration By Different Methods

RUNOFF CHARACTERISTICS

Rating curve technique and area-velocity method were used to compute the runoff at each gauging station. The stage-discharge relationship has been established with the observations of discharge for various stages of river flow. The area of cross-section was multiplied by the mean velocity to quantify the discharge. The rate of discharge was converted to daily and monthly values. Daily water levels observed at the gauging stations were converted to discharge with the help of stage-discharge rating curves. Stage-discharge rating curves for the seven selected stations are given in figures 13 to 20computed from the collected data.

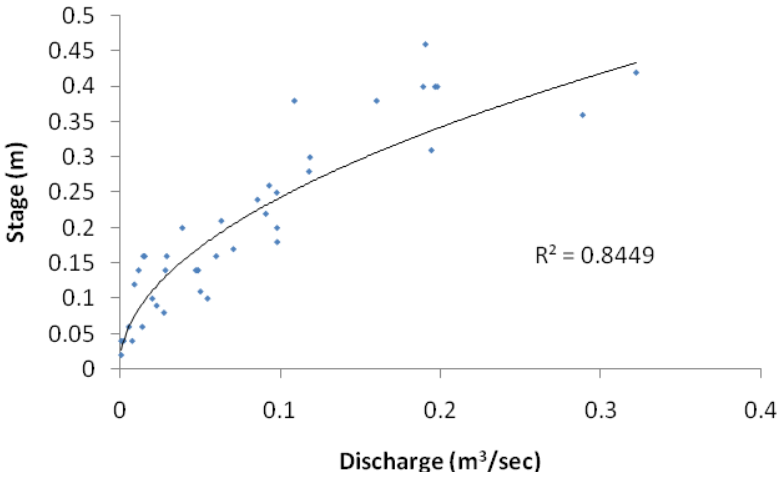

Figure 13 Stage discharge curve at Thankamony

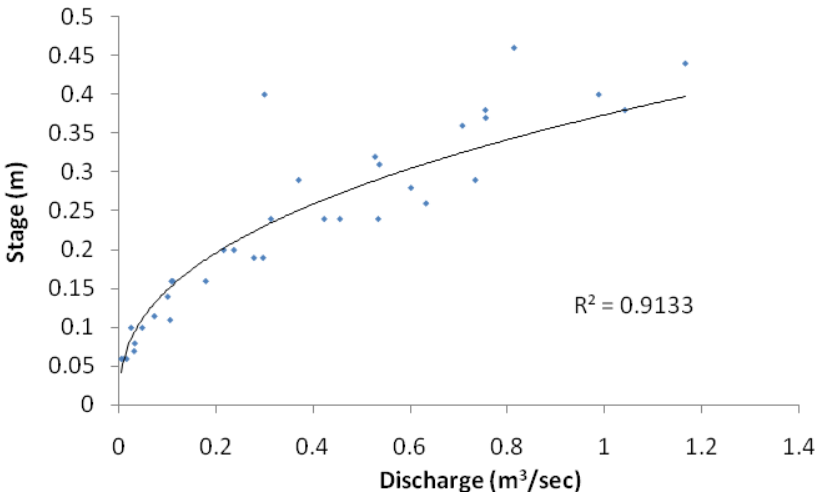

Figure 14 Stage discharge curve at Kamakshy

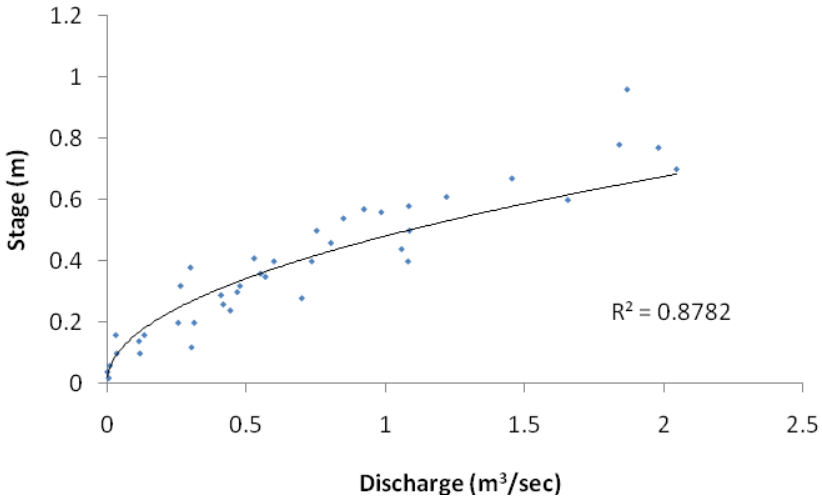

Figure 15 Stage discharge curve at Parakadavu

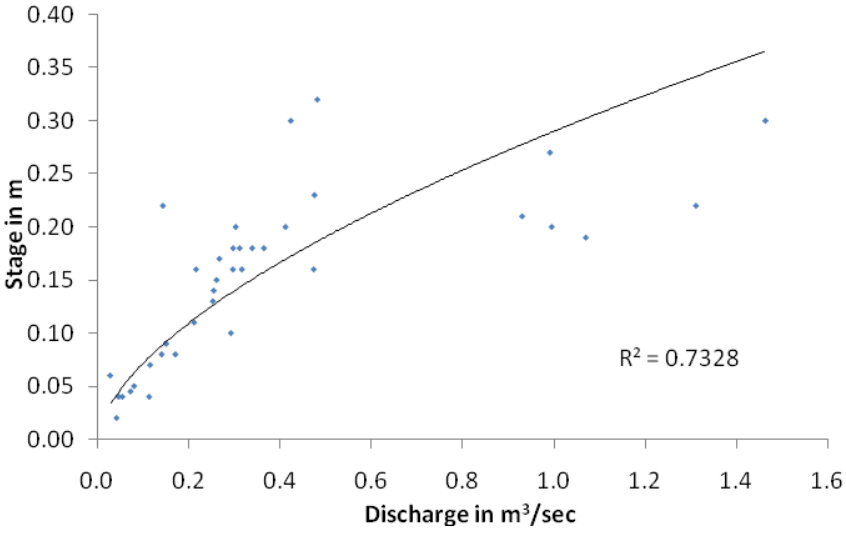

Figure 16 Stage discharge curve at Idinjamala

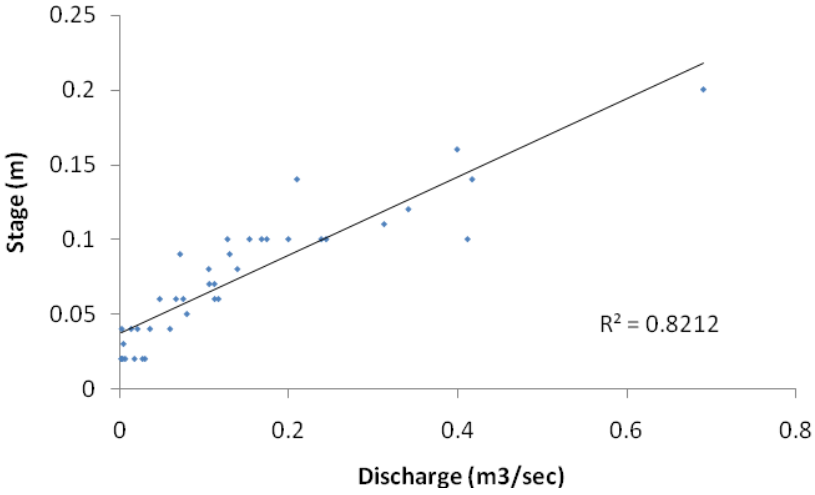

Figure 17 Stage discharge curve at 8th mile

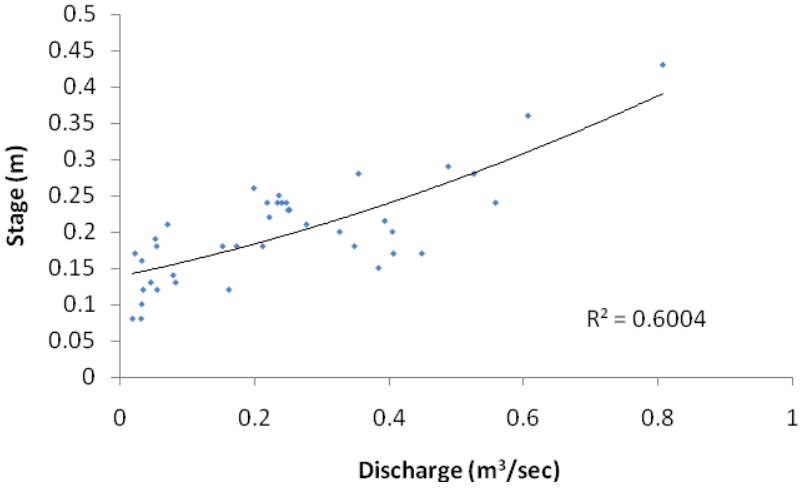

Figure 18 Stage discharge curve at Vazhavara

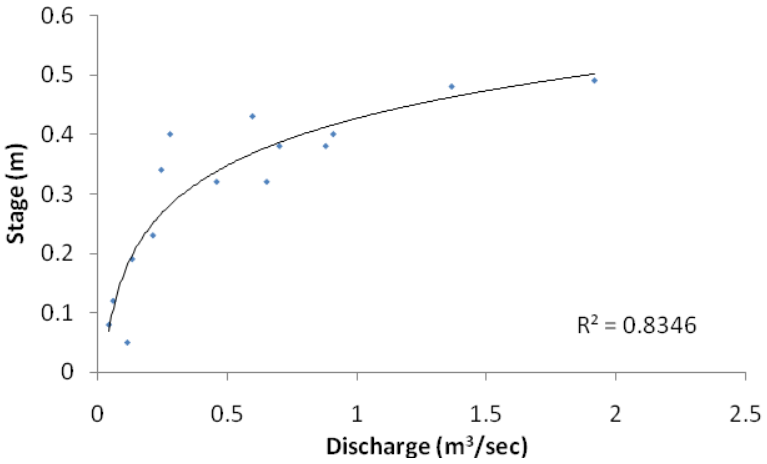

Figure 19 Stage discharge curve at Nalumukku - curve 1

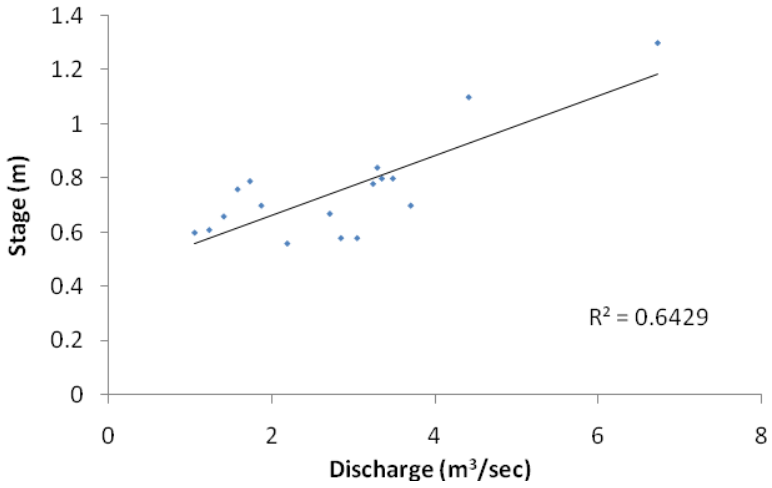

Figure 20 Stage discharge curve at Nalumukku – curve 2

Monthly streamflow values computed for two stations, Vazhavara and Idinjamala are given in figures 21 and 22.

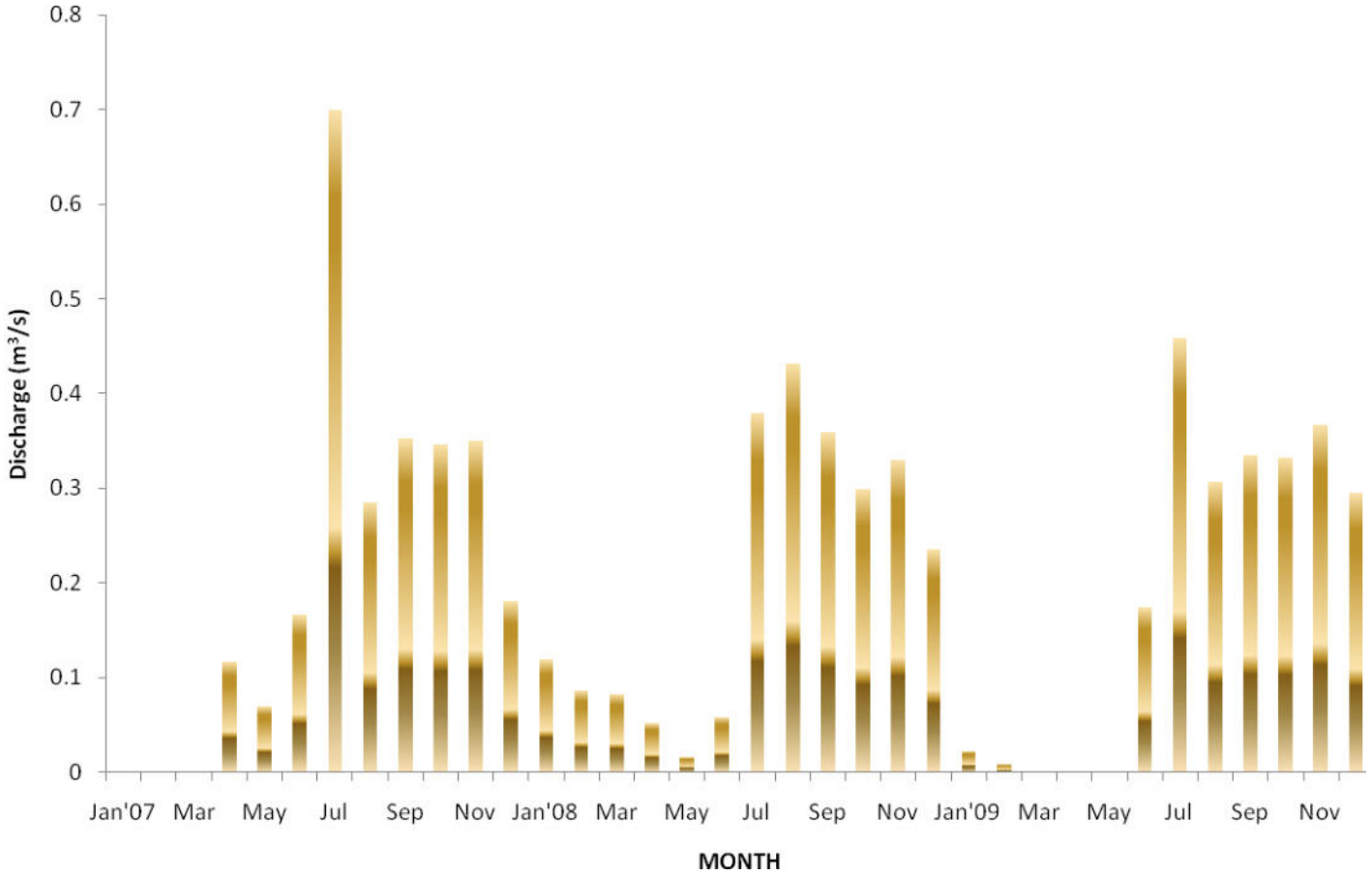

Figure 21 Mean monthly discharge at Vazhavara

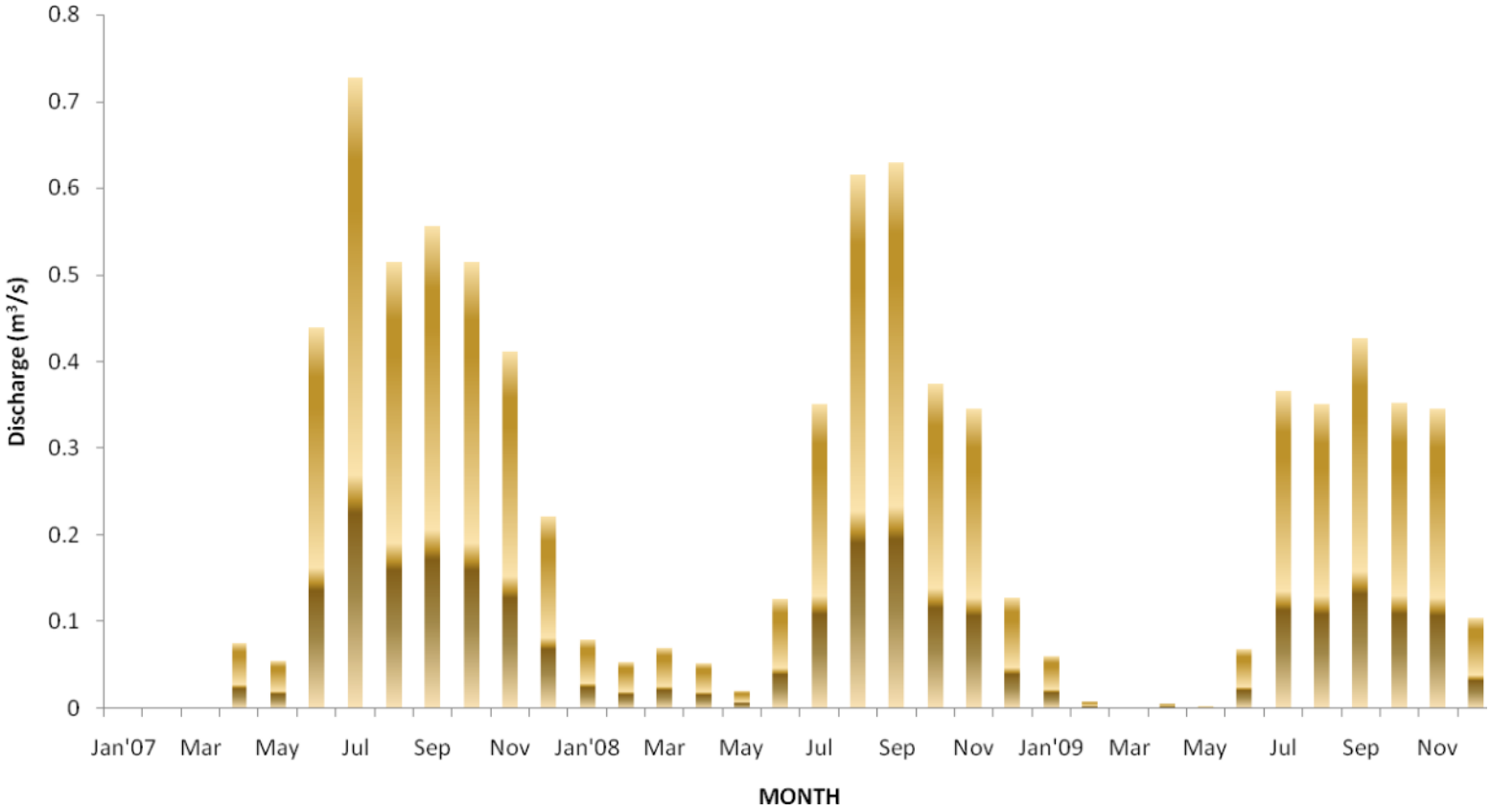

Figure 22Monthly mean discharge at Idinjamala

INFILTRATION STUDIES

The infiltration characteristic of soil is one of the basic and important parameters in many hydrologic problems such as runoff estimation, soil moisture budgeting, irrigation scheduling, drainage requirements, and water management. It is a single parameter to measure the composite effect of texture, structure, porosity and hydraulic conductivity of the soil. There are three different approaches to the determination of infiltration rates. Parr and Bertrand (1960) in a review article classified instruments as being : (i) those in which infiltration is determined as the difference between applied water and runoff, usually employing raindrop simulators; (ii) those in which water is impounded inside a cylinder; (iii) those which attempt to determine infiltration from rainfall data.

Cylinder infiltrometers (Ring infiltrometers) are the most widely used method in the field for measuring the cumulative infiltration. A major drawback of the cylinder infiltrometer is that the infiltrated water percolates laterally at the bottom of the ring. Thus the cylinder is not truly representing the area through which the infiltration is taking place. This drawback is rectified to a large extent in the double-ring infiltrometer.

Infiltration study was conducted during the period April 2007 at Idinjamala where the soil texture is sandy clay loam. Double ring infiltrometer with diameters 30cms and 60cms and height 30cms were used for conducting the test. The cylinders were installed at 10cms deep into the soil. Water was then applied in both the inner and outer rings to maintain a constant depth of about 10cms. Water was replenished after the level falls by about 1cm. The water depths in the inner and the outer rings were kept the same during the observation period. Readings of volume of water added at successive time intervals to maintain constant depth of flooding in the inner ring were taken. As the purpose of the outer ring is to suppress the lateral percolation of water from the inner ring, the water added to it need not be measured though the water was added to maintain the same depth as in the inner ring. The experiment was carried out till a constant infiltration rate was obtained. The rate of infiltration and time elapsed were noted down in standard formats. Figure 23 show the curve of the rate of infiltration on elapsed time and cumulative infiltration on elapsed time for the watershed.

The infiltration study conducted at Idinjamala (Latitude 9°49'54"N and Longitude 77°04'04"E) in Erattayar watershed show an initial infiltration rate of 60cm/hr and after three and a half hours it reduces to 8 cm/hr and remains constant. The soil type is observed as sandy loam with a moisture content of 23.4% at the time of the test.Figure 23 shows the infiltration curve at Idinjamala.

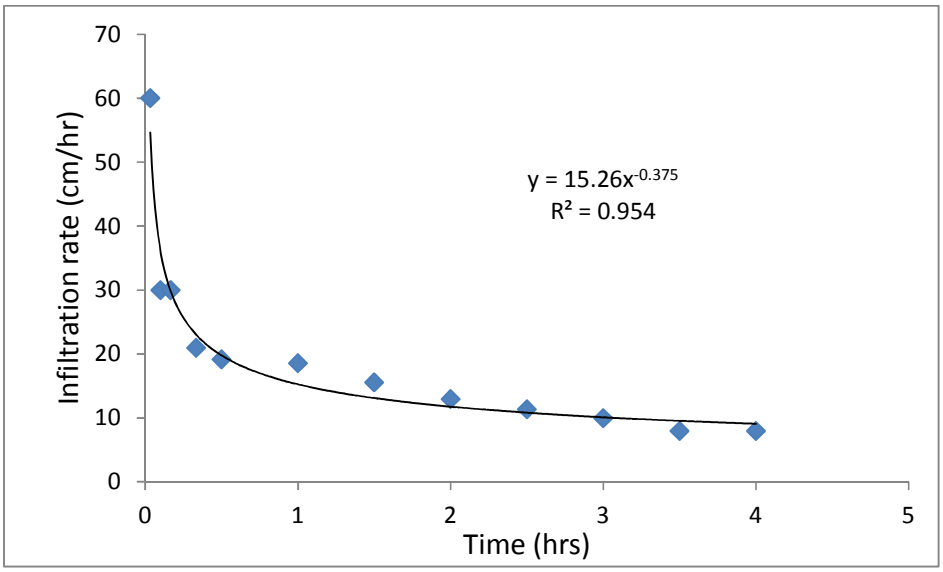

Figure 23 Infiltration Curve atIdinjamala Watershed

A similar study conducted at different points in the Pooppara tribal colony which lies between 9° 58' 10" and 9° 58' 30" N latitude and 77° 11' 28" and 77° 12' 20" E longitude during the year 2005 shows that the initial infiltration rate varies from 34.31 cm/hr to 105.11 cm/hr and arrives at a steady value of 6.6 cm/hr to 24 cm/hr after two and a half hours where the soil is sandy clay loam. This area also lies in the Periyar river basin in the Idukki district of Kerala State (Celine et. al., 2011).

GROUND WATER STORAGE AND SOIL MOISTURE FLUCTUATIONS

The groundwater recharge depends upon the rock or soil formation and the average annual rainfall of the area. Six monitoring wells were selected to observe the groundwater fluctuations in the area. It is observed that the water table rises maximum during the south-west monsoon season. A general decline in the water table is observed from November to May.

The water table fluctuation data was used to compute the change in groundwater storage. The change in ground water storage has been arrived at considering the volume of aquifer saturated or de-saturated in different months (CGWB, 1978). Theissen polygon approach was adopted to get the area-wise weightage. The weighted change in groundwater level over a period multiplied by the specific yield and the involved area gives the total volume of aquifer material either saturated or de-saturated depending upon the rise or fall in the water level. Specific yield is the water removed from the unit volume of the aquifer by pumping or drainage and is expressed as the percentage volume of the aquifer. The average specific yield taken is 2.5%, as recommended by CGWB.

From the change in groundwater storage, it is observed that the water table rises very near to the ground surface during the south-west monsoon, especially in the valley portion. The trend shows that the recharge in groundwater storage takes place immediately after the rain occurs. After the monsoon season, a general decline in the water table has been observed for the entire summer season. Figure 24 shows the changes in the groundwater storage the Erattayar watershed.

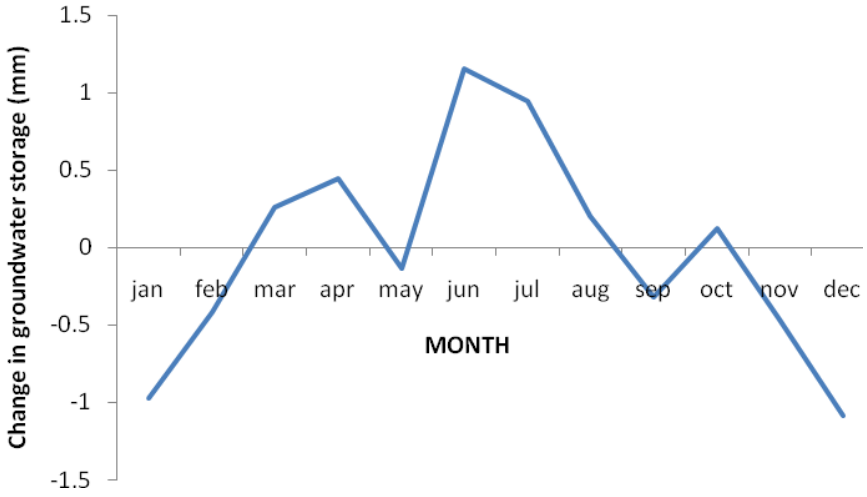

Figure 24 Periodic Change In Groundwater Storage

For determining soil moisture, ten representative sites were selected in the watershed. Bimonthly sample collection was done and the moisture content of the soil samples determined by the gravimetric method. Figure 25 gives the percentage soil moisture variations in the Erattayar watershed. Table 9 shows the average monthly groundwater and soil moisture fluctuations in the watershed. The results show that an average minimum moisture level of 16.47 percent has been observed for the month of January and a maximum of 26.88 percent for the month of August.

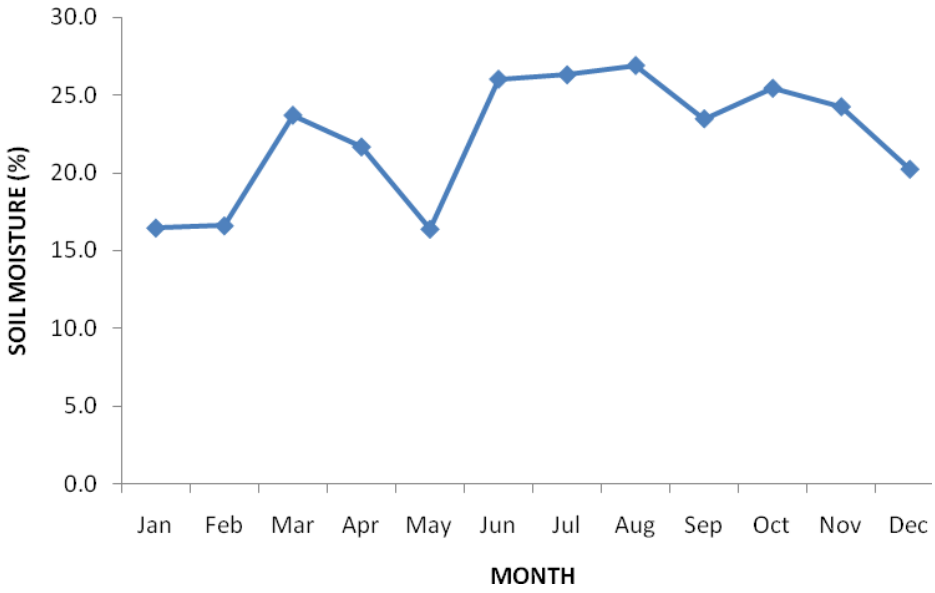

Figure 25 Periodic Soil Moisture Fluctuations by Gravimetric Method

Table 9 Groundwater Storage and Soil Moisture Fluctuations in the Erattayar Watershed

MONTH	Avg. Groundwater Storage, mm	Percentage Soil Moisture
Jan	-0.968	16.47
Feb	-0.417	16.61
Mar	0.264	23.69
Apr	0.450	21.66
May	-0.136	16.40
Jun	1.155	26.00
Jul	0.950	26.28
Aug	0.205	26.88
Sep	-0.318	23.47
Oct	0.122	25.42
Nov	-0.462	24.24
Dec	-1.083	20.24

SHEET EROSION AND SEDIMENT TRANSPORT STUDIES

The presence of sediments in streams and rivers has its origin in soil erosion. The erosion is a result of series of complex and interrelated natural processes that would loosen and move away from the soil and rock materials under the action of water, wind, and other geological factors. Soil erosion may be classified into two general types: sheet erosion and channel erosion.

Sheet erosion phenomenon in the Erattayar watershed and the sediment transport in its stream has been studied. Water samples were collected once in a week for determining the quantity of suspended sediments. An attempt was made to estimate the sheet erosion from the Erattayar watershed by using the Universal Soil Loss Equation (USLE). A relationship between rainfall and erosion index has been established for predictive purposes. It is observed that the soil loss is considerable during the monsoon season. Water samples were analyzed for suspended sediments and the sediment rating curve was prepared. The study is expected to be useful for the quantitative determination of soil loss through sheet erosion and to predict the suspended load if streamflow data is available. The relationship may have applicability in identical watersheds in the Western Ghats region.

Estimation Of Sheet Erosion

The universal soil loss equation developed by the Agricultural Research Service of the United States Department of Agriculture (1961) was made use for computing sheet erosion from the Erattayar watershed. This equation considers all the factors affecting erosion namely, the rainfall regime, vegetal cover, soil type, land slope and land use and is given by the equation :

$$A = RKLSCP \tag{18}$$

in which A is the average soil loss in tons/hectare/year, R the rainfall factor, K the soil erodibility factor, L the slope length factor, S the slope gradient factor, C the crop management factor and P the supporting conservation practice factor.

R is determined by the following relationship reported by Wischmeir and Smith (1958) :

$$R = \sum \frac{EI_{30}}{100} \tag{19}$$

where E is the kinetic energy (metric tones) and I_{30} the maximum 30 – minute intensity of rainfall (cm/hr). The kinetic energy of each storm is given by

$$E = 210 + 89 \log_{10} I \tag{20}$$

where I is the rainfall intensity (cm/hr).

Estimation Of Suspended Load

The total sediment in a stream or river may be split into two parts: bed load and suspended load. Bed load is that sediment in the bed layer moved by siltation, rolling or sliding, whereas suspended load remains in suspension in the flowing water for a considerable period of time.

Study was conducted to determine the suspended load in the tributary of Erattayar. Water samples were collected once in a month from Nalumukku. The daily discharge was also

collected from the station. The samples were filtered and sediments oven-dried. The ratio of the dry weight of sediment to the total volume of the sample is the sediment concentration, expressed in parts per million or mg/litre. The sediment load (kg/sec) was computed by multiplying the sediment concentration and the daily discharge. The sediment rating curve relating to the suspended sediment discharge and water discharge was plotted as shown in figure 26. The relationship between suspended load and discharge is given by the equation :

$$S = KQ^n \tag{21}$$

where S is the suspended load in kg/sec, Q the discharge in m^3/sec, K and n are constants. The regression equation obtained for the Nalumukku station is

$$S = 0.201Q^{1.251} \tag{22}$$

The relationship developed for the suspended sediment load would be useful for computing the suspended load for varying discharges. This relationship may have applicability in identical watersheds in the Western Ghat region.

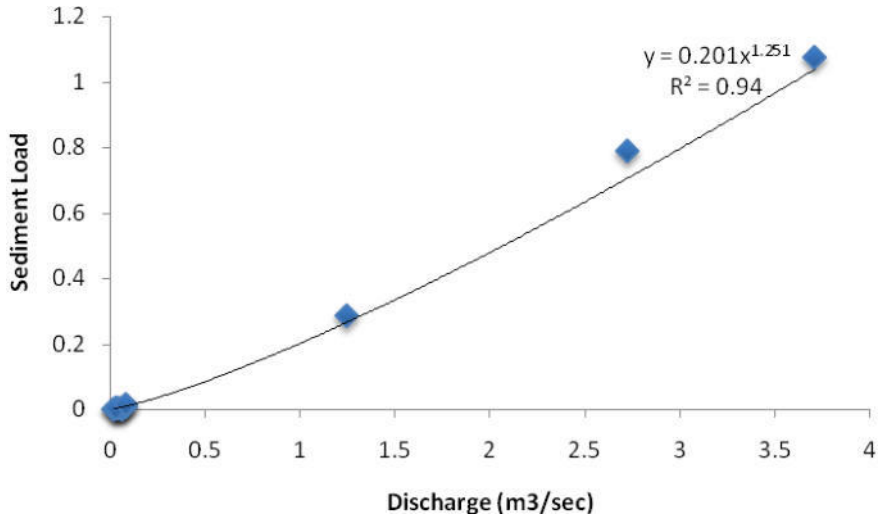

Figure 26 Sediment Rating Curve For Erattayar Watershed

USING SOIL AND WATER ASSESSMENT TOOL (SWAT)TO SIMULATE RUNOFF

The Soil and Water Assessment Tool (SWAT) was developed in the early 1990s by the U. S. Department of Agriculture, Agricultural Research Service (USDA-ARS) and it has undergone many changes and improvements since its formation. The SWAT model is a direct descendant of the Simulator for Water Resources in Rural Basins (SWRRB) model, which was designed to simulate management effects on water and sediment movement for ungauged rural basins across the United States.

Hydrological processes simulated by the SWAT model include precipitation, infiltration, surface runoff, evapotranspiration, lateral flow and percolation. Commands are included for routing flows through streams and reservoirs, adding flows and using measured data for point sources. SWAT is incorporated into a Geographical Information System (GIS) platform using the ArcView and SWAT (AVSWAT) interface tool. This platform provides the user with a complete set of GIS tools for developing, running and editing hydrologic and management inputs and finally for calibrating the model. SWAT2005 version of SWAT uses an upgraded version of AVSWAT, termed AVSWAT-X. Presently SWAT 2012 with ArcGIS as the GIS platform is in use and is adopted for this study.

SWAT allows several different physical processes to be simulated ina watershed. For modelling purposes, a watershed is partitioned into many sub-watersheds or sub-basins. The use of sub basins in a simulation is particularlybeneficial when different areas of the watershed are dominated by land uses or soilsdissimilar enough in properties to impact hydrology. By partitioning the watershedinto sub basins, the user is able to reference different areas of the watershed to oneanother spatially.

Input information for each sub-basin is grouped or organized into thefollowing categories: climate; hydrologic response units or HRUs; ponds/wetlands;groundwater; and the main channel, or reach, draining the sub-basin. Hydrologicresponse units are lumped land areas within the sub basin that are comprised ofunique land cover, soil and management combinations. No matter what type of problem is studied with SWAT, water balance is the driving force behind everythingthat happens in the watershed. To accurately predict the movement of

pesticides,sediments, or nutrients, the hydrologic cycle as simulated by the model must conformto what is happening in the watershed.

Simulation of the hydrology of a watershed can be separated into twomajor divisions. The first division is the land phase of the hydrologic cycle. The land phase of the hydrologic cycle controls the amount of water,sediment, nutrient and pesticide loadings to the main channel in each sub-basin. Thesecond division is the water or routing phase of the hydrologic cycle which can bedefined as the movement of water, sediments, etc. through the channel network ofthe watershed to the outlet.

SWAT simulation is based on the water balance equation:

$$SW_t = SW_o + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw}) \quad (23)$$

where,

SW_t = soil water content at time t,
SW_o = initial soil water content,
t = time (in days),
R_{day} = amount of precipitation on day i,
Q_{surf} = amount of surface runo on day i,
E_a = amount of evapotranspiration on day i,
w_{seep} = water percolation to the bottom of the soil profile on

SWAT's input parameters are physically based and can be varied for calibration within a given uncertainity range defined in SWAT tool input and output file documentationversion 2005. SWAT model calibration can be completed in two ways : manual and (or) auto-calibration. Manual calibration requires the user to compare measured data to simulated data and to use judgment to determine whether simulated data are acceptable. Auto-calibration can be done using the SWAT CUP software. SWAT Calibration and Uncertainty Program (SWAT-CUP) is a computer program which provides the calibration, validation and sensitivity analysis of SWAT models. SWAT-CUP is a public domain program, and is freely downloadable from internet. It

involves several methods such as SUFI2, PSO, GLUE, ParaSol, and MCMC which can be chosen for the purpose of calibration and uncertainty analysis. This access the SWAT input files and runs the SWAT simulations by modifying the given parameters. The storage of the value of the objective function and the modification of parameters is the basis for the comparison.

Statistical methods can be used to assist in evaluation of simulation results and to help adjust model parameters. Santhi et al. (2001) and Coffey et al. (2004) used calibration and validation of SWAT for streamflow, sediment, nitrogen and phosphorous loss simulation for different watersheds. They recommended using two statistical measures, the Nash-Sutcliff Index (N_{SE}) and the square of the correlation coefficient (R^2), to assess the simulation results for monthly data.

The R^2 value is a measure of the strength of the linear correlation between the predicted and observed values. The N_{SE} value is a measure of the predictive power of the model. N_{SE} is defined by the equation :

$$N_{SE} = 1 - \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_o^t - \overline{Q}_o)^2} \qquad (22)$$

where

N_{SE} = Nash-Sutcliffe coefficient
Q_o = observed discharge
Q_m = modeled discharge
Q_o = mean observed discharge
Q_t = discharge at time t

A value of 1 for N_{SE} indicates a perfect match between simulated and observed data values. A value of 1 for the R^2 also indicates a perfect linear correlation between simulated and observed data values. The overall reliability of model simulations depends on factors that vary from study to study. Thus, while the statistical parameters R^2 and N_{SE} provide a means for assessing the reliability of model simulations for a given input data set, there are no standards or range of

values for the statistical parameters that definitively indicate acceptable model performance. In general, the longer the time period selected for simulation and the more high quality measured data that are available for input for both calibration and validation periods, the more reliable are the simulations. In addition, simulations of data averaged over longer time periods, such as annual or monthly mean streamflows, are more reliable than simulations of daily data.

ArcSWAT MODEL APPLICATION TO ERATTAYAR WATERSHED

All the parameters required to run a watershed model may not be measured directly. Some parameters must be estimated. The watershed model must be calibrated by adjusting some or all the estimated parameters to utilize the model for effective future management practices. After calibration, the model must be tested and validated by using an independent set of measured data, without any additional change in model parameters. A calibrated and validated watershed model generally is considered capable of making reasonable simulations of streamflow under varying climate or land-use change scenarios.

Here in this study, the Soil and Water Assessment Tool (ArcSWAT) version 2012 watershed model was first run without calibration for the years 2007 and 2008, to identify the parameters to which the model is most sensitive. The model then was calibrated by adjusting those parameters to reasonably predict the measured streamflow. The model was validated using the monthly flow values for the year 2009 to demonstrate the model's capability of reasonably simulating streamflow in the Erattayar watershed.

Input Data

Basin topographic information for the Erattayar watershed was obtained from Digital Elevation Model (DEM) data. The ArcSWAT interface in the model is unable to predict the correct topography and the streamflow paths for the watershed for low-resolution DEMs. ASTERDEM of 30m resolution is used here for watershed delineation. In SWAT, a watershed is divided into multiple sub-watersheds, which are then further subdivided into hydrologic response units (HRUs) that consists of homogeneous land use, management and soil characteristics (Neitsch et al., 2005). Here the Erattayar watershed is divided into 79 sub-watersheds. Of this the sub-

watersheds numbered 8 (Parakkadavu), 12 (Idinjamala), 14 (8thmile) and 42 (Vazhavara) were selected for calibration. Figure 27 shows the DEM used for watershed delineation in SWAT simulation. Figure 28 gives the sub-watersheds delineated by SWAT 2012 for model analysis. The land use and soil maps are shown in figures 4&3 were used with their details suited for SWAT simulation.

Daily precipitation and temperature data for the years 2007 and 2008 were given as input data. Measured streamflow from stations Parakkadavu, Idinjamala, 8th mile, and Vazhavara were used for model calibration and validation. Mean monthly streamflow data for the years 2007 and 2008 for the stations Parakkadavu, Idinjamala, 8th mile, and Vazhavarawere used for the calibration of the model. The calibrated model was then tested with the data for the year 2009 for testing and validating the model. For the other three stations continuous data could not be collected due to various reasons.

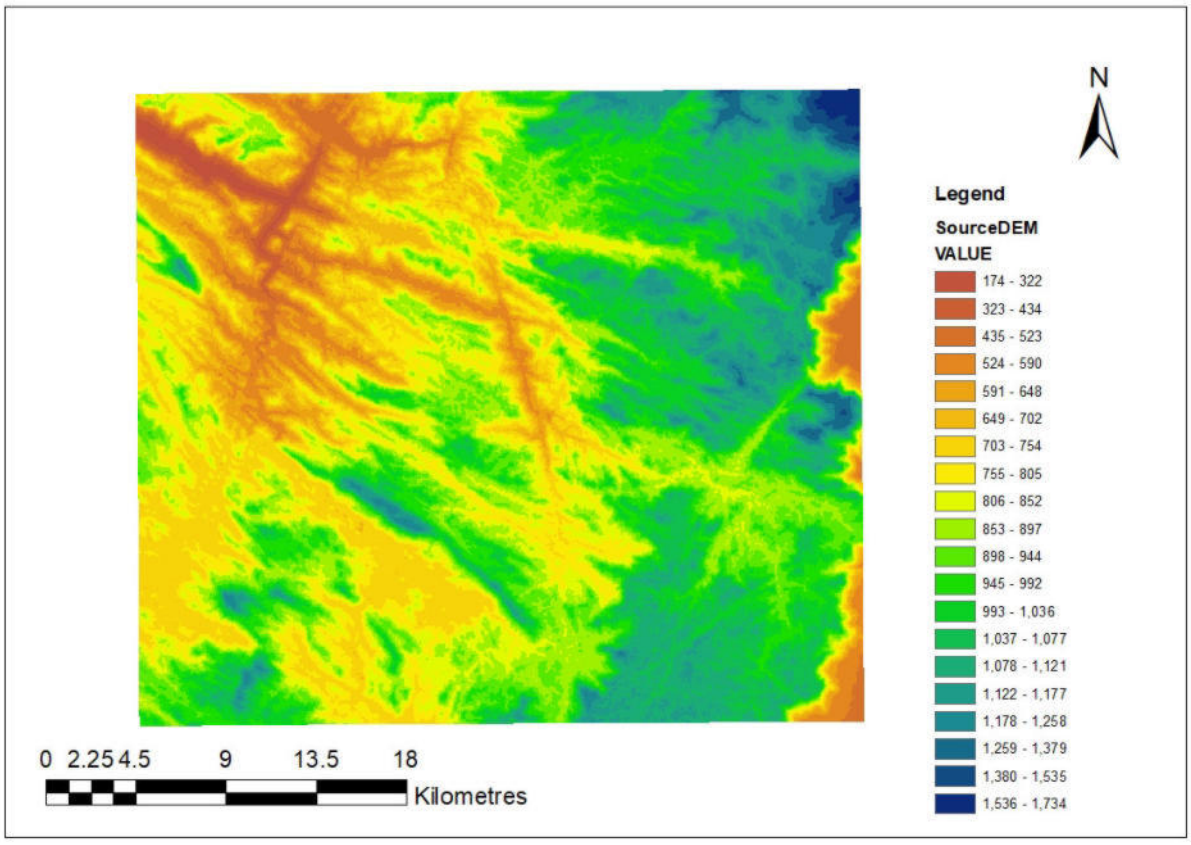

Figure 27 Topographic relief of Erattayar area used for watershed delineation in SWAT simulation

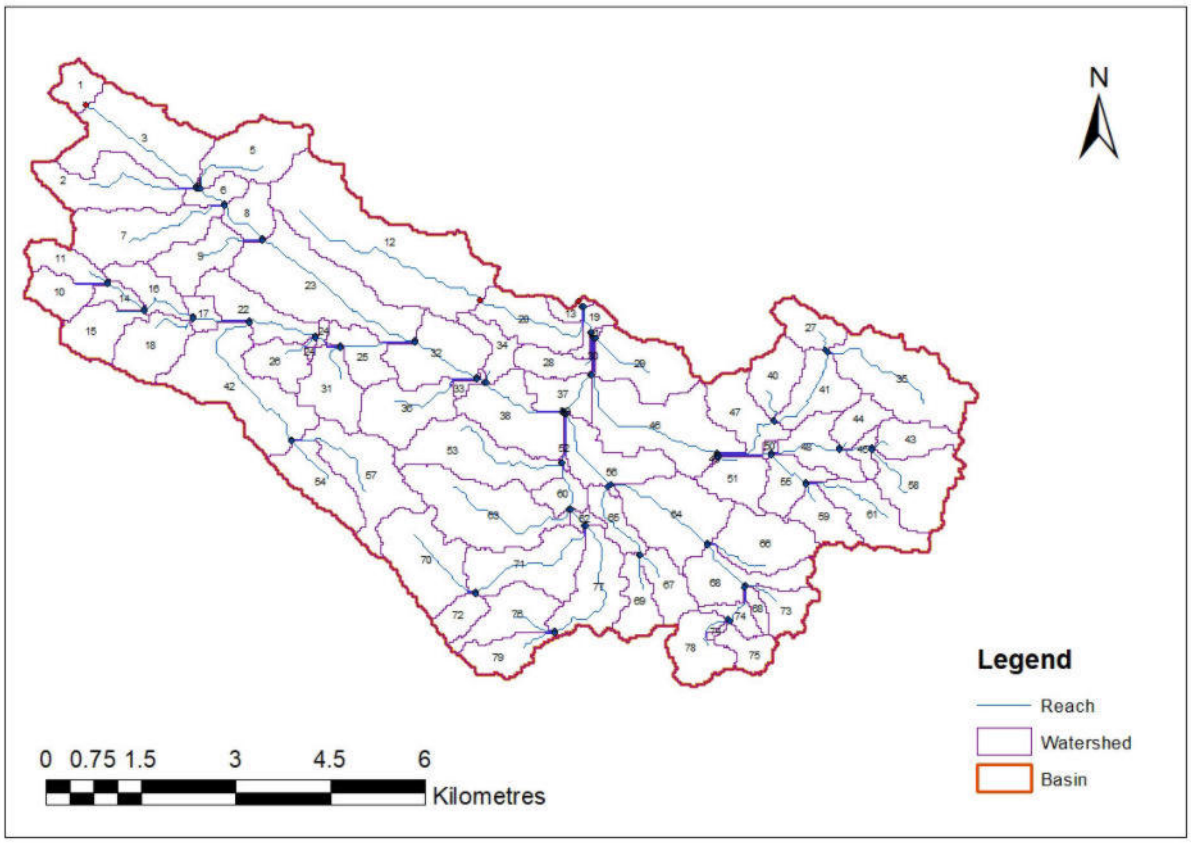

Figure 28 SWAT delineated sub-watersheds in Erattayar Watershed

Model Calibration

With a complex watershed model having a large number of model input parameters, a sensitivity analysis is a process of varying model input parameters over a reasonable range and observing the change in the model output. The magnitude of change in model output for various changes in input parameters provides a key for determining which parameters may need adjustment for model calibration. For this study, a preliminary sensitivity analysis based on all available climate and hydrologic input data for the years 2007 and 2008 was performed using SWAT CUP software.

Results from the calibrated simulation of mean monthly discharge for 2007 and 2008 for selected stations are compared to recorded discharges. Table 10 to 13 give the sensitive parameters obtained for the four stations using SWAT CUP model.

Table 10 Sensitive parameter values for thesimulation of streamflow at Idinjamala

Rank	**Parameter**	**Fitted value**
1	Alpha_bf	0.017
2	SOL_K	-0.5808
3	SOL_AWC	0.097
4	CN2	0.1972
5	CH_K2	92.375
6	GW_DELAY	35.46
7	GwQmn	0.042
8	GW_Revap	0.1678
9	CH_N2	0.0891
10	ESCO	0.8402

Table 11 Sensitive parameter values for thesimulation of streamflow at Vazhavara

Rank	**Parameter**	**Fitted value**
1	CN2	-0.006
2	Alpha_bf	0.019
3	CH_K2	110.875
4	SOL_K	-0.142
5	GW_DELAY	138.78
6	GwQmn	0.874
7	GW_Revap	0.1918
8	ESCO	0.8558
9	CH_N2	0.2409
10	SOL_AWC	0.0334

Table 12 Sensitive parameter values for the simulation of streamflow at Parakkadavu

Rank	Parameter	Fitted value
1	Alpha_bf	0.073
2	CH_K2	128.125
3	GW_DELAY	426.9
4	ESCO	0.827
5	CN2	0.0844
6	GwQmn	1.574
7	GW_Revap	0.107
8	CH_N2	0.1917
9	SOL_AWC	0.193
10	SOL_K	0.2928

Table 13 Sensitive parameter values for the simulation of streamflow at 8th mile

Rank	Parameter	Fitted value
1	Alpha_bf	0.051
2	CN2	0.138
3	GW_DELAY	321.9
4	ESCO	0.8338
5	SOL_AWC	0.1798
6	GwQmn	1.81
7	GW_Revap	0.1966
8	CH_N2	0.1851
9	CH_K2	92.625
10	SOL_K	0.264

In this calibration run, SWAT 2012 was successful in predicting flows in the Erattayar watershed at the sub-watershed points.The performance of the model has been evaluated graphically and numerically. Graphical evaluation is done with the scattered plot as given in figures 29 to 32.

Simulated discharge is in good agreement with the observed discharge values. To check the predictive capability of the SWAT model, as suggested by Santhiet. al., (2001) and Coeffy et. al., (2004) the correlation coefficient (R^2) and the Nash-Sutcliffe model efficiency coefficient (N_{SE}) are computed. To avoid certain problems associated with R^2, an index of agreement (d) given by equation (23) has been introduced by Willmott, 1981. This statistics reflects the degree to which the observed variable is accurately estimated by the predictive variable; d is not a measure of correlation in the formal sense but rather a measure of the degree to which a model's prediction is error-free. Moriasi et. al., (2007) suggested a general performance rating for the monthly time step for SWAT model. Accordingly if the performance statistics values are in the range N_{SE}> 0.65, RSR (root mean square error-observations standard deviation ratio)< 0.6 and percent bias (PBIAS)< 15% the model is good for prediction. Table 14 summarises the comparison statistics for the simulated and recorded monthly discharges for the calibrated the SWAT model for the years 2007 and 2008. The overall R^2 indicate a strong linear correlation between recorded and simulated mean monthly discharges and the N_{SE} values indicates a good match between recorded and simulated mean monthly discharges for the calibration period.

Table 14 Statistics for the calibrated simulation of streamflow at Idinjamala, Vazhavara, 8th mile and Parakkadavu for 2007-2008

Station	N_{SE}	R^2	d	PBIAS	RSR
Idinjamala	0.865	0.872	0.965	-4.42	0.37
Vazhavara	0.827	0.888	0.959	-19.36	0.42
8th mile	0.703	0.741	0.926	-1.50	0.54
Parakadavu	0.872	0.873	0.964	1.56	0.36

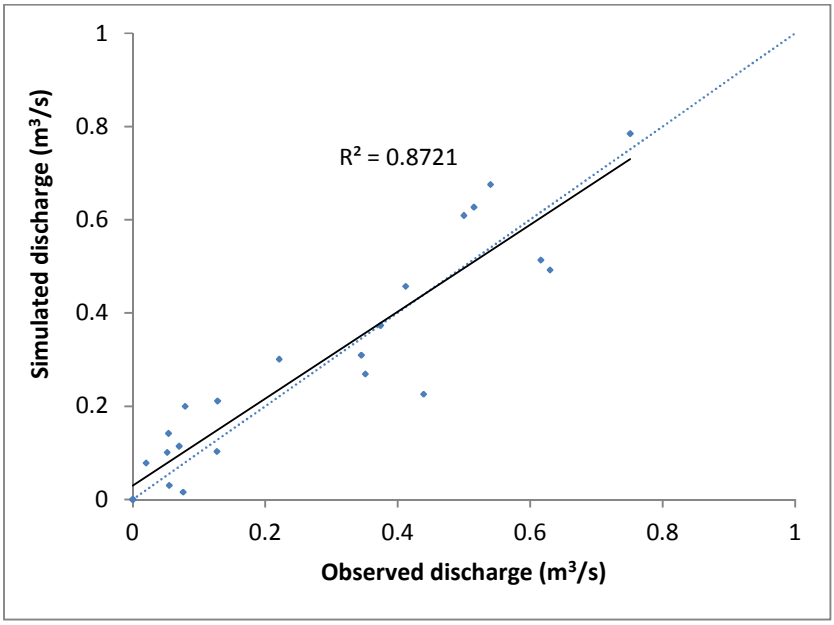

Figure 29 SWAT 2012 calibration result for Idinjamala station

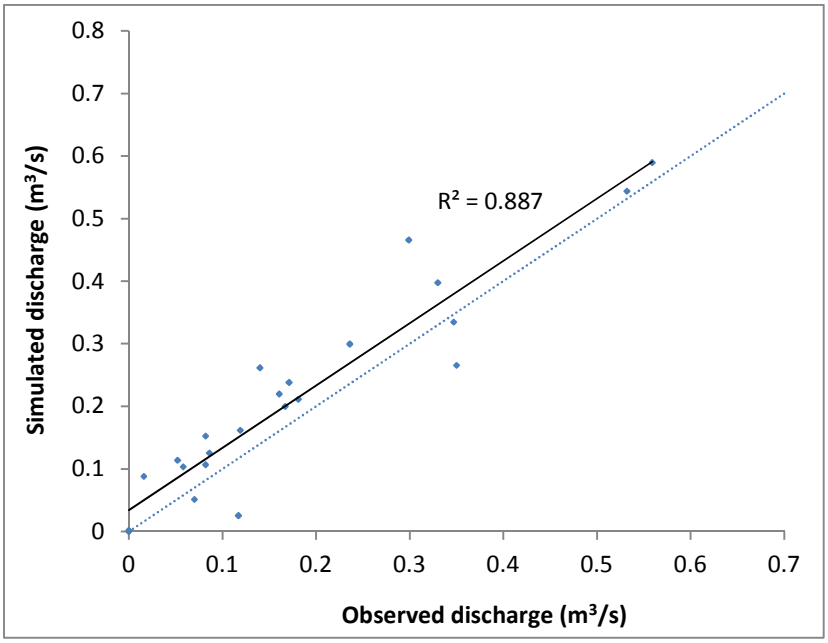

Figure 30 SWAT 2012 calibration result for Vazhavara station

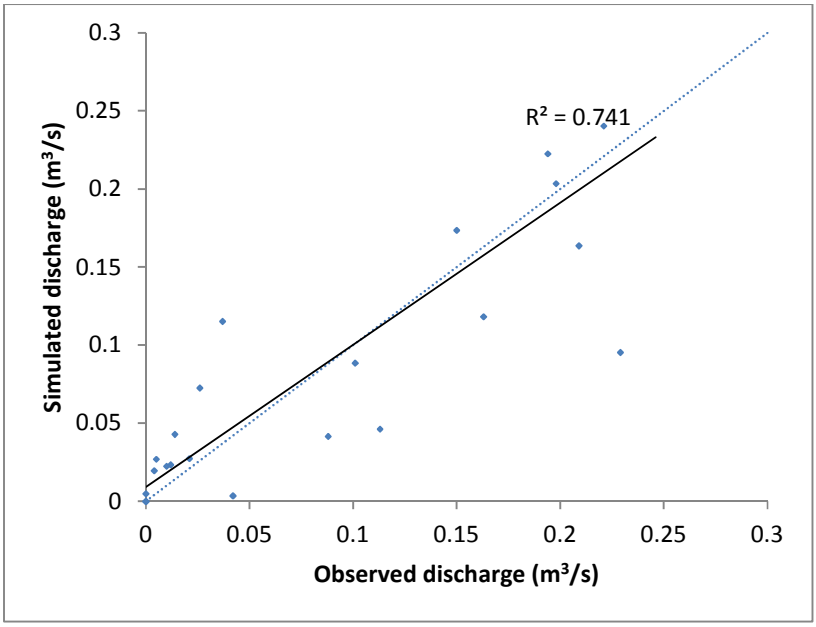

Figure 31 SWAT 2012 calibration result for 8th mile station

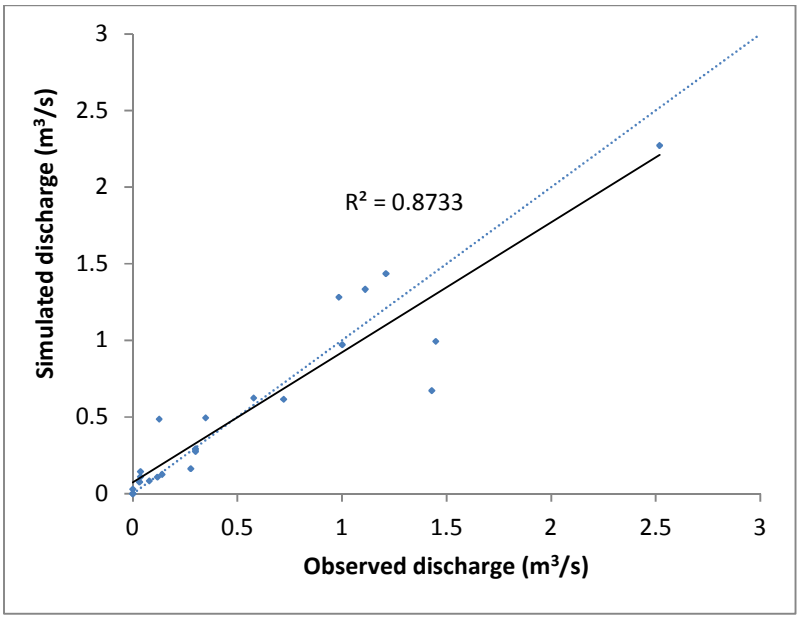

Figure 32 SWAT 2012 calibration result for Parakkadavu station

Model Validation

Streamflow data collected during the year 2009 were used for validation of the predictive capability of the SWAT model applied to the Erattayar watershed. As shown in Figures 33 to36, the calibrated SWAT model was successful in predicting the discharge for all the selected stations for the validation period. The comparison statistics for the measured and simulated mean monthly discharges for the validation period are shown in table 15. The R^2 values are very high indicating a strong linear relationship between simulated and recorded values. The N_{SE} values are also significantly high indicating that the simulated values are in a good match with the recorded values. The observed data for the station Kamakshy station which lies in the Parakkadavu sub-watershed was not taken for the calibration of the model. The observed data for this station is now taken for validating the model. The three year's monthly discharge data were compared with the simulated discharge values at Kamakshy sub watershed. The statistics obtained are given in table 16 and the scattered plot is given in figure 37. Thus the predicted discharge values at Kamakshy using the calibrated SWAT model can be rated as very good. On this basis, the SWAT model is considered to be good for the simulation of mean monthly discharge in the Erattayar watershed.

Table 15 Statistics for the simulation of streamflow at Idinjamala, Vazhavara, 8th mile and Parakkadavu for 2009 (validation)

Station	N_{SE}	R^2	d	PBIAS	RSR
Idinjamala	0.878	0.929	0.968	-18.60	0.35
Vazhavara	0.788	0.884	0.953	-11.70	0.46
8th mile	0.871	0.895	0.960	-10.36	0.36
Parakadavu	0.827	0.834	0.950	-9.52	0.42

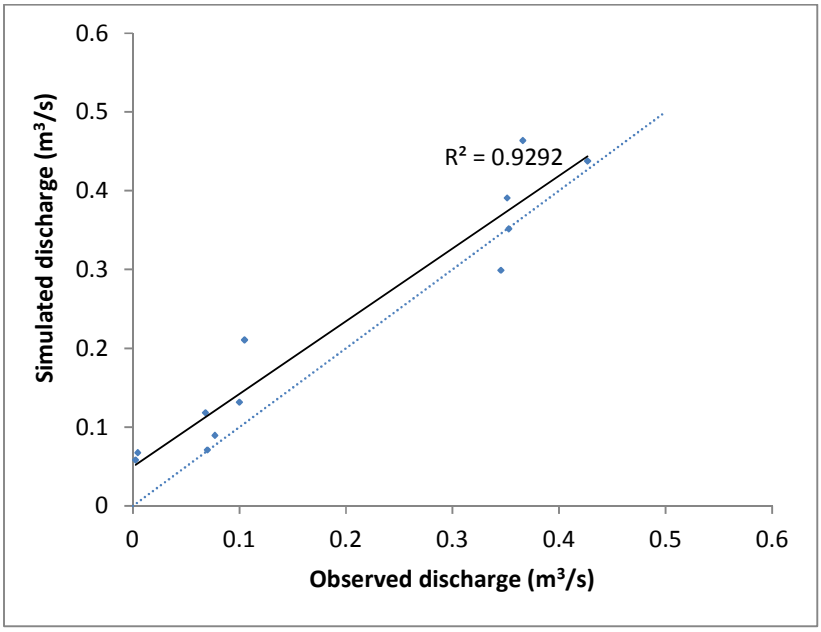

Figure 33 SWAT 2012 validation result for Idinjamala station

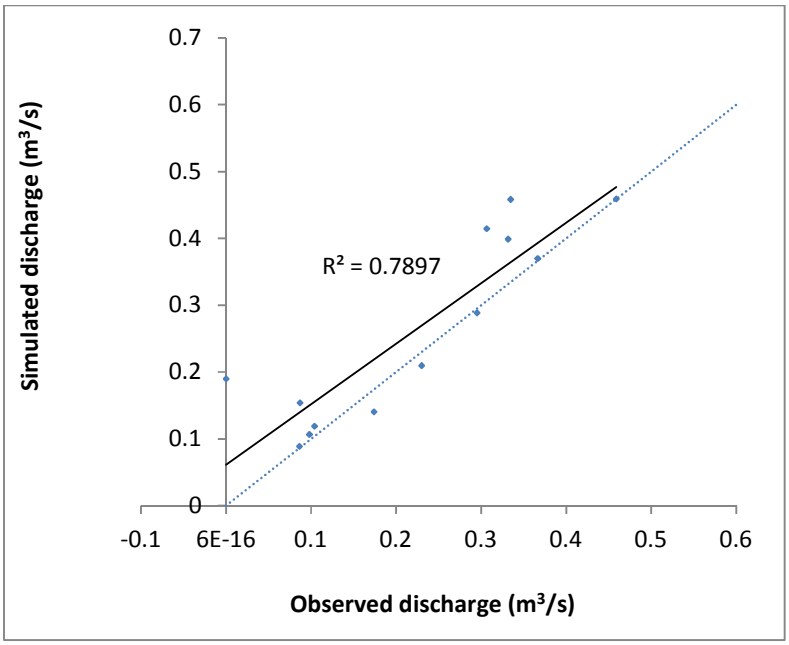

Figure 34 SWAT 2012 validation result for Vazhavara station

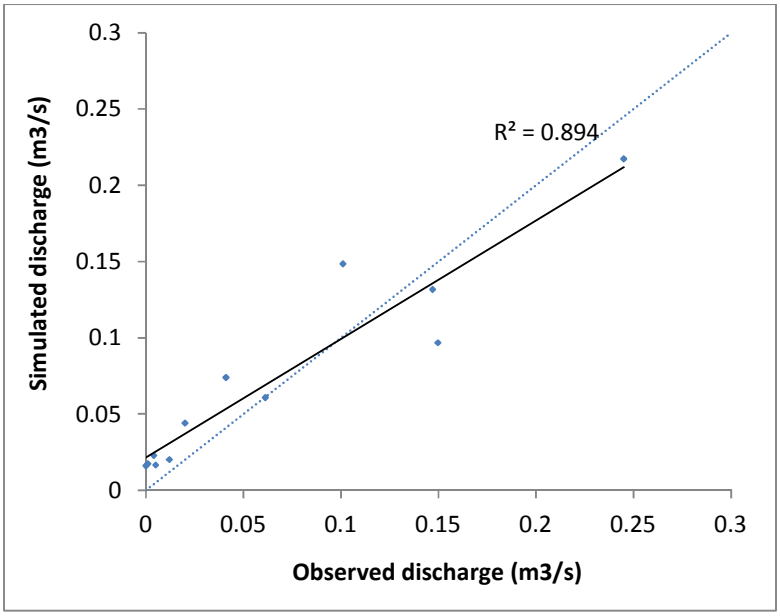

Figure 35 SWAT 2012 validation result for 8th mile station

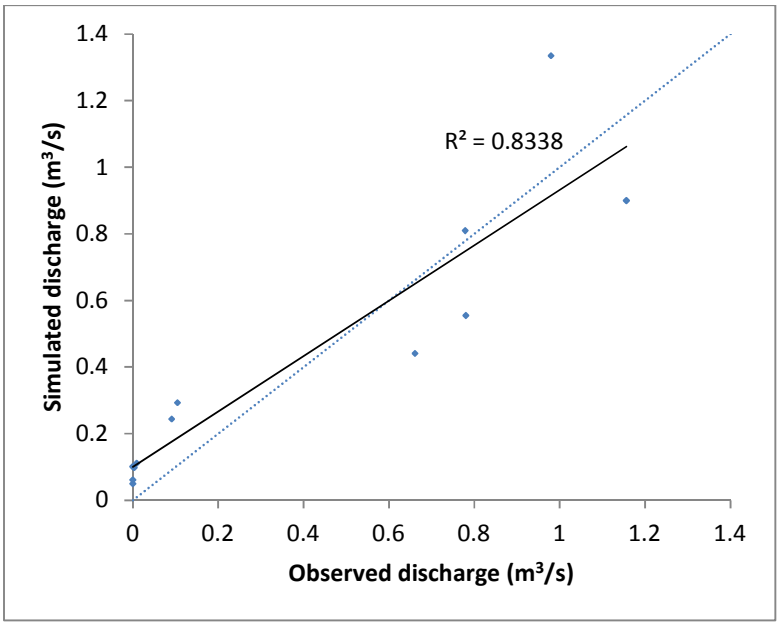

Figure 36 SWAT 2012 validation result for Parakkadavu station

Table 16 Statistics for the simulation of streamflow at Kamakshy (2007-2009)(validation)

Station	N_{SE}	R^2	d	PBIAS	RSR
Kamakshy	0.852	0.874	0.964	-11.69	0.385

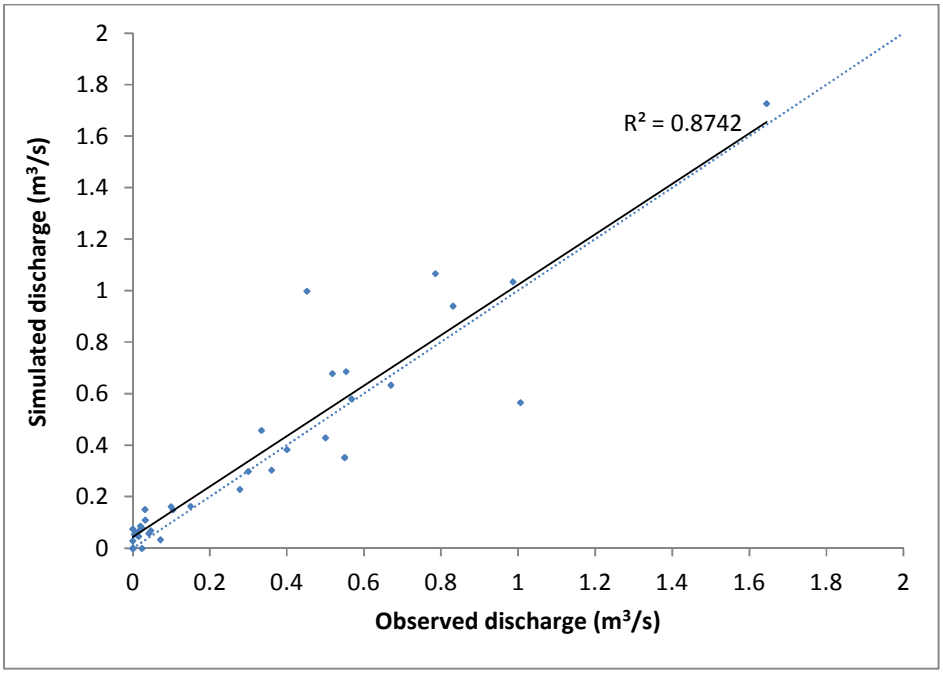

Figure 37 SWAT 2012 validation result for Kamakshy station

XI. Conclusions/Recommendations

Seven small watersheds which lie in theErattayar watershed with an area of 64.6 km^2 situated between 09° 45' 30" and 09° 51' 00" N latitude and 77° 01' 00" and 77° 10' 00" E longitude has been selected for the study under this project. Erattayar watershed is mainly situated in the eastern highland region of KeralaState and is a part of the Periyar river basin. The lowest most valley portion of the watershed is at 720 m above the mean sea level and the highest point is at 1270 m above the mean sea level. The average slope is 18.33%. The entire watershed is having ~~a~~ mixed cultivation with seasonal crops like tapioca, plantain and other plantation crops like coffee, pepper, coconut, arecanut, etc. Few patches of cardamom cultivation are also found in the watershed. Daily data on rainfall, temperature, humidity, wind speed, and bi-weekly observations on discharge, soil moisture, water level,etc. were collected and analyzed. For the three years under study, the average annual rainfall received in the watershed is 2634mm with 58% during the south-west monsoon (June –August), 28% during the north-east monsoon (September-December), and remaining during the dry months (January-May). The annual average rainy days is 145. Comparing this data with the long term data of a nearby station, Chinnar of Water Resources Department, there is variation in total rainfall (3452mm) but the similarity is observed in percentage contribution (58%, 26% and 16% seasonally), and rainy days (142). The maximum temperature observed is 34°C and the minimum is 11°C. The monthly average potential evapotranspiration has been observed to vary from 2.75mm/day in July to 4.34mm/day in March. Stage discharge curves at seven gauging locations prepared. Continuous data could be collected for five stations only. For the other two stations, ie., at Thankamani and Nalumukku staff gauges get washed away due to high flow. The average monthly discharge values were computed for the five locations. An infiltration study was conducted at one location and the infiltration rate was found to be 60cm/hr initially and becomes constant at 8cm/hr in the sandy clay loam soil with a moisture content of 23.4%. Average soil moisture variation is observed to be 16.5% in January to 26.9% in August. Sediment rating curve has been developed for the watershed at Nalumukku.

The SWAT 2012 model was used to simulate streamflow for the selected watersheds. The rainfall, other climate data, soil moisture, evapotranspiration data,etc were taken as the input data

for the model in addition to the DEM, soil, and land use data as thematic layers. Two years of data were taken for calibrating the model. The most sensitive parameter in predicting the streamflow values was arrived for each station by using SWAT CUP software. The model was calibrated and validated for the prediction of flow at four stream gauging stations, Idinjamala, Vazhavara, 8th mile and Parakkadavu. The calibrated model was also validated with the data from the Kamakshy station. SWAT 2012 is found to be good in predicting mean monthly flows in the Erattayar watershed, with good accuracy. The average annual water yield per unit area for the sub watersheds obtained from the model simulation is 1400.71mm for Kamakshy, 2902.2mm for 8th mile, 1253.21mm for Vazhavara, 484.15mm for Idinjamala and 2032.04mm for Parakadavu sub watersheds. For the less elongated sub watershed (8th mile) the yield per unit area is observed to be high. The more elongated sub watershed, Idinjamala gives the lowest yield per unit area. As the watershed area increases yield per unit area decreases.

Based on the above work a much detailed study is recommended considering more number of sub watersheds in different parts of the State, so that the model can be regionalized to use in ungauged areas for watershed management and planning processes.

XII. How do the conclusions/recommendations compare with current thinking?

Watershed based study is essential for any water resources management and planning projects. Similar studies are not done for any high land watersheds in Kerala. Hence this study will be useful for the water resources management projects of high land Kerala.

XIII. Field tests conducted

An infiltration study was conducted during the period April 2007 at Idinjamala where the soil texture is sandy clay loam. Double ring infiltrometer with diameters 30cms and 60cms and height 30cms were used for conducting the test. The cylinders were installed at 10cms deep into the soil. Water was then applied in both the inner and outer rings to maintain a constant depth of about 10cms. Water was replenished after the level falls by about 1cm. The water depths in the inner and the outer rings were kept same during the observation period. Readings of the volume of water added at successive time intervals to maintain a constant depth of flooding in the inner

ring were taken. As the purpose of outer ring is to suppress the lateral percolation of water from the inner ring, the water added to it need not be measured though the water was added to maintain the same depth as in the inner ring. The experiment was carried out till a constant infiltration rate was obtained. The rate of infiltration and time elapsed were noted down in standard formats. Figure 23 shows the curve of the rate of infiltration on elapsed time and cumulative infiltration on elapsed time for the watershed.

The infiltration study conducted at Idinjamala in Erattayar watershed shows an initial infiltration rate upto 60cm/hr, after three hours it reduces to 8cm/hr and becomes almost constant. The soil type is observed as sandy loam with a moisture content of 23.4%.

XIV. Software generated, if any. : **Nil**

***XV. Possibilities of any patents/copyrights. If so, then action taken in this regard.*: N.A.**

XVI. Suggestions for future work.

More data collection is required for studying the hydrology of small watersheds. Also, we have to select more stations or else there arise unexpected situations where data collection can't be continued.

More length of period of data available can make more accurate the model prediction. Thus the values of the sensitivity parameters arrived at all the stations can be made the same if more years of data can be obtained and can be generalized.

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APPENDIX -1

DATA COLLECTED

CLIMATOLOGICAL DATA							
Name of station: Thankamani		Year: 2007				Month: January	
Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C				
			Max.	Min.	Dry	Wet	Ordinary
1	0.00	4.00					21.00
2	0.00	6.00	26.00	25.00			25.00
3	0.00	4.00	26.00	21.00			23.00
4	0.00	2.00	24.00	19.00	22.00	19.00	25.00
5	0.00	4.00	24.00	19.00	23.00	18.00	27.00
6	0.00	4.00	25.00	20.00	22.00	19.00	25.00
7	0.00	4.00	23.00	21.00	23.00	18.00	21.00
8	0.00	4.00	24.00	20.00			22.00
9	0.00	2.00	23.00	19.00			21.00
10	0.00	2.00	24.00	21.00	24.00	20.00	27.00
11	0.00	4.00	26.00	21.00	25.00	20.00	26.00
12	0.00	4.00	28.00	22.00	24.00	21.00	27.00
13	0.00	2.00	26.00	21.00	22.00	18.00	21.00
14	0.00	4.00	23.00	20.00			23.00
15	0.00	4.00	26.00	21.00	26.00	21.00	28.00
16	0.00	3.40			24.50	20.00	27.00
17	0.00	4.80			23.50	18.50	27.50
18	0.00	4.00			22.50	19.00	26.00
19	0.00	4.00	25.00	20.00	22.00	17.00	25.50
20	0.00	4.40	21.00	20.00	24.50	18.50	26.50
21	0.00	5.80			23.00	17.00	25.00
22	0.00	4.00	26.00	20.00	24.00	18.50	25.50
23	0.00	4.00	26.00	20.00	24.00	15.50	27.00
24	0.00	4.40	21.00	19.00	23.50	17.00	26.00
25	0.00	4.00	20.00	18.00	22.00	19.00	24.00
26	0.00	4.40	21.00	20.00	23.00	18.00	36.00
27	0.00	4.00	20.00	18.00	23.50	17.50	25.00
28	0.00	4.40	21.00	20.00	22.00	19	26.00
29	0.00	4.00	22.00	21	24.00	18	27.00
30	0.00	4.00	27.00	20	24	19.50	25.5
31	0.00	2.6	26.00	21.00	25	20.00	25.5
Total	0.00						
Mean		3.88	24	20.27	23.44	18.64	25.39

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year:2007** **Month:February**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C				
			Max.	Min.	Dry	Wet	Ordinary
1	0.00	6.00	26.00	21.00	24.50	19.00	26.00
2	0.00	4.10	27.00	20.00	23.00	17.00	26.50
3	0.00	4.00	26.00	21.00	24.50	19.50	27.00
4	0.00	4.40	25.00	20.00	23.00	19.00	26.00
5	0.00	4.20	28.00	21.00	25.50	19.00	27.50
6	0.00	3.40	28.00	22.00	25.00	20.50	28.50
7	0.00	6.00	28.00	22.00	24.50	19.00	25.50
8	0.00	5.60	27.00	21.00	24.00	20.50	27.50
9	0.00	4.00	25.00	20.00	23.00	19.00	26.00
10	0.00	3.60	26.00	21.00	24.00	18.00	28.00
11	0.00	4.00	25.00	20.00	23.00	17.50	27.00
12	0.00	4.40	29.00	21.00	25.00	17.00	28.00
13	0.00	5.20	27.00	23.00	25.00	18.00	26.00
14	0.00	4.20	29.00	22.00	25.50	19.00	25.50
15	0.00	5.00	28.00	21.00	24.00	24.00	26.00
16	0.00	5.20	25.00	22.00	25.00	21.50	26.00
17	0.00	4.20	27.00	23.00	24.00	20.00	25.50
18	1.20	3.20	28.00	22.00	23.50	18.50	26.00
19	0.00	4.00	25.00	21.00	23.00	21.00	25.00
20	0.00	6.00	26.00	21.00	24.00	20.00	27.00
21	0.00	5.40	27.00	21.00	23.50	18.50	26.00
22	0.00	6.00	26.00	20.00	23.00	18.00	25.00
23	0.00	6.10	25.00	20.00	22.50	17.50	24.50
24	0.00	5.60	29.00	23.00	23.00	19.00	25.00
25	0.00	5.20	27.00	20.00	25.00	21.50	27.50
26	0.00	4.10	25.00	21.00	24.50	18.50	26.00
27	14.60	4.60	28.00	23.00	26.00	22.00	27.00
28	0.00	4.00	28.00	22.00	26.50	19.50	28.00
Total	15.80	131.70					
Mean		4.70	26.79	21.25	24.18	19.34	26.41

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month: March**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reding	Wind Speed(km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	5.20	28.00	23.00	25.50	21.50	21.00			
2	0.00	5.00	29.00	24.00	26.00	22.00	25.00			
3	0.00	6.00	28.00	23.50	27.50	20.50	23.00			
4	NA	NA	NA	NA	NA	NA	NA			
5	NA	NA	NA	NA	NA	NA	NA			
6	0.00	16.00	28.00	22.00	27.00	25.00	25.00			
7	0.00	4.80	29.00	23.00	25.50	19.00	21.00			
8	0.00	6.40	28.00	22.00	25.00	17.50	22.00			
9	0.00	6.00	27.00	23.00	26.00	19.50	21.00			
10	0.00	4.80	28.00	22.00	26.00	18.00	27.00			
11	0.00	6.00	28.00	23.00	25.00	19.00	26.00			
12	0.00	6.60	27.00	23.00	27.00	25.00	27.00			
13	0.00	5.00	28.00	22.00	25.00	20.00	21.00			
14	0.00	6.60	27.00	23.00	27.00	21.50	23.00			
15	0.00	6.80	29.00	24.00	26.00	22.00	28.00			
16	0.00	5.20	28.00	23.00	27.00	21.50	27.00			
17	0.00	4.80	27.00	22.00	25.00	21.00	27.50			
18	0.00	5.00	28.00	23.00	26.00	22.00	26.00			
19	0.00	5.20	29.00	24.00	27.00	21.00	25.50			
20	0.00	6.00	NA	NA	NA	NA	26.50			
21	0.00	5.60	29.00	25.00	28.50	21.50	25.00			
22	0.00	5.50	28.00	25.00	26.50	22.50	25.50			
23	0.00	5.20	28.00	24.00	26.50	21.50	27.00			
24	0.00	5.30	32.00	20.00	28.50	24.00	26.00	N-W	9754.2	
25	0.00	4.40	33.00	20.00	30.00	23.50	24.00	W	9757.2	0.13
26	0.00	4.80	33.00	20.00	28.50	23.00	36.00	N-W	9761.2	0.17
27	0.00	6.40	32.00	17.00	30.00	20.00	25.00	W	9775.9	0.61
28	0.00	6.80	33.00	24.00	30.00	29.50	26.00	E	9834	2.42
29	0.00	6.00	32.00	21.00	28.50	21.00	27.00	S	9869.5	1.48
30	0.00	5.60	32.00	19.00	29.00	22.50	25.5	N-W	9895.9	1.04
31	0.00	5.2	32.00	16.00	28.5	21.50	25.5	W	990.1	0.28
Total	0.00	171.2								
Mean	0.00	5.9	29.29	22.16	27.07	28.66	28.66			0.86

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month: April**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	4.40	32	20.00	28.50	22.50	29.00	W	9906	0.20
2	0.00	4.00	31.00	21.00	31.50	22.50	31.00	N	9918.9	0.54
3	1.10	5.30	33.00	20.00	27.50	23.50	29.50	N	9920.3	0.06
4	0.00	5.10	33.00	20.00	29.50	24.00	30.00	S	9925.2	0.20
5										
6										
7	0.00	17.00	32.00	17.00	29.00	28.00	29.50	NW	105.7	2.49
8	0.00	4.00	33.00	20.00	25.50	21.50	26.50	W	135.2	1.23
9	0.00	2.60	32.00	18.00	29.00	22.00	30.00	NW	148.3	0.55
10	0.20	4.60	31.00	19.00	28.50	22.50	29.50	W	177.8	1.23
11	35.20	4.00	29.00	20.00	28.50	25.00	28.50	NW	185.3	0.31
12	0.00	2.60	28.00	20.00	26.50	23.00	28.00	N	185.5	0.01
13	0.00	3.10	31.00	21.00	28.00	24.50	30.00	NW	186.4	0.04
14	0.00		30.00	20.00	28.50	23.00	29.50	W	200	0.57
15	54.10	4.10	31.00	17.00	24.50	22.50	26.00	S	240	1.67
16	1.20	3.20	27.00	18.00	27.00	22.00	28.50	N	245.6	0.23
17	0.00	2.00	29.00	19.00	28.50	24.00	28.50	W	255.7	0.42
18	0.00	5.20	30.00	18.00	29.50	24.00	30.50	NW	257.3	0.07
19	0.00	4.00	31.00	18.00	28.00	23.50	29.50	S	259.4	0.09
20										
21	70.80	0.80	32.00	17.00	28.00	22.50	28.50	NW	269.3	0.21
22	8.30	2.30	29.00	19.00	27.00	22.50	26.50	W	272.2	0.12
23	7.00	2.90	30.00	18.00	27.50	23.50	28.00	S	279.3	0.30
24	4.20	5.20	31.00	19.00	30.00	24.50	28.50	NW	297.4	0.75
25	0.00	4.00	32.00	21.00	28.50	24.00	29.50	N	298.9	0.06
26	0.00	4.00	33.00	20.00	29.00	24.00	29.50	NW	300.4	
27	0.00	4.00	31.00	19.00	28.50	25.00	29.50	N	302.3	
28	0.00	2.40	30.00	21.00	28.50	24.5	29.50	S	302.5	
29	0.00	3.00	31.00	20.00	228.00	24.00	29.00	SW	303.5	
30	6.20	4.20	32.00	19.00	30.00	24.50	29.50	NW	306.3	
31										
Total	188.30	108.00								
Mean		4.15	30.89	19.22	35.67	23.6	28.97			0.49

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month:May**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	3.1	31	21	27.5	24.5	29	NW	306.4	-1.33
2	0.00	4.6	31	21	29	24.5	30.5	NW	307.2	0.033
3	1.2	3.2	30	22	26	23.5	26.5	NW	308.6	0.058
4	0.00									
5	7.00	4	31	19	27.5	24.5	28.5	NW	310.2	12.93
6	11.0	4	30	18	27	24	28	NW	310.9	0.029
7	0.00	2.8	31	20	30.5	25	30.5	NW	312.2	0.054
8	0.00	2.8	32	21	26.5	24	27.5	SW	312.3	0.004
9	15.2	1.2	28	20	24.5	23.5	26.5	NW	312.3	0
10	0.00									
11	8.6	2.6	29	19	26	23	27.5	N	313.5	13.06
12	0.00	4	28	21	29.5	25	29.5	NE	314.2	0.029
13	0.00	4	29	20	28	24.5	29	SW	315.1	0.038
14	0.00	4	28	20	28.5	25	29.5	NW	316.2	0.046
15	0.00	4	29	21	25.5	23	27.5	N	316.7	0.021
16	0.00	4	28	19	28	24	28.5	N	317.4	0.029
17	0.00	5	29	18	26	23	28	NW	318.7	0.054
18	0.00	4	28	20	27	24	27	W	319.3	0.025
19	0.00	4.2	30	17	30.5	22.5	29.5	N	320.4	0.05
20	0.00	3.2	31	18	28.5	23	28.5	NW	312.1	-0.346
21	0.00	4	30	17	27.5	22.5	28.5	W	322.3	0.023
22	0.00	4.8	29	20	28	24	27	WN	323.4	0.046
23	0.00	4	28	20	27	22.5	28	WN	324.3	0.038
24	8.6	6	32	18	30	21.5	31.5	WN	330.4	0.254
25	2.2	4	33	19	28.5	25	29	W	332.2	0.075
26	0.00	2	29	18	29	23	30	W	333.1	0.038
27	0.00	3	28	20	27	22	28	W	334.2	0.046
28	44.2	4.4	31	19	24.5	22	24.5	W	334.6	0.017
29	7.6	1.6	26	18	23.5	21.5	25.5	WN	335.5	0.037
30	0	2	26	18	25.5	25	29.5	WN	338.4	0.121
31	24.2	6.2	25	19	24	25.5	29	WN	339.2	0.033
Total	129.80	106.7								
Mean		3.68	29.31	19.34	27.26	23.62	28.34			0.88

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year:2007** **Month:June**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0	2	26	18	25	25	29.5	WN	339.9	0.029
2	0	6	24	19	25.5	24	29	N	340.1	0.008
3	0	3	25	18	25	24.5	28.5	WN	341.2	0.046
4	0	4	24	20	25	24	28.5	SN	342.3	0.046
5	0	3	26	18	25	24	29	SN	348.7	0.267
6	2.6	3.2	30	17	27	23.5	27.5	N	344.5	-0.18
7	1.6	3.6	28	19	28	24.5	29.5	WN	344.7	0.008
8	0	2	29	20	28.5	25	29	WN	345	0.013
9	0	0	28	20	28	25	29	WN	346.2	0.05
10	0	0	29	19	25	23.5	27	N	347	0.033
11	0	4	29	20	28	24	29	WN	347.7	0.029
12	13.6	1.6	24	19	23	21.5	24.5	WN	347.8	0.004
13	25.8	1	25	20	25	22.5	26.5	WN	347.9	0.004
14	9.4	0.4	21	18	21.5	19.5	22.5	SN	348.6	0.029
15	7.4	1.4	27	19	25	22.5	26	WN	349.1	0.021
16	7.6	3.6	21	20	25	22.5	22.5	WN	350.2	0.046
17	5.4	0.4	25	19	28	24	24	SN	353.4	0.133
18	12.6	0.6	29	20	25	23	29	WN	356.7	0.143
19	9	0	21	18	25	23.5	26	W	357.5	0.033
20	7	2.2	21	20	28	24	26	W	357.8	0.013
21	9	0	27	20	23	25	22.5	WN	358.7	0.037
22	133.2	53.2	22	19	20	19.5	21.5	W	425.2	2.771
23	12.6	0.6	29	20	25	23	29	WN	426.3	0.046
24	9.4	3.4	21	20	25	24	27.5	W	428.4	0.087
25	9.4	3.4	22	18	23.5	21.5	24.5	WN	534.1	4.404
26	0	0.8	25	19	25	22	26.5	NE	537.1	0.125
27	3.2	1.2	26	18	23.5	21.5	24.5	W	542	0.204
28	9.4	1.4	25	19	25	22	26.5	WN	620.2	3.258
29	9.2	0	22	18	23	21.5	24.5	W	628.4	0.342
30	9.4	1.4	21	19	25	22	24.5	WN	636.5	0.338
31										
Total	306.8	107.4								
Mean		3.58	25.1	19.0	24.9	23.3	26.5			0.4

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month:July**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	9	1	21	18	25	23.5	26	WN	750.2	4.74
2	6	0	29	20	24	25	29	WN	757.5	0.304
3	9	0.6	20	20	25	23.5	27	WN	760.5	0.125
4	4	0.4	25	19	25	22.5	23.5	WN	787.7	1.133
5	6.4	0.4	25	20	25	23.5	23	WN	855.4	2.821
6	7	1	21	19	25	21	21	WN	831.5	-0.996
7	6.8	0	20	18	25	23	26	WN	832.4	0.037
8	7.4	0	20	19	25	22.5	23	WN	832.8	0.017
9	6	0	27	20	25	23.5	21	WN	852.4	0.817
10	7	0.1	25	20	23.5	22	21	WN	858.3	0.246
11	6	0	20	19	25	23.5	23	W	860.4	0.088
12	5	0	24	19	22	23	25.5	WN	865.4	0.208
13	45.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	31.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	31.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	45.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	154.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	34.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	13	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	4.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
21	32.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	10.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
23	6.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
24	8.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
25	25.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
26	9.2	3	24	18	22	20.5	23.5	WN	NA	NA
27	20.6	0.6	22	19	21.5	20.5	22.5	W	NA	NA
28	9	0	22	18	22.5	20.5	23.5	WW	NA	NA
29	8	0	23	19	21.5	20.5	22.5	WW	NA	NA
30	9.2	3.2	22	18	22	20.5	24.5	WW	NA	NA
31	3.6	0	25	19	22	21.5	23.5	WN	NA	NA
Total	582	10.3								
Mean		1.14	23.06	19	23.67	22.25	23.83			0.79

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year:2007** **Month: August**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	18.80	0.80	24.0	18.0	21.5	20.5	23.5	WN	921.1	-3.71
2	9.90	0.40	22.0	19.0	22.0	20.5	23.5	WN	927.6	0.271
3	9.60	1.60	23.0	18.0	24.5	21.5	25.5	NE	932.3	0.196
4	5.00	0.00	25.0	19.0	25.5	22.5	27.0	SW	935	0.113
5	6.00	0.40	23.0	18.0	24.0	21.0	25.0	WN	938.1	0.129
6	9.40	1.40	27.0	18.0	22.5	21.5	23.5	S	957.8	0.821
7	17.20	0.80	26.0	19.0	23.0	21.5	24.5	W	968.3	0.438
8	6.00	1.00	27.0	18.0	22.0	21.5	23.5	W	990.4	0.921
9	9.00	1.00	26.0	19.0	23.0	22.5	24.5	WN	999.5	0.379
10	45.20	0.00	21.0	18.0	21.0	20.5	21.5	W	1006.9	0.308
11	6.00	1.00	21.0	18.0	23.0	20.5	24.5	W	1010.2	0.138
12	5.00	0.00	26.0	19.0	22.0	22.0	23.5	WN	1011.8	0.067
13	9.20	0.40	21.0	19.0	22.5	21.0	25.0	W	1012	0.008
14	5.00	0.00	21.0	18.0	21.0	20.8	21.5	WN	1014.6	0.108
15	0.00	2.00	23.0	19.0	25.5	21.5	25.5	W	1016.7	0.088
16	0.00	3.00	26.0	20.0	22.0	21.0	24.0	WN	1018.3	0.067
17	0.00	4.00	23.0	19.0	23.0	22.0	23.5	W	1020.4	0.088
18	0.00	2.00	22.0	20.0	24.0	21.5	21.5	WN	1021.5	0.046
19	0.00	6.00	22.0	19.0	22.0	21.0	23.5	W	1024	0.104
20	0.00	2.00	26.0	20.0	25.0	22.0	23.0	W	1028.7	0.196
21	0.00	3.00	23.0	18.0	22.0	21.5	23.5	W	1029.8	0.046
22	0.80	2.00	23.0	17.0	26.0	23.0	26.5	WN	1024.1	-0.238
23	0.00	3.00	23.0	18.0	22.0	21.0	23.5	WN	1028.2	0.171
24	0.00	2.00	22.0	17.0	23.0	22.0	23.0	W	1030.7	0.104
25	0.00	6.00	22.0	20.0	22.0	21.0	23.5	WW	1081.2	2.104
26	0.00	2.00	22.0	20.0	23.0	21.5	21.0	W	1033.5	-1.988
27	0.00	4.00	23.0	20.0	23.0	21.5	23.5	WW	1034.6	0.046
28	0.00	2.00	20.0	20.0	22.0	21.0	24.5	W	1038.5	0.163
29	0.00	4.00	20.0	18.0	23.0	21.0	23.0	WN	1039.5	0.042
30	0.00	2.00	22.0	20.0	23.0	21.0	23.0	WN	1040.5	0.042
31										
Total	162.10	57.80								
Mean		1.93	23.2	18.8	22.9	21.4	23.8			0.04

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month: September**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	2.00	23.0	19.0	25.5	21.5	25.5	WN	1019.5	-1.083
2	0.00	4.00	21.0	18.0	23.0	22.0	23.5	W	1020.4	0.037
3	0.00	6.00	22.0	19.0	22.0	21.0	23.5	WN	1021.7	0.054
4	0.00	2.00	21.0	18.0	23.0	20.0	23.5	W	1023.1	0.058
5	6.20	2.20	27.0	20.0	22.0	21.0	23.0	N	1025.6	0.104
6	6.40	1.00	22.0	20.0	22.0	20.0	23.0	N	1025.7	0.004
7	1.40	0.00	22.0	20.0	22.0	20.0	23.5	WN	1025.8	0.004
8	2.40	0.50	21.0	18.0	23.0	21.0	22.0	WN	1025.9	0.004
9	4.00	0.00	23.0	20.0	22.0	20.0	23.0	N	1026.7	0.033
10	15.3									
11	50.60	4.60	28.0	21.0	26.0	23.0	27.5	N	1026.8	0.004
12	2.40	0.40	27.0	21.0	20.0	23.5	27.5	W	1027	42.79
13	7.60	1.60	22.0	19.0	22.5	21.5	23.5		1027.2	0.017
14	7.00	1.60	22.0	19.0	22.0		23.5	W	1027.4	0.017
15	2.40	0.40	27.0	21.0	26.0	21.5	27.5	WN	1027.5	0.012
16	4.00	0.00	23.0	19.0	22.0	23.5	25.5	W	1027.7	0.012
17	1.20	0.00	22.0	18.0	23.0	20.0	23.5	WN	1028.2	0.029
18	2.00	0.00	21.0	20.0	25.5	21.0	22.5	WN	1028.2	0.021
19	1.20	0.00	21.0	20.0	25.5	21.0	NA	WN	1029.2	0.042
20	4.00	0.00	22.0	18.0	23.0	20.0	22.5	W	1030.4	0.092
21	2.40	0.40	23.0	19.0	25.5	23.5	25.5	WN	1035.1	0.246
22	1.20	0.00	21.0	20.0	22.0	21.0	23.5	W	1032.1	0.071
23	2.40	0.40	22.0	19.0	26.0	22.0	23.0	WN	1038.3	0.133
24	7.60	1.60	21.0	18.0	22.5	21.0	22.0	S	1041.5	0.392
25	9.80	2.80	22.0	19.0	22.5	21.0	22.0	WN	1042.5	0.175
26	26.20	1.40	28.0	17.0	29.0	24.0	29.5	WN	1043.3	0.075
27	20.0									
28	21.60	1.60	29.0	18.0	23.0	21.5	25.0	WN	1043	-0.012
29	0.0									
30	0.0									
31										
Total	209.30	34.50								
Mean		1.33	23.2	19.2	23.5	21.4	24.2			1.667

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month: October**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	6.00	1.00	26.0	19.0	26.0	23.0	27.0	W-N	1043.6	0.025
2	5.20	0.80	27.0	17.0	23.5	21.0	25.0	N	1043.7	0.004
3	0.00	4.20	22.0	16.0	24.5	22.0	26.5	N	1043.7	0
4	0.00									
5	0.00	4.80	27.0	17.0	26.5	22.0	28.0	W-N	1044	0.012
6	0.00	2.20	21.0	17.0	25.5	21.0	25.0	W-N	1043.3	-0.029
7	0.00	4.00	22.0	16.0	25.5	22.0	25.0	W-N	1045.1	0.075
8	0.00	4.60	21.0	17.0	24.5	21.0	26.0	N-E	1045.6	0.021
9	0.00	2.00	22.0	17.0	24.0	20.0	26.0	W-N	1045.7	0.004
10	0.00	2.60	27.0	18.0	25.0	20.5	26.5	W-N	1046.9	0.05
11	0.00	5.00	31.0	31.0	26.5	24.0	28.0	W-E	1052	0.212
12	4.20	2.20	31.0	31.0	28.5	24.5	27.5	N	1052	0
13	13.00	5.00	32.0	32.0	23.5	22.5	27.0	W	1053	0.042
14	6.60	1.40	31.0	31.0	26.5	23.5	29.5	N	1053	0
15	3.60	2.15	31.0	31.0	25.5	22.5	30.0	N	1053	0
16	0.00	2.00	31.0	31.0	24.5	22.0	26.5	W	1054	0.042
17	3.80	1.80	31.0	31.0	23.0	21.5	25.0	W	1056	0.083
18	4.80	0.80	31.0	31.0	21.0	20.5	22.5	W	1060	0.167
19	2.60	10.60	32.0	32.0	23.0	21.5	25.0	N	1062	0.083
20	44.00	0.00	32.0	32.0	22.0	21.0	24.0	W	1062	0
21	4.40	2.80	34.0	34.0	27.5	23.0	28.0	W	1062	0
22	14.20	0.00	33.0	33.0	21.5	20.5	23.5	N	1063	0.042
23	21.20	5.80	32.0	32.0	21.5	20.0	23.0	N-W	1067	0.167
24	1.00	9.00	34.0	34.0	24.0	21.5	26.0	W	1129	2.583
25	118.20	Overflow	34.0	34.0	79.5	19.0	21.5	N-W	1148	0.792
26	0.00	7.00	34.0	34.0	21.5	20.5	25.0	N-W	1206	2.417
27	4.60	6.40	33.0	33.0	24.0	21.5	25.5	N	1216	0.417
28	18.20	0.00	33.0	33.0	23.0	21.5	24.5	W	1219	0.125
29	19.40	3.00	34.0	34.0	21.5	21.0	24.0	W	1219	0
30	28.60	0.00	34.0	34.0	23.5	22.0	25.0	W	1219	0
31	2.20	0.00	34.0	34.0	25.5	22.5	27.0	W	1219	0
Total	325.80	91.15								
Mean		3.14	29.9	27.9	26.1	21.6	25.8			0.244

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2007** **Month: November**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	2.60	32.0	23.0	28.5	25.0	33.5	N	1219	0
2	0.00	2.30	23.0	32.0	26.5	23.0	28.0	W	1219	0
3	49.20	1.20	32.0	23.0	24.0	21.5	25.5	N-W	1221	0.083
4	0.80	3.45	32.0	23.0	22.0	21.0	24.0	N	1222	0.042
5	0.00	6.00	32.0	23.0	24.0	21.5	25.5	N	1223	0.042
6	0.20	10.20	31.0	23.0	22.5	21.5	24.0	S	1223	0
7	6.20	4.20	31.0	23.0	25.5	23.5	27.0	N	1223.9	0.038
8	0.00	4.40	31.5	23.0	28.0	25.0	29.0	E	1223.9	0
9	19.00	1.00	31.0	23.0	26.0	22.5	27.5	E	1224	0.004
10	0.00	4.80	31.0	23.0	24.0	25.0	25.0	W	1224	0
11	15.00	0.00	31.0	23.0	23.0	26.0	26.0	W	1224.1	0.004
12	1.20	10.00	31.0	23.0	24.0	25.5	25.5	N-W-E	1224.4	0.013
13	0.20	3.40	31.0	23.0	24.5	26.0	26.0	N	1226.3	0.079
14	0.00	2.20	31.0	23.0	24.5	21.0	25.5	W	1226.3	0
15	0.00	4.70	23.0	23.0	24.5	20.0	29.0	W-N	1226.5	0.008
16	0.00	6.30	31.0	29.0	26.5	20.0	25.0	E	1229.4	0.121
17	1.00	11.00	31.0	29.0	20.0	16.0	23.0	W	1229.4	0
18	0.60	4.80	31.5	29.0	24.5	21.0	35.0	N-W	1232.2	0.117
19	0.00	0.00	31.0	29.0	24.5	21.5	25.5	N-W	1240.5	0.346
20	0.00	4.70	31.0	29.0	27.5	23.0	28.0	W	1252.3	0.492
21	0.20	11.20	31.5	29.5	25.0	22.0	26.0	N-W	1224.6	-1.154
22	0.20	1.30	31.0	29.0	25.0	25.0	27.0	N-W	1302.4	3.242
23	0.00	10.00	31.5	29.0	21.0	19.5	22.5	N-W	1309.5	0.296
24	15.00	5.00	31.0	29.0	23.5	21.5	25.0	W	1311.2	0.071
25	9.00	3.40	31.0	29.0	26.5	21.5	27.5	W	1316.1	0.204
26	0.00	16.00	31.0	29.0	22.0	16.0	23.5	W-N	1318.7	0.108
27	0.00	6.40	31.0	29.0	22.5	20.5	24.5	W-N	1328.9	0.425
28	0.20	12.20	31.5	29.0	25.5	22.0	27.0	W	1331.2	0.096
29	0.60	5.20	31.0	29.0	25.5	22.0	27.0	W	1343.1	0.496
30	0.00	4.20	31.0	29.0	23.0	19.5	24.5	W-W	1360.6	0.729
31										
Total	118.60	162.15								
Mean		5.41	30.7	26.3	24.5	22.0	26.4			0.197

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year:2007** **Month: December**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0	4.00	31.5	29	23.5	19.5	25	NW	1380.1	0.813
2	0	4.60	31.5	29	23	20.5	24.5	ES	1411.7	1.317
3	0	4.80	31.5	29	23.5	21	25	NW	1444.6	1.371
4	0	4.85	24	23	25.5	23	25	NW	1505.2	2.525
5	0	4.55	24	23	25.5	24	28	W	1520.5	0.637
6	0	4.80	33	28	27.5	25.5	28	WS	1646.3	5.242
7	0.6	7.60	34	28	22	19.5	23	NW	1690.1	1.825
8	0	4.60	33	28	20	19.5	23.5	SW	1720	1.246
9	0	4.60	33	28	25	21.5	27.5	W	1748.1	1.171
10	0	6.80	34	28	26.5	25.5	27.5	NW	1763.7	0.65
11	0	6.60	34	28	21.5	17	22.5	SW	1768.1	0.183
12	0	8.00	33	28	28	22.5	28	WN	1771.3	0.133
13	0	4.60	34	28	26	22	25	SW	1772.2	0.038
14	9.8	5.00	33	28	23.5	21	25	NW	1773.8	0.067
15	0	1.00	34	28	18.5	18.5	22	WN	1788.8	0.625
16	0	4.00	34	28	26.5	21.5	26.5	SW	1818.2	1.225
17	0	4.00	33	28	26.5	22	27	WS	1828.7	0.438
18	0.2	4.00	34	28	20	20	23.5	NW	1836	0.304
19	45.2	11.80	34	28	20.5	20	22	N	1837.3	0.054
20	9.4	8.60	34	27	19.5	19	21	NW	1840.4	0.129
21	2.6	0.08	34	28	23	21	24	NW	1886.5	1.921
22	0.6	5.20	34	28	22.5	20.5	24.5	W	1901.8	0.637
23	0.2	4.80	34	28	23.5	19.5	20.5	NW	1902.6	0.033
24	0.2	4.80	34	28	16.5	16	18	NW	1903.5	0.038
25	0	4.80	27	19	22	19	19	WN	1912	0.354
26	0.8	4.20	33	29	15	13.5	17	W	1914.5	0.104
27	0	4.00	25	25	26	24	30	SW	1914.5	0
28	1	5.60	28	11	26.5	22.5	24	W	1919.5	0.208
29										
30										
31										
Total	70.6	142.28								
Mean		9.81	31.98	26.71	23.13	20.68	24.16			0.832

Daily Rainfall (mm) at Pathammile for the Year 2007

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	53	19.4	11.1	7.3	0	0
2	0	0	0	0	0	0	73	9.2	9	9.1	0	0
3	0	0	0	0	5.4	1	63	13	16.3	0	34.4	0
4	0	0	0	0	0	0	57	5	1.3	0	1	0
5	0	0	0	0	5.2	0	11.2	20.2	2.4	0.4	0.2	0
6	0	0	0	0	9.6	0	44	24.6	39.1	0	0	0
7	0	0	0	0	0	3	53	26.2	10.3	0	5.2	0.4
8	0	0	0	0	0	0	26	27.4	11.2	0	0	0
9	0	0	0	0	13.6	0.6	25.8	32	10.1	0	11.4	0
10	0	0	0	0	10.2	1.2	75.2	71.8	28.4	0.3	0	0
11	0	0	0	31.4	0	0.6	32.2	27.2	22	0	10.2	0
12	0	0	0	0	0	6.2	42.8	18.2	26.2	0.4	1	0
13	0	0	0	0	0	32.8	45.6	1.4	5	11.2	0.5	0
14	0	0	0	0	0	13.2	31.2	0.4	2.1	4.3	0	6.4
15	0	0	0	61.6	0	8.4	31.2	0	32.4	2.1	0	0
16	0	0	0	0	0	24	45.4	0.4	32.3	3.6	0	0
17	0	0	0	0	0	18.2	154.4	0	31	4.1	0	0
18	0	0	0	0	0	20.2	34.4	0	23.4	14	0	1
19	0	0	0	0	0	40.2	13	0	99.3	3.2	0	38.1
20	0	0	0	0	0	0	4.8	0	36.3	58.2	0	13.2
21	0	0	0	0	0	47	32.4	7.4	31.1	8.1	0	3.1
22	0	0	0	0	0	167	10.4	20.4	24.2	12	0	2.3
23	0	0	0	0	0	22	6.6	3.4	39.3	19.3	0	0
24	0	0	0	5.4	0	19.2	8.2	27	25.4	1.2	11.4	0
25	0	0	0	0	0	9.6	25.2	51	25	99.1	1.3	0
26	0	0	0	0	0	1.2	8.2	8	16.1	0	0	0.5
27	0	0	0	0	0	3	22.2	11.2	0.3	5.1	0	0
28	0	0	0	0	48	5.6	21.4	9.8	26.4	25.2	0.2	0
29	0		0	0	7	37.2	8	12.1	2	20.1	0.4	0
30	0		0	0	7.6	34.8	6.8	15.3	2.1	32.1	0	0
31	0		0		9.4		9.2	12.4		0		0
Total	0	0	0	98.4	116	516.2	1074.8	474.4	641.1	340.4	77.2	65

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2008** **Month: January**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	4.60			26.0	22.0	27.0	N-W	1977.4	
2	0.00	5.00	29.0	17.0	27.0	24.0	28.0	W	2011.7	1.43
3	0.00	4.20	26.0	15.0	25.0	21.0	26.5	N-W	2085.4	3.07
4	0.60	4.00	28.0	17.0	27.0	24.0	27.0	N	2169.8	3.52
5	0.00	5.40	27.0	17.0	28.0	26.0	29.0	N	2201.2	1.31
6	0.00	4.00	24.0	13.0	24.0	20.0	26.0	N	2246.6	1.89
7	0.00	4.60	28.0	16.0	27.5	24.0	28.0	W	2289.5	1.79
8	0.00	4.60	23.0	11.0	24.0	21.0	25.0	W	2331.7	1.76
9	0.00	4.60	25.0	14.0	25.0	24.0	26.0	N-W	2352.1	0.85
10	0.00	4.80	29.0	15.0	26.0	22.5	28.0	W	2391.4	1.64
11	0.00	5.00	28.0	16.0	26.5	25.0	27.5	N-W	2410.3	0.79
12	0.00	4.00	22.0	12.0	22.0	19.0	24.0	N-W	2444.7	1.43
13	0.00	4.00	24.0	13.0	23.0	20.0	25.0	N-W	2463.8	0.80
14	0.00	4.60	26.0	15.0	26.0	22.0	26.0	N-W	2500.1	1.51
15	0.00	4.80	29.0	16.0	27.0	24.0	28.0	N-W	2521.2	0.88
16	0.00	4.40	27.0	17.0	27.0	25.0	27.0	W	2546.1	1.04
17	0.00	4.60	28.5	16.0	28.0	26.0	28.5	N-W	2587.6	1.73
18	0.00	4.80	29.0	17.0	28.0	26.5	29.0	N	2602	0.60
19	0.00	4.60	26.5	15.0	28.0	23.0	27.0	N	2623.5	0.90
20	0.00	4.60	27.0	17.5	28.0	24.0	27.5	N	2658.4	1.45
21	0.00	4.00	25.0	14.0	24.0	21.0	26.0	N	2671.3	0.54
22	0.00	4.60	27.0	16.0	26.5	22.0	27.0	N	2711.1	1.66
23	0.00	5.00	30.0	17.0	29.0	26.0	29.0	W	2735.9	1.03
24	0.00	4.60	29.0	16.0	26.5	25.0	28.5	N-W	2726.3	-0.40
25	0.00	4.60	29.0	15.0	25.5	24.0	27.0	N-W	2800	3.07
26	0.00	4.60	29.0	18.0	27.5	25.0	29.0	N	2819.8	0.83
27	0.00	4.00	28.0	16.0	25.0	22.0	27.0	W	2843.2	0.97
28	0.00	4.60	29.0	15.0	24.5	23.5	28.0	W	2865.7	0.94
29	0.00	4.40	29.0	17.0	24.5	22.0	26.0	W	2865.8	0.00
30	13.60	9.60	28.0	18.0	29.5	25.0	29.0	W	2865.9	0.00
31	0.00	4.00	28.0	19.0	27.0	21.5	28.5	S	2865.8	0.00
Total	14.2	145.20								
Mean		9.08	27.2	15.7	26.2	23.2	27.3			1.23

CLIMATOLOGICAL DATA

Name of station: Thankamani | **Year 2008** | **Month: February**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	4.60	29.0	18.0	27.5	25.0	29.0	N	2865.9	0.004
2	0.20	4.40	28.0	18.0	24.5	22.0	28.0	N	2865.9	0.000
3	0.00	4.50	30.0	16.0	25.0	20.0	27.0	S	2866	0.004
4	0.60	4.60	28.0	24.5	16.5	16.5	25.5	N-W	2867.1	0.046
5	0.00	4.40	26.0	17.0	26.0	18.0	28.0	N-W	2874.3	0.300
6	0.00	4.80	27.0	16.0	29.0	20.5	29.5	N	2889.5	0.633
7	0.00	4.60	29.0	17.0	26.0	21.0	27.5	N	2895.9	0.267
8	1.90	4.30	26.0	15.0	27.0	23.0	27.5	N-W	2901.9	0.250
9	9.40	5.40	29.0	18.0	20.0	19.0	22.0	N	2911.1	0.383
10	36.20	0.00	28.0	19.0	26.5	23.0	28.0	N	2911.1	0.000
11	0.80	4.00	27.0	17.0	27.0	21.0	28.5	E-N	2912.1	0.042
12	2.00	3.20	29.0	19.0	26.5	20.5	28.0	W	2924.4	0.513
13	0.00	4.00	28.0	18.0	25.5	21.0	27.0	N	2936.9	0.521
14	0.00	4.60	23.0	17.0	23.0	20.0	25.0	N-W	2946.9	0.417
15	0.00	4.60	28.0	17.0	18.5	17.0	20.5	N-W	2973.9	1.125
16	0.00	4.00	27.0	18.0	23.5	20.0	25.0	W	3027.5	2.233
17	0.00	4.60	28.0	18.0	25.5	20.5	27.0	W	3062.7	1.467
18	0.00	4.60	28.0	17.0	28.0	18.5	29.0	W	3091.6	1.204
19	0.00	4.60	22.0	20.0	24.0	19.0	29.0	W	3100.1	0.354
20	0.00	4.00	31.0	12.0	25.5	19.5	30.0	W	3104.2	0.171
21	0.00	4.60	30.0	13.0	24.5	19.0	26.0	W	3110.8	0.275
22	0.00	4.00	29.0	15.0	29.5	20.5	30.0	N	3125.2	0.600
23	2.60	4.00	30.0	15.0	29.0	20.5	29.5	N-W	3132.2	0.292
24	0.00	4.00	29.0	12.0	15.0	14.0	16.5	W	3134.5	0.096
25	0.00	4.60	28.0	12.0	25.0	21.0	30.0	W	3144.6	0.421
26	0.00	4.00	30.0	13.0	30.5	18.5	31.0	W	3154.8	0.425
27	0.00	4.60	30.0	13.0	22.0	21.5	28.5	N	3166.60	0.492
28	2.00	4.20	29.0	14.0	15.0	15.0	19.0	N	3187.30	0.863
29	0.00	4.60	28.0	16.0	29.5	19.5	30.0	N-W	3243.20	2.329
Total	55.70	120.00								
Mean			28.1	16.4	24.7	19.8	26.9			0.542

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2008** **Month: March**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.20	4.80	29.0	18.0	24.5	20.0	26.0	N	3264.1	0.87
2	3.20	7.20	28.0	19.0	21.5	20.0	23.0	N-W	3291.3	1.133
3	0.00	4.00	27.0	25.0	25.0	19.5	32.0	W	3311.2	0.829
4	0.00	4.60	30.0	19.0	28.0	23.0	29.0	N	3318.7	0.313
5	0.20	4.20	30.0	19.0	25.0	20.0	24.5	W	3320.9	0.092
6	0.20	4.20	29.0	12.0	22.0	18.5	20.0	W	3334.9	0.583
7	0.00	4.60	29.0	18.0	27.0	17.0	29.0	N-W	3340.6	0.237
8	0.00	4.60	29.0	14.0	24.0	18.0	26.0	W	3413	3.017
9	0.00	4.60	29.0	16.0	16.0	14.5	20.0	N-W	3477.2	2.675
10	0.20	4.20	28.0	18.0	20.0	15.5	22.0	N	3518.6	1.725
11	0.00	4.80	29.0	16.0	20.5	15.0	22.5	N-W	3525.9	0.304
12	0.00	4.60	29.0	17.0	29.5	17.5	30.0	N-W	3584.7	2.450
13	1.80	6.40	29.0	17.0	29.0	22.5	30.5	W	3604.2	0.813
14	8.00	A	25.0	25.0	24.0	22.5	30.0	N-W	3604.5	0.013
15	30.60	A	24.0	23.0	24.0	24.0	30.0	W	3610	0.229
16	4.80	A	23.0	19.0	23.5	23.0	25.0	W	3617.1	0.296
17	16.20	4.20	20.0	18.0	22.0	21.0	22.0	W	3652.1	1.458
18	3.60	A	23.0	20.0	21.0	20.0	22.0	N-W	3671.3	0.800
19	3.40	A	20.0	19.0	21.5	20.0	25.0	N	3696	1.029
20	15.20	A	24.0	19.0	24.5	21.5	26.0	W-S	3702	0.250
21	25.60	A	23.0	17.0	22.0	20.0	23.0	N	3734.7	1.362
22	3.20	A	20.0	18.0	24.0	22.5	20.0	N	3761.8	1.129
23	3.00	A	25.0	20.0	29.0	23.0	25.0	N-W	3761.9	0.004
24	8.40	A	29.0	18.0	27.5	24.0	29.0	N	3762.3	0.017
25	0.00	A	29.0	17.0	29.5	22.5	29.0	W	3762.8	0.021
26	0.00	6.20	30.0	15.0	28.5	24.5	30.5	N	3762.9	0.004
27	0.00	6.00	30.0	18.0	29.0	27.0	30.2	W	3763	0.004
28	0.00	4.80	25.0	20.0	21.0	20.5	22.5	W	3763.2	0.008
29	16.90	1.10	27.0	25.0	25.0	24.0	29.0	W	3763.8	0.025
30	10.60	0.60	29.0	19.0	30.0	24.0	30.5	N-W	3764.2	0.017
31	23.00	3.00	30.0	18.0	20.0	19.5	22.0	N-W	3764.4	0.008
Total	178.30	88.70								
Mean		4.44	26.8	18.6	24.5	20.8	26.0			0.70

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2008** **Month: April**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.20		29.0	18.0	28.5	23.5	29.0	N-W	3764.5	0.004
2	3.60	1.60	29.0	20.0	29.0	24.5	30.0	N-W	3764.5	0
3	22.20	8.20	29.0	19.0	30.5	21.5	31.0	N	3767.9	0.142
4	0.00	4.00	30.0	17.0	32.0	22.0	32.0	N	3772.9	0.208
5	1.00		30.0	19.0	32.0	24.5	30.5	S	3778.3	0.225
6	0.00	4.80	30.0	19.0	32.5	24.0	32.5	N	3792.2	0.579
7	0.00	4.80	29.0	17.0	25.5	20.0	37.0	N	3798.5	0.263
8	0.00	4.80	28.0	18.0	28.5	23.5	26.5	N-W	3812.6	0.587
9	0.00	4.80	29.0	17.0	21.0	19.5	22.0	W	3825.7	0.546
10	2.00	4.00	29.0	20.0	30.0	21.5	31.0	N-W	3833.3	0.317
11	5.00	4.00	28.0	22.0	36.0	22.0	27.0	N-W	3840.1	0.283
12	0.00	4.80	29.0	24.0	35.5	22.0	30.0	N-W	3842.2	0.087
13	2.20	0.20	29.0	20.0	30.0	25.0	30.0	N	3842.2	0
14	2.00	0.00	30.0	22.0	28.5	22.5	28.0	N-W	3842.2	0
15	0.00	4.80	28.0	22.0	28.0	23.0	27.0	N-W	3842.6	0.017
16	0.00	6.00	24.0	22.0	29.0	23.0	29.0	W	3842.6	0
17	0.00	4.80	24.0	22.0	30.0	22.0	27.0	W	3842.6	0
18	0.00	4.80	26.0	25.0	26.0	23.5	28.0	W	3842.6	0
19	0.00	6.20	25.0	21.0	27.0	24..5	29.0	N-W	3842.7	0.004
20	0.00	4.80	24.0	23.0	30.5	23.0	30.0	N-W	3842.7	0
21	0.00	4.80	26.0	21.0	28.5	23.5	30.0	N-W	3842.7	0
22	0.00	4.00	24.0	23.0	25.0	24.0	27.0	N	3842.7	0
23	0.00	4.80	24.0	23.0	32.0	22.0	30.0	W	3842.8	0.004
24	0.00	4.00	22.0	21.0	29.0	20.0	30.0	W	3842.8	0
25	0.00	4.00	26.0	23.0	26.5	24.5	29.0	W	3842.8	0
26	35.00		23.0	22.0	23.0	22.0	29.0	N	3843.1	0.012
27	0.00	1.80	23.0	22.0	26.0	25.0	29.0	N	3843.1	0
28	1.80		27.0	18.0	20.0	18.0	21.0	N	3843.1	0
29	0.00	4.00	23.0	22.0	23.0	22.0	28.0	N	3843.1	0
30										
Total	75.00	104.80								
Mean		4.19	26.8	20.8	28.4	22.6	28.9			0.11

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2008** **Month: May**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	4.00	32.0	18.0	22.0	21.0	23.5	W	3843.3	0.000
2	0.00	4.80	30.0	14.0	20.5	17.5	22.0	W	3843.3	0
3	0.00	4.00	29.0	17.0	23.5	21.5	24.0	W	3843.4	0.004
4	0.00	4.80	29.0	20.0	28.5	25.0	29.0	E	3843.5	0.004
5	0.00	4.00	27.0	17.0	21.0	18.0	25.0	W	3843.5	0
6	0.00	4.00	30.0	19.0	21.5	21.0	23.5	N	3843.6	0.004
7	0.20	4.20	29.0	19.0	21.5	20.5	23.5	W	3843.7	0.004
8	1.00	4.00	30.0	19.0	21.0	20.5	22.5	W	3843.9	0.008
9	0.00	4.00	29.0	19.0	23.0	22.0	23.0	S	3844	0.004
10	0.20	5.00	29.0	19.0	24.0	22.5	27.0	N	3844.1	0.004
11	0.00	2.00	29.0	18.0	28.0	24.0	29.5	W	3844.1	0
12	0.00	4.00	29.0	19.0	24.0	22.0	23.0	W	3844.2	0.004
13	25.20	3.20	31.0	18.0	20.0	20.0	22.0	W	3845.1	0.038
14	0.00	4.00	28.0	18.0	22.5	21.5	24.0	N-W	3845.1	0
15	0.00	4.80	29.0	18.0	20.0	20.0	22.0	W	3845.2	0.004
16	0.00	2.00	24.0	23.0	23.0	22.0	26.0	N	3845.3	0.004
17	0.20	4.60	26.0	24.0	24.0	21.0	25.0	W	3845.4	0.004
18	0.00	5.20	29.0	18.0	24.5	24.0	29.5	W	3845.5	0.004
19	0.00	4.00	28.0	18.0	24.0	22.0	28.0	W	3845.6	0.004
20	0.00	4.80	30.0	19.0	26.0	24.5	27.0	W	3845.7	0.004
21	0.00	4.20	25.0	24.0	28.0	23.0	29.0	N-W	3845.8	0.004
22	1.00	5.80	25.0	25.0	27.0	24.0	32.0	N-W	3845.9	0.004
23	2.00	4.00	22.0	21.0	23.0	22.0	23.0	N-W	3846.1	0.008
24	0.00	4.00	27.0	26.0	27.0	23.0	30.0	N-W	3846.2	0.004
25	1.60	5.60	31.0	17.0	29.5	29.0	31.5	N	3846.3	0.004
26	0.20	4.20	29.0	18.0	28.0	26.0	28.0	N	3846.4	0.004
27	0.00	4.20	23.0	22.0	24.0	22.0	29.0	N-W	3846.4	0
28	0.00	4.50	25.0	23.0	27.0	23.0	29.0	N	3846.5	0.004
29	1.80	6.20	24.0	23.0	25.0	23.0	29.0	W	3846.5	0
30	2.90	4.90	24.0	22.0	25.0	23.0	A	W	3846.6	0.004
31										
Total	36.30	129.00								
Mean		4.30	27.7	19.8	24.2	22.3	26.2			0.005

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2008** **Month: June**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	2.20	25.0	24.0	27.0	25.0	30.0	W	3846.6	0.000
2	0.00	1.80	25.0	24.0	25.0	23.0	29.0	W	3846.7	0.004
3	0.00	2.00	25.0	24.0	27.0	25.0	29.0	N-W	3846.7	0.000
4	0.00	4.80	24.0	23.0	25.0	23.0	30.0	W	3846.9	0.008
5	14.00	4.50	28.0	27.0	27.0	25.0	30.0	W	3847.5	0.025
6	3.70	3.70	26.0	27.0	28.0	25.0	30.0	W	3847.9	0.017
7	18.20	2.20	29.0	18.0	21.0	21.0	22.5	N-W	3847.7	-0.008
8	19.20	2.60	27.0	26.0	26.0	23.0	28.0	W-S	3847.8	0.004
9	0.00	2.00	28.0	24.0	23.0	21.0	27.0	N	3847.9	0.004
10	18.60	2.80	23.0	22.0	24.5	23.0	26.0	N	3848.1	0.008
11	8.20	1.40	22.0	20.0	25.0	24.0	28.5	N-W	3848.1	0.000
12	2.20	A	25.0	23.0	23.5	22.0	26.0	N	3848.2	0.004
13	9.60	4.00	20.0	22.0	24.5	24.0	26.5	N	3848.3	0.004
14	0.00	1.00	22.0	21.0	24.0	23.0	27.0	N-W	3848.4	0.004
15	32.00	3.20	26.0	22.0	21.5	21.0	23.5	N-W	3848.4	0.000
16	0.00	1.20	25.0	23.0	22.0	21.0	24.0	W	3848.5	0.004
17	58.00	Over flow	28.0	21.0	25.0	23.5	26.5	N-W	3848.6	0.004
18	12.00	4.00	21.0	20.0	23.0	22.0	22.0	N-W	3848.7	0.004
19	10.00	4.00	22.0	19.0	23.0	22.0	26.0	W	3848.8	0.004
20	0.00	0.00	25.0	24.0	25.0	23.0	29.0	N-W	3848.8	0.000
21	15.80	3.60	28.0	22.0	23.5	22.0	25.0	N-W	3848.8	0.000
22	10.20	3.60	28.0	22.0	28.0	24.5	28.5	N-W	3848.8	0.000
23	5.70	A	28.0	23.0	24.0	23.0	29.0	N-W	3848.8	0.000
24	33.00	21.00	24.0	23.0	25.0	22.0	28.0	W	3848.8	0.000
25	11.20	0.10	23.0	21.0	23.0	22.0	26.0	W	3848.8	0.000
26	8.80	3.00	28.0	23.0	21.0	20.5	24.0	N-W	3848.8	0.000
27	17.00	7.00	27.0	21.0	21.0	20.5	22.0	W	3849	0.008
28	21.00	6.20	28.0	29.0	22.0	21.0	23.0	N-W	3849.2	0.008
29	18.00	8.00	24.0	24.0	25.0	26.0	28.0	N-W	3849.2	0.000
30	41.00	Over flow	25.0	22.0	20.1	20.1	23.0	N-W	3849.2	0.000
31										
Total	387.40	99.90								
Mean		3.84	25.3	22.8	24.1	22.7	26.6			0.004

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month: July**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	16.20	NA	23.0	21.0	23.0	22.0	26.0	N-W	3849.2	0.000
2	0.00	2.20	27.0	22.0	24.0	23.0	25.0	N-W	3849.2	0.000
3	4.80	4.80	29.0	21.0	24.0	22.5	26.0	N-W	3849.2	0.000
4	0.00	4.00	28.0	22.0	24.5	22.5	26.0	N-W	3849.2	0.000
5	0.00	4.20	25.0	23.0	23.0	23.0	26.0	W	3849.3	0.004
6	19.50	5.50	25.0	22.0	23.0	21.0	25.0	N-W	3849.3	0.000
7	19.50	5.50	20.0	19.0	22.0	22.0	24.0	N	3849.3	0.000
8	4.00	4.80	26.0	25.0	25.0	23.0	28.0	W	3849.3	0.000
9	5.80	NA	21.0	20.0	21.0	21.0	20.0	W	3849.4	0.004
10	14.20	0.00	23.0	21.0	22.0	21.0	22.0	W	3849.4	0.000
11	7.90	7.00	23.0	21.0	23.0	22.0	27.0	N-W	3849.4	0.000
12	17.00	NA	24.0	23.0	24.0	22.0	28.0	W	3849.4	0.000
13	4.30	2.00	24.0	22.0	24.0	23.0	29.0	W	3849.4	0.000
14	0.00	4.80	24.0	23.0	25.0	22.0	26.0	W	3849.4	0.000
15	0.00	2.20	28.0	17.0	26.5	26.0	29.0	N	3849.4	0.000
16	4.20	0.00	29.0	22.0	24.0	22.5	26.0	N	3849.4	0.000
17	1.40	1.40	25.0	22.0	26.0	23.5	29.0	N-W	3849.4	0.000
18	8.20	4.20	28.0	21.0	24.0	23.0	25.0	W	3849.4	0.000
19	61.80	Overflow	26.0	21.0	21.0	20.5	23.0	W	3849.4	0.000
20	2.20	2.00	23.0	20.0	25.5	23.5	27.0	N-W	3849.4	0.000
21	0.00	4.80	26.0	21.0	23.5	22.0	25.0	N	3849.4	0.000
22	4.80	4.00	25.0	23.0	24.0	22.0	28.0	W	3849.4	0.000
23	8.20	3.40	26.0	24.0	25.0	23.5	27.0	W	3849.4	0.000
24	24.80	8.00	25.0	23.0	24.0	22.0	24.0	N-W	3849.4	0.000
25	20.00	6.00	21.0	20.5	20.0	19.5	23.0	N-W	3849.4	0.000
26	36.00	21.20	21.0	23.0	20.5	20.0	22.0	N	3849.4	0.000
27	41.00	Overflow	22.0	20.5	19.5	19.5	21.0	W	3849.4	0.000
28	69.00	Overflow	21.0	21.0	23.5	21.5	21.5	N-W	3849.5	0.004
29	58.00	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	63.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
31	74.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	590.80	102.00								
Mean			24.6	21.6	23.4	22.1	25.3			0.000

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month: August**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	18.00	NA	22.0	21.0	20.5	21.0	22.0	W	3849.5	0.004
2	33.00	NA	23.0	22.0	20.5	20.0	22.0	N	3849.5	0.000
3	2.40	NA	19.0	21.0	24.5	23.0	25.5	W	3849.5	0.000
4	34.00	NA	21.0	22.0	24.5	24.0	26.0	W	3849.5	0.000
5	9.80	NA	22.0	21.0	25.0	23.0	26.0	N-W	3849.5	0.000
6	3.60	NA	26.0	21.0	25.0	24.0	27.0	N-W	3849.5	0.000
7	0.00	NA	26.0	21.0	24.0	22.5	25.0	W	3849.5	0.000
8	15.00	NA	25.0	21.0	20.5	21.0	23.0	N	3849.5	0.000
9	0.00	NA	24.0	22.0	20.0	21.0	23.0	N	3849.5	0.000
10	42.40	NA	22.0	21.0	20.0	20.0	22.0	W	3849.5	0.000
11	56.00	NA	21.0	20.0	23.0	22.0	24.0	N-W	3849.5	0.000
12	78.00	NA	23.0	21.0	21.5	21.0	24.0	N-W	3849.5	0.000
13	29.00	NA	21.0	22.0	22.0	21.5	24.0	N-W	3849.5	0.000
14	23.20	NA	24.0	21.0	24.0	22.5	25.5	N	3849.5	0.000
15	40.00	NA	22.0	21.0	23.5	22.0	24.0	N	3849.5	0.000
16	0.00	NA	25.0	20.0	24.0	25.0	28.0	N	3849.5	0.000
17	2.00	NA	25.0	23.0	24.5	23.0	26.5	N-W	3849.5	0.000
18	1.20	NA	25.0	25.0	26.0	25.0	27.0	W	3849.5	0.000
19	3.20	NA	24.0	23.0	26.0	25.5	27.0	W	3849.5	0.000
20	1.20	NA	22.0	21.0	23.0	22.0	24.0	N-W	3849.5	0.000
21	15.20	NA	25.0	23.0	26.0	25.0	27.0	N-W	3849.5	0.000
22	4.00	4.00	28.0	21.0	29.5	28.5	30.0	W	3849.5	0.000
23	4.50	NA	25.0	25.0	23.0	22.0	27.0	N-W	3849.5	0.000
24	1.20	3.00	25.0	25.0	22.0	25.0	27.0	N-W	3849.5	0.000
25	7.20	5.00	27.0	21.0	28.0	25.0	28.5	N-W	3849.5	0.000
26	17.80	3.60	29.0	23.0	32.5	28.0	34.0	E-S	3849.5	0.000
27	27.60	10.60	34.0	23.0	39.5	33.5	42.0	W	3849.5	0.000
28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	68.00	Overflow	36.0	22.0	41.5	33.5	33.0	N	3849.50	0.00
30	68.00	Overflow	35.0	22.0	29.5	25.5	30.0	N	3849.5	0.000
31										
Total	605.50									
Mean		5.55	25.0	21.9	25.3	24.0	26.7			0.000

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month: September**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	1.00	1.00	24.0	20.0	28.0	26.0	28.0	N-W	3849.5	0
2	24.20	6.00	28.0	22.0	29.0	25.5	30.0	W	3849.5	0
3	0.00	4.00	29.0	22.0	29.0	25.5	30.0	S	3849.5	0
4	0.00	4.80	30.0	21.0	30.5	26.5	31.5	N	3849.5	0
5	1.27	0.00	21.0	21.0	22.0	21.0	20.3	N-W	3849.5	0
6	66.00	1.20	22.0	21.0	21.0	20.0	24.0	N-W	3849.5	0
7	4.50	0.00	27.0	25.0	27.0	25.0	20.8	N-W	3849.5	0
8	4.00	0.00	29.0	26.0	23.0	26.0	24.0	N	3849.5	0
9	0.00	4.00	26.0	21.0	28.0	26.0	28.0	W	3849.5	0
10	0.00	4.00	27.0	23.0	27.0	25.0	27.0	N-W	3849.5	0
11	0.00	4.80	28.0	25.0	25.0	23.0	26.5	N-W	3849.5	0
12	0.00	4.80	29.0	24.0	29.0	25.0	23.0	W	3849.5	0
13	0.00	4.80	29.0	22.0	28.0	26.0	26.0	N-W	3849.5	0
14	0.00	4.00	30.0	24.0	30.0	27.0	24.0	W	3849.5	0
15	0.00	6.00	34.0	23.0	32.5	28.0	36.0	N-W	3849.5	0
16	0.00	4.00	36.0	21.0	23.5	22.0	24.5	W	3849.5	0
17	0.00	4.80	27.0	22.0	27.0	24.5	28.5	W	3849.5	0
18	0.00	4.80	27.0	23.0	33.0	30.0	31.0	W	3849.5	0
19	0.00	4.80	29.0	23.0	31.5	27.0	40.0	W	3849.5	0
20	109.80	4.80	30.0	22.0	26.0	24.0	28.0	W	3849.5	0
21	4.50		27.0	23.0	26.0	25.0	33.0	N-W	3849.6	0.004
22	2.60		29.0	24.0	28.0	25.0	30.0	N	3849.6	0.004
23	0.00	5.20	30.0	28.0	27.5	28.0	39.0	N-W	3849.6	0.004
24	0.00	4.80	29.0	22.0	28.5	27.0	30.0	S-W	3849.6	0.004
25	0.00	4.80	29.0	22.0	27.5	25.0	29.0	N	3849.6	0.004
26	0.00	4.00	29.0	24.0	27.5	25.0	30.0	N	3849.6	0.004
27	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
28	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
29	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
30	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
31										
Total	217.87									
Mean		3.81	28.3	22.9	27.5	25.3	28.5			0.001

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month:October**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	4.80	30.0	26.0	30.0	28.0	28.0	N-W	3849.6	0.000
2	0.00	4.80	28.0	25.0	30.0	26.0	30.0	N	3849.6	0.000
3	0.00	5.20	30.0	28.0	30.0	28.0	30.0	N-W	3849.6	0.000
4	0.00	5.00	30.0	28.0	30.5	30.0	31.0	N-W	3849.6	0.000
5	1.80	5.80	30.0	27.5	30.5	28.0	31.0	N	3849.7	0.004
6	0.00	4.80	30.0	26.0	30.0	26.0	28.0	W	3849.7	0.004
7	0.00	4.80	30.5	28.0	30.0	27.0	28.0	N-W	3849.7	0.004
8	4.60	0.00	30.5	27.5	30.5	28.0	30.0	W	3849.8	0.008
9	0.00	4.80	28.0	26.0	30.5	26.0	31.0	W	3849.8	0.008
10	0.00	4.00	30.0	28.0	28.0	28.5	32.0	N-W	3849.8	0.008
11	0.00	5.20	30.0	27.0	30.0	28.0	30.0	W	3849.8	0.008
12	40.00	0.00	30.0	26.5	28.0	25.0	28.0	N-W	3849.9	0.013
13	46.00	0.00	28.0	26.0	28.5	25.0	28.5	N-W	3849.9	0.013
14	28.00	0.00	30.5	28.0	26.0	24.0	28.0	N-W	3849.9	0.013
15	8.00	0.00	28.0	22.0	22.0	22.0	24.0	N-W	3849.9	0.013
16	26.00	0.00	26.0	21.0	26.5	24.0	28.0	W	3850	0.017
17	2.00	0.00	28.0	26.0	30.0	28.0	28.0	N	3850.1	0.021
18	1.00	4.00	27.0	21.0	27.0	24.0	28.5	N	3850.2	0.025
19	3.00	0.00	28.0	26.0	28.0	26.0	31.0	N	3850.2	0.025
20	64.00	0.00	28.0	21.0	27.0	25.5	28.0	W	3850.2	0.025
21	35.20	0.00	28.0	21.0	21.0	20.5	22.5	N	3850.2	0.025
22	4.80	6.80	27.0	21.0	26.0	23.5	27.0	N-W	3850.2	0.025
23	32.00	0.00	24.0	23.5	25.0	23.0	25.0	N-W	3850.2	0.025
24	0.00	0.00	26.0	23.0	24.0	22.0	24.0	W	3850.2	0.025
25	2.60	0.00	25.0	22.0	22.0	21.5	23.5	N	3850.2	0.025
26	24.50	0.00	20.0	20.0	20.0	20.0	20.0	N	3850.2	0.025
27	0.20	5.00	28.0	23.0	28.0	24.5	29.0	N	3850.2	0.025
28	8.20	4.20	30.0	22.0	27.5	25.0	29.0	N	3850.2	0.025
29		0.00	28.0	22.0	26.5	24.0	28.0	W	3850.2	0.025
30		0.00								
31	0	6	29.0	22.0	30.0	25.5	31.0	N	3850.2	
Total	331.90									
Mean		2.43	28.2	24.5	27.4	25.2	28.0			0.015

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month:November**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	5.20	30.0	17.8	29.5	25.5	30.0	N	3850.2	0.000
2	0.00	4.80	29.0	28.5	28.0	26.5	28.0	N-W	3850.2	0.000
3	0.00	4.80	28.5	26.0	29.0	27.0	30.0	N	3850.2	0.000
4	0.00	4.80	28.0	26.0	29.5	28.0	28.5	W	3850.2	0.000
5	0.00	4.80	26.0	24.0	28.0	26.5	28.0	N-W	3850.2	0.000
6	0.00	4.60	29.5	28.0	28.0	26.5	28.0	W	3850.2	0.000
7	0.00	4.80	28.0	21.0	26.0	25.5	30.0	W	3850.2	0.000
8	1.80	4.20	29.0	16.0	22.5	21.0	23.5	W	3850.2	0.000
9	0.00	4.80	28.5	26.0	26.0	25.0	26.0	N-W	3850.2	0.000
10	0.00	4.60	29.0	26.5	28.0	26.5	28.0	N-W	3850.2	0.000
11	0.00	5.00	28.0	26.0	26.5	26.0	26.0	N-W	3850.2	0.000
12	0.00	4.60	29.0	28.0	26.5	25.0	28.0	N-W	3850.2	0.000
13	29.20	8.00	29.5	26.0	23.0	20.5	26.0	W	3850.3	0.046
14	2.80	0.00	30.0	24.0	29.0	25.0	30.0	N	3850.3	0.000
15	0.00	4.60	29.0	17.0	28.5	24.5	30.0	E-N	3850.3	0.000
16	29.20	8.00	25.0	25.0	25.0	24.5	25.0	E-W	3850.3	0.000
17	0.00	4.60	28.5	26.0	24.0	23.0	24.5	N-W	3850.3	0.000
18	0.00	4.00	29.0	26.0	22.5	21.0	24.0	W	3850.3	0.000
19	7.40	1.60	28.0	26.5	23.5	21.0	23.0	W	3850.3	0.000
20	1.20	5.20	29.0	22.0	22.0	20.0	26.5	N-W	3850.4	0.005
21	4.50	0.00	29.0	22.0	27.5	24.0	29.0	W	3850.5	0.005
22	19.20	2.20	26.0	24.5	23.5	21.0	24.0	W	3850.6	0.005
23	0.00	4.80	28.0	26.5	26.5	26.0	23.5	N-W	3851.2	0.025
24	6.20	0.00	28.0	26.0	24.5	22.0	24.0	W	3851.2	0.000
25	3.40	0.00	28.5	26.5	23.5	21.0	24.5	N	3851.2	0.000
26	0.00	4.60	24.5	24.5	24.5	22.5	26.0	N	3851.2	0.000
27	0.00	5.20	29.5	23.0	28.0	24.5	29.5	N	3851.2	0.000
28										
29										
30										
31										
Total	104.90									
Mean		4.07	28.3	24.4	26.0	24.1	26.8			0.003

CLIMATOLOGICAL DATA

Name of station: Thankamany **Year 2008** **Month:December**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	4.40	2.20	29.0	16.0	26.0	22.5	28.0	N-W	3852.5	
2	2.00	0.00	29.0	17.0	27.5	23.5	29.0	N-W	3853	0.021
3	0.00	2.40	29.0	16.0	28.0	23.0	29.0	N	3853.2	0.003
4	0.00	2.00	22.0	16.0	21.0	16.5	18.0	N	3858.7	0.229
5	0.00	2.20	23.5	17.0	22.0	18.0	16.0	N-W	3861.3	0.108
6	0.00	2.40	24.5	16.0	22.5	19.5	18.5	N	3862.2	0.038
7	0.00	2.40	26.0	17.0	22.0	18.5	19.0	W	3863.1	0.038
8	0.00	2.60	26.0	18.0	23.0	20.0	20.0	W	3864.2	0.046
9	0.00	2.80	26.5	18.0	24.0	20.5	17.0	W	3866.8	0.108
10	0.00	4.00	26.5	16.0	24.0	20.5	16.5	N-W	3866.9	0.004
11	0.00	4.00	26.5	16.0	25.0	21.0	16.0	N-W	3867.2	0.013
12	0.00	4.60	27.0	16.0	26.0	22.5	16.5	N	3867.4	0.008
13	0.00	4.00	27.5	14.0	21.0	19.5	17.0	N	3868.9	0.063
14	0.00	2.80	25.0	16.0	20.0	16.5	16.5	N	3869.2	0.013
15	0.00	4.00	24.0	16.0	21.0	18.5	18.0	W	3869.5	0.013
16	0.00	4.60	25.5	17.0	22.0	20.0	18.5	N-W	3872.4	0.021
17	0.00	4.80	26.5	18.0	22.5	19.0	16.5	W	3874.8	0.100
18	0.00	4.40	26.0	18.0	22.5	20.5	17.0	N	3882.6	0.325
19	0.00	4.40	24.0	18.0	22.5	22.0	16.5	N	3884.3	0.070
20	4.40	0.00	29.0	20.0	22.0	21.0	23.0	N-W	3886.1	0.075
21	0.00	2.20	23.0	16.0	18.5	17.0	16.0	N-W	3887.6	0.063
22	0.00	2.40	26.0	12.0	15.5	15.0	12.0	W	3889.8	0.092
23	0.00	2.40	27.0	11.0	18.5	17.5	19.0	N	3895	0.217
24	0.00	4.00	27.5	12.0	24.5	22.0	20.0	W	3912.8	0.742
25	0.00	4.20	24.0	11.0	25.0	21.0	14.5	W	3913.6	0.021
26	2.20	0.40	27.0	11.0	15.0	14.5	11.5	N-W	3913.6	0.013
27	0.00	4.20	26.0	13.0	23.0	21.0	22.5	N	3916.4	0.116
28	0.00	4.20	26.0	11.0	26.0	24.0	22.0	W	3917.9	0.063
29	0.00	2.40	22.0	14.0	18.0	17.0	16.0	W	3919.4	0.063
30	0.00	2.20	22.5	16.0	19.0	17.5	18.5	N	3925	0.233
31	0	4.8	28.0	11.0	25.0	24.0	26.0	W	3926.6	0.066
Total	13.00									
Mean	0.81	3.03	25.9	15.3	22.3	19.8	18.9			0.100

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: January**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	2.60	28.0	11.0	28.5	27.0	28.0	N-W	3941.4	0.617
2	0.00	2.80	28.5	12.5	26.5	24.5	28.5	N-W	3941.4	0.000
3	0.00	3.20	28.0	12.5	28.0	26.0	28.0	N-W	3945.4	0.167
4	0.60	3.20	28.0	11.5	28.5	27.0	28.0	N-W	3947.6	0.092
5	0.00	3.20	28.5	11.0	28.0	27.0	28.5	N-W	3949.7	0.088
6	0.00	2.80	28.0	11.0	28.0	27.0	28.5	N	3950.7	0.042
7	0.00	2.00	28.0	12.0	27.0	22.5	28.5	N-W	3953.2	0.104
8	0.00	2.00	28.0	12.0	26.5	25.5	28.0	N-W	4023.9	2.945
9	0.00	2.80	28.5	11.5	28.5	27.5	28.5	N-W	4023.9	0.000
10	0.00	2.80	28.5	11.5	27.0	26.0	28.5	N-W	4023.9	0.000
11	0.00	2.80	28.0	11.5	26.0	25.5	28.5	W	4023.9	0.000
12	0.00	3.00	28.0	11.0	26.5	25.5	28.0	W	4023.9	0.000
13	0.00	3.00	28.0	12.0	26.5	25.5	28.0	W	4023.9	0.000
14	0.00	3.00	28.0	11.0	26.5	25.5	28.0	N-W	4042.8	0.788
15	0.00	3.00	27.5	12.0	26.0	24.0	27.0	N	4060.8	0.750
16	0.00	2.80	28.0	12.0	26.5	26.0	28.0	N	4075.5	0.613
17	0.00	2.80	28.5	12.5	27.5	26.0	28.0	N	7083.6	0.337
18	0.00	2.80	28.5	12.5	27.5	26.0	27.5	N	7091.7	0.338
19	1.60	0.00	28.0	12.5	28.0	27.0	27.5	N	4103.5	0.492
20	0.00	2.80	28.0	14.0	26.5	26.0	28.0	N	4110.4	0.287
21	0.00	2.00	27.5	13.5	26.5	25.5	27.0	N-W	4110.7	0.013
22	0.00	2.00	27.5	14.0	27.0	26.5	27.0	N-W	4110.8	0.004
23	0.00	2.00	27.0	14.0	26.5	26.0	26.5	N-W	4110.9	0.004
24	0.00	2.80	27.0	14.0	26.5	26.0	26.5	W	4111.2	0.013
25	0.00	2.80	27.0	14.5	26.5	26.0	26.5	W	4111.4	0.008
26	0.00	2.80	27.0	12.0	26.5	26.0	26.0	W	4111.7	0.017
27	10.20	1.40	27.5	14.0	27.5	26.5	27.5	N-W	4112.1	0.017
28	0.00	2.00	28.0	14.5	28.0	27.0	28.0	N-W	4112.5	0.017
29	0.00	2.80	27.0	12.5	28.5	27.0	26.0	N	4112.6	0.004
30	0.00	4.00	28.0	12.0	25.0	22.0	28.0	N	4113	0.017
31	0.00	4.80	28.0	12.0	25.5	22.5	29.0	W	4115	0.083
Total	**12.40**									
Mean		**2.67**	**27.9**	**12.4**	**27.0**	**25.7**	**27.7**			**0.253**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: February**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	6.20	29.0	12.0	27.5	22.5	27.0	W	4117.8	0.116
2	0.00	6.00	29.0	12.0	27.5	27.0	29.0	N	4120.3	0.104
3	0.00	6.00	29.0	12.0	27.0	22.5	29.0	W	4124.8	0.188
4	0.00	6.20	29.0	12.0	30.0	23.5	29.0	N	4130.4	0.233
5	0.00	6.20	29.0	12.0	30.0	22.0	29.0	N	4132.9	0.104
6	0.00	6.20	29.0	12.0	30.0	22.5	29.0	W	4134.4	0.063
7	0.00	6.00	29.0	12.0	29.0	22.5	29.0	W	4140.1	0.238
8	0.00	6.00	29.0	12.0	0.0	0.0	29.0	N	4143.7	0.150
9	0.00	6.00	29.0	12.0	27.5	27.0	29.0	N-W	4145.1	0.058
10	0.00	6.00	29.0	12.0	27.0	21.5	29.0	N	4147.2	0.088
11	0.00	6.20	29.0	12.0	30.0	22.5	29.0	W	4147.2	0.000
12	0.00	6.00	29.5	12.0	29.0	22.0	29.5	W	4147.2	0.000
13	9.40	5.20	31.0	11.0	18.5	18.0	31.0	W	4147.2	0.000
14	0.00	0.00	29.5	12.0	27.5	27.0	29.5	N	4147.3	0.004
15	0.00	6.00	29.0	12.0	28.5	22.5	29.0	N-W	4147.5	0.008
16	0.00	6.20	29.0	12.0	30.0	21.5	29.0	N-W	4152.5	0.208
17	0.00	6.20	29.0	12.0	30.0	22.5	29.0	N	4158.4	0.246
18	0.00	6.20	29.0	11.0	30.0	22.0	29.0	N-W	4162.6	0.175
19	0.00	6.20	29.5	12.0	28.5	22.0	29.5	N	4173.1	0.438
20	0.00	6.00	29.5	12.0	28.5	22.5	29.5	N	4173.1	0.000
21	0.00	6.00	29.5	12.0	29.0	22.5	29.5	N	4179.9	0.324
22	0.00	6.20	29.5	12.0	28.5	22.5	29.5	N	4180.1	0.008
23	0.20	0.08	29.5	12.0	28.0	22.0	29.5	N-W	4189.4	0.388
24	0.20	0.10	29.0	11.0	28.5	27.0	29.0	N-W	4190.1	0.029
25	0.20	0.08	29.0	11.0	28.5	27.5	29.0	N-W	4190.1	0.000
26	0.00	0.00	30.0	12.0	33.5	32.5	30.0	N	4190.9	0.033
27	0.00									
28	0.00									
29										
30										
31										
Total	**10.00**									
Mean	**0.69**	**4.9**	**29.3**	**11.8**	27.4	**22.6**	**29.2**			**0.123**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: March**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	2.20	32.0	13.0	28.5	28.0	30.0	W	4180.3	
2	0.00	4.20	32.0	13.0	26.5	26.0	30.0	N-W	4181.4	0.046
3	0.00	4.80	33.0	12.0	26.5	26.0	28.0	N-W	4190.7	0.388
4	0.00	4.80	33.0	12.0	19.5	19.0	21.0	W	4194.3	0.150
5	0.00	4.80	33.0	12.0	26.0	25.5	28.0	N	4196.4	0.087
6	0.00	5.20	32.0	13.5	26.5	26.0	28.0	N	4196.5	0.004
7	0.00	4.80	32.5	12.5	28.0	27.0	28.0	N	4196.6	0.004
8	0.00	4.00	32.0	13.0	28.0	26.5	30.0	N	4196.8	0.008
9	0.00	4.00	33.0	13.0	28.5	28.0	30.0	N	4198.2	0.058
10	0.00	4.80	33.0	13.5	28.0	26.5	31.0	W	4198.4	0.008
11	0.00	4.80	33.0	13.0	28.5	26.0	30.0	W	4201.2	0.117
12	0.00	4.80	32.5	12.0	26.0	25.5	30.5	W	4203.8	0.108
13	43.00	1.60	33.0	12.5	29.5	29.0	30.0	N	4205.3	0.063
14	0.00	2.60	32.0	12.5	29.5	28.0	30.0	N	4205.4	0.004
15	0.00	2.80	32.0	13.0	28.5	28.0	28.0	W	4205.9	0.021
16	20.00	3.60	32.5	13.5	26.5	26.0	29.0	W	4206.5	0.025
17	26.00	4.80	33.0	13.0	28.5	28.0	31.0	W	4207.3	0.033
18	0.00	7.90	33.0	13.0	26.5	26.0	31.0	N	4208.4	0.046
19	0.00	4.80	32.0	13.0	30.0	28.0	32.5	N	4208.4	0.000
20	0.00	6.00	33.0	13.0	30.5	30.0	30.0	N	4208.4	0.000
21	0.00	6.00	32.0	13.0	22.5	21.5	25.0	W	4208.6	0.008
22	0.00	6.00	32.5	13.5	32.0	31.0	29.0	W	4208.7	0.004
23	0.00	6.00	33.0	13.5	32.0	31.5	30.0	W	4208.8	0.004
24	0.00	6.00	33.0	12.5	32.0	30.5	31.0	N	4209.3	0.021
25	16.20	0.00	32.0	12.5	26.5	24.0	31.0	N	4209.4	0.004
26	0.00	6.00	32.0	12.0	30.0	28.0	31.0	W	4209.5	0.004
27	0.00	6.00	32.0	12.0	30.5	30.0	30.0	W	4209.6	0.004
28	5.00	0.80	32.0	12.0	19.5	19.0	21.0	W	4210	0.017
29	0.00	6.00	32.0	12.0	30.5	30.0	21.0	W	4210.2	0.008
30	0.00	6.00	32.0	13.0	30.0	28.0	21.0	W	4210.7	0.021
31	0.00	6.20	32.0	13.5	30.0	28.5	22.0	W	4212.7	0.083
Total	**110.20**									
Mean		**4.6**	**32.5**	**12.8**	**27.9**	**26.9**	**28.3**			**0.045**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: April**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	6.00	33.0	13.0	26.0	24.5	24.5	W	4193.7	0.079
2	0.00	6.20	32.0	13.0	26.0	24.0	24.0	W	4195.6	0.046
3	0.00	6.20	33.5	13.5	26.5	24.5	24.0	N	4196.7	0.067
4	0.00	6.00	33.0	13.5	26.0	24.0	24.5	N	4198.3	0.054
5	0.00	4.80	33.0	13.5	26.0	24.5	24.0	N-W	4199.6	0.133
6	0.00	4.80	33.5	13.0	26.5	22.0	24.5	N-W	4202.8	0.079
7	0.00	4.80	33.5	13.0	26.0	22.5	24.0	N-W	4204.7	0.004
8	0.00	4.80	33.0	13.5	26.5	24.0	24.5	N	4204.8	0.054
9	33.20	6.80	33.0	13.5	25.5	24.0	25.5	N	4206.1	0.008
10	0.00	4.00	33.0	13.5	26.0	24.0	24.0	W	4206.3	0.063
11	0.00	4.00	33.5	12.0	26.5	24.0	24.5	W	4207.8	0.029
12	0.00	4.80	33.0	12.5	26.0	24.5	24.0	N	4208.5	0.008
13	0.00	4.80	33.0	13.5	24.0	22.0	22.5	N-W	4208.7	0.079
14	0.00	4.80	33.5	13.5	24.5	24.0	24.0	N-W	4210.6	0.012
15	0.00	4.80	33.5	13.0	24.5	24.0	24.0	N-W	4210.9	0.067
16	0.00	5.20	33.0	13.0	24.5	24.0	24.0	W	4212.5	0.008
17	0.00	4.80	33.0	13.0	26.0	24.5	24.0	W	4212.7	0.021
18	30.00	9.00	32.5	13.0	22.5	22.0	21.5	N	4213.2	0.004
19	0.00	4.80	32.5	13.5	23.5	22.0	22.5	N	4213.3	0.004
20	0.00	5.20	32.5	13.0	23.5	22.5	22.0	N-W	4213.4	0.029
21	0.00	4.80	33.0	12.5	23.5	22.5	22.0	N-W	4214.1	0.008
22	0.00	4.80	32.5	12.5	24.5	24.0	24.5	S	4214.3	0.079
23	0.00	4.80	32.5	12.5	24.5	24.0	24.0	N-W	4216.2	0.008
24	0.00	4.00	33.0	13.0	26.5	26.0	21.5	W	4216.4	0.092
25	16.00	4.80	32.0	13.5	24.5	22.5	21.5	W	4218.6	0.004
26	0.00	4.80	32.0	13.5	26.5	22.5	22.0	N	4218.7	0.017
27	0.00	4.80	32.0	13.0	23.5	23.0	24.5	N-W	4219.1	0.063
28	0.00	4.00	32.0	13.0	23.0	22.5	24.5	N-W	4220.6	0.225
29	0.00	4.80	33.5	13.0	22.5	22.0	24.0	N-W	4226	0.033
30	0.00	4.00	31.5	13.0	27.0	26.5	24.0	N-W	4226.8	0.000
Total	**79.20**									
Mean		**5.1**	**32.8**	**13.1**	**25.1**	**23.6**	**23.6**			**0.045**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: May**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00	0.00	32.0	14.0	30.0	28.0	32.0	N	4226.8	0.004
2	0.00	0.00	32.0	14.0	29.0	27.5	29.5	N	4226.9	0.000
3	0.00	0.00	32.0	14.0	29.0	26.5	29.5	W	4226.9	0.000
4	0.00	0.00	32.0	14.0	26.0	25.5	28.5	N	4226.9	0.000
5	0.00	0.00	32.0	14.0	27.0	25.5	28.0	N	4226.9	0.000
6	0.00	0.00	32.0	14.0	23.5	22.5	25.0	N	4226.9	0.004
7	8.80	0.00	32.0	14.0	19.5	19.5	21.0	W	4227	0.000
8	0.00	0.00	32.0	14.0	22.0	21.5	23.5	W	4227	0.000
9	0.00	0.00	32.0	14.0	26.0	25.0	27.0	N	4227	0.004
10	0.00	0.00	32.0	14.0	26.0	25.5	28.5	N	4227.1	0.000
11	0.00	0.00	32.0	14.0	27.0	25.0	29.5	N	4227.1	0.000
12	0.00	0.00	32.0	15.0	30.0	27.0	31.5	N	4227.1	0.000
13	3.60	0.00	32.0	14.0	30.0	20.0	29.5	W	4227.1	0.000
14	0.00	0.00	32.0	15.0	30.0	27.0	32.0	W	4227.1	0.000
15	0.00	0.00	32.0	15.0	27.5	25.5	29.0	N	4227.1	0.000
16	5.20	0.00	32.0	15.0	20.0	20.0	22.5	S	4227.1	0.000
17	0.00	0.00	32.0	15.0	27.0	26.0	28.5	N	4227.1	0.000
18	0.00	0.00	32.0	15.0	27.5	26.0	28.5	N	4227.1	0.000
19	0.00	0.00	32.0	15.0	25.0	25.0	29.0	N	4227.1	0.000
20	18.00	0.00	32.0	15.0	25.0	24.5	28.0	N-W	4227.1	0.000
21	23.00	0.00	32.0	15.0	26.0	22.0	26.5	N	4227.1	0.000
22	0.00	0.00	32.0	15.0	26.5	24.5	27.5	N-W	4227.1	0.000
23	1.40	0.00	32.0	15.0	28.0	25.0	27.5	N-W	4227.1	0.000
24	0.80	0.00	32.0	16.0	27.0	24.0	27.5	N	4227.1	0.000
25	19.60	0.00	32.0	16.0	24.0	20.0	25.5	N	4227.1	0.000
26	0.00	0.00	32.0	15.0	27.0	24.0	26.0	N	4227.1	0.000
27	0.00	0.00	32.0	15.0	27.5	25.0	27.0	N	4227.1	0.000
28	0.00	0.00	32.0	16.0	27.0	25.5	28.0	N	4227.1	0.000
29	0.00	0.00	32.0	17.0	27.0	25.0	28.0	W	4227.1	0.000
30	3.40	0.00	32.0	17.0	26.0	24.0	27.0	N	4227.1	0.000
31	6.00	0.00	32.0	17.0	27.5	25.5	29.0	N-W	4227.1	
Total	**89.80**									
Mean			**32.0**	**14.9**	**26.5**	**24.4**	**27.7**			**0.000**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: June**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemo meter Reding	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	0.00		32.0	17.0	26.0	24.0	27.0	N-W	4227.2	0.000
2	0.00		32.0	17.0	28.5	25.5	30.0	N	4227.2	0.000
3	0.00		32.0	17.0	28.0	25.0	29.5	N	4227.2	0.000
4	0.80		32.0	17.0	26.0	23.5	27.5	N	4227.2	0.000
5	0.40		32.0	16.5	26.0	25.5	22.0	N	4227.2	0.000
6	46.00		32.0	17.0	22.0	21.0	18.0	N-W	4227.2	0.000
7	54.00		32.0	17.0	22.0	20.5	18.0	N-W	4227.2	0.000
8	46.00		32.0	17.0	24.0	22.0	19.0	N	4227.2	0.000
9	26.00		32.0	17.0	26.0	23.5	21.0	N	4227.2	0.000
10	6.00		32.0	17.0	26.5	23.5	28.0	N	4227.2	0.000
11	0.00		26.0	23.0	24.5	23.5	28.0	N	4227.2	0.000
12	0.00		33.0	20.0	27.5	24.5	28.0	N	4227.2	0.000
13	7.40		33.0	19.5	23.5	22.5	24.5	N-W	4227.2	0.000
14	0.40		26.0	20.0	25.0	23.0	26.0	N-W	4227.2	0.000
15	0.40		33.0	22.5	26.5	23.5	27.0	N	4227.2	0.000
16	10.50		32.0	21.0	27.5	24.0	27.0	N-W	4227.2	0.000
17	4.80		32.5	20.5	24.5	23.5	26.0	N-W	4227.2	0.000
18	11.00		24.0	19.0	24.0	23.0	26.0	N-W	4227.2	0.000
19	3.80		34.5	20.0	27.0	24.0	27.0	N	4227.2	0.000
20	3.50		25.0	20.5	23.0	22.0	24.0	N-W	4227.2	0.000
21	2.80		24.0	19.0	26.0	23.0	26.0	N-W	4227.2	0.000
22	3.40		25.0	20.5	26.0	23.0	27.0	N-W	4227.2	0.000
23	14.20		25.5	21.0	22.5	22.0	24.0	N-W	4227.2	0.000
24	11.00		24.5	20.5	25.0	23.0	26.0	N	4227.2	0.000
25	8.60		25.0	21.0	23.0	22.0	25.0	N-W	4227.2	0.000
26	60.00		23.5	18.5	19.5	19.0	21.0	N	4227.2	0.000
27	3.20		25.0	20.5	26.0	23.0	27.0	N-W	4227.2	0.000
28	2.00		26.0	20.5	26.0	23.0	27.0	N-W	4227.2	0.000
29	19.20		26.0	20.0	26.0	23.0	26.0	N-W	4227.2	0.000
30	32.40		25.5	19.0	23.5	22.5	25.0	N	4227.2	0.000
Total	**377.80**									
Mean			**29.0**	**19.2**	**25.1**	**23.0**	**25.3**			**0.000**

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year : 2009** **Month: July**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	25.00		21.0	19.0	21.0	20.5	22.5	N-W		
2	45.60		22.0	20.0	21.0	20.0	23.0	N		
3	46.90		25.0	18.5	21.5	21.0	23.0	N		
4	37.00		22.5	19.0	21.5	21.0	23.0	N-W		
5	34.80		21.0	19.0	22.0	21.5	23.5	N		
6	0.00		22.0	19.0	22.0	21.0		N		
7	19.40		24.0	19.0	26.0	24.0	24.0	N-W		
8	16.30		21.0	19.0	21.5	21.0	24.0	N-W		
9	33.20		23.0	19.0	22.0	21.5	24.0	N-W		
10	11.40		22.5	19.0	23.5	22.0	26.0	N		
11	12.20		23.5	19.0	23.5	21.0	26.0	N-W		
12	3.00		24.0	19.0	22.5	22.0	26.0	N		
13	12.00		23.0	19.0	23.0	22.0	24.0	N		
14	46.40		24.0	19.0	22.0	21.5	24.0	N-W		
15	24.00		22.5	19.0	22.5	21.5	25.0	N		
16	75.40		22.5	19.5	22.0	21.0	23.5	N-W		
17	42.00		21.5	18.5	21.5	21.0	24.0	N-W		
18	88.20		21.0	18.0	19.5	19.0	21.5	N-W		
19	12.00		22.5	19.0	22.5	21.5	24.5	N		
20	8.20		22.0	21.0	21.5	20.0	23.5	N-W		
21	28.00		22.0	20.0	22.0	21.5	24.0	N		
22	13.00		23.5	19.5	23.5	19.5	25.0	N		
23	5.20		25.0	20.0	25.5	23.0	27.5	N-W		
24	0.00		26.0	19.0	27.0	23.0	28.5	N-W		
25	0.00		24.0	20.0	22.0	21.0	27.0	N		
26	0.00		24.0	20.0	24.0	20.5	23.0	N-W		
27	1.00		25.0	20.0	22.0	20.0	24.0	N		
28	5.60		26.0	21.0	22.0	21.0	25.0	N		
29	23.40		27.0	20.0	22.0	21.5	24.0	N		
30	11.00		26.0	20.0	26.0	23.0	28.0	N-W		
31	6.40		25.5	19.5	24.0	23.0	25.5	N-W		
Total	**686.60**									
Mean			**23.4**	**19.4**	**22.7**	**21.3**	**24.6**			

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: August**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	19.40	3.00	24.0	19.5	21.0	20.5	23.5	N		
2	8. 0	2.50	22.5	20.0	23.5	22.0	26.0	N		
3	2.40	2.00	25.0	18.0	24.0	22.5	26.5	N-W		
4	15.00	2.10	25.0	20.0	22.5	22.0	24.5			
5	4.80	3.80	26.0	20.0	26.0	25.0	25.0	N-W		
6	2.20	0.60	26.5	21.0	26.5	25.5	27.0	N		
7	1.90	2.50	26.5	21.0	26.0	25.0	26.0	W		
8	0.00	3.80	27.0	21.0	25.5	21.5	26.0	N-W		
9	1.20	0.80	27.5	20.0	26.5	23.0	26.0	N-W		
10	47.40	8.60	27.0	20.0	22.0	21.5	23.5	N		
11	21.40	0.40	23.0	19.0	23.5	22.0	25.0	N-W		
12	10.00	0.80	24.5	19.5	25.0	23.0	27.0	N		
13	1.60	0.60	27.5	19.5	25.5	22.5	28.0	N		
14	1.90	1.10	26.5	19.5	25.0	23.0	27.5	N-W		
15	9.50	0.60	27.0	20.0	26.0	23.0	27.0	N-W		
16	12.60	0.00	27.5	18.0	26.0	22.5	28.0	N-W		
17	2.00	1.00	26.0	16.0	20.5	20.0	24.0	W		
18	4.40	4.40	32.0	18.0	30.0	25.0	31.0	N		
19	26.20	3.20	30.0	18.0	27.5	22.5	29.0	W		
20	4.20	0.20	30.0	22.0	25.5	21.5	26.5	W		
21	0.00	3.20	32.0	22.0	27.0	23.0	28.0	N		
22	3.20	6.00	32.5	22.5	27.0	23.0	28.5	N		
23	26.40	0.20	32.0	22.0	22.0	21.5	24.0	W		
24	0.00	0.00								
25	0.00	0.00								
26	46.00	0.00	32.0	20.0	24.0	21.5	25.5	N		
27	0.00	0.00	25.0	21.0	26.5	25.0	27.5	N		
28	26.00	0.00	25.0	22.0	26.5	26.0	25.5	N		
29	2.20	0.20	27.0	20.0	28.0	25.5	29.0	N		
30	24.60	6.00	27.0	21.0	20.5	19.5	21.5	N		
31	7.40	1.20	25.0	21.0	25.5	24.0	27.0	N		
Total	**323.90**									
Mean		**1.9**	**27.2**	**20.1**	**25.0**	**22.8**	**26.3**			

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year 2009** **Month: September**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C					Wind direction	Anemometer Reading	Wind Speed (km/hr)
			Max.	Min.	Dry	Wet	Ordinary			
1	28.70	0.90	26.0	21.0	21.5	21.0	23.0	N		
2	46.20	7.20	26.0	21.0	21.5	21.0	23.0	N		
3	10.00	3.80	26.0	21.0	21.0	20.5	22.0	N		
4	4.20		26.5	22.0	22.5	22.0	25.0	W		
5										
6										
7										
8	18.00	4.00	24.0	20.0	24.5	24.0	26.0	W		
9										
10	4.00	2.00	32.0	22.0	28.5	26.0	31.0	N		
11	0.00		23.5	20.0	24.5	24.0	25.0	W		
12										
13										
14										
15										
16	0.00		27.0	20.0	25.5	24.0	27.0	N		
17										
18	2.60		26.0	21.0	27.5	25.0	28.5	N		
19	5.00		27.0	21.0	26.5	24.0	28.0	N		
20			27.0	21.0	26.5	24.0	28.0	N		
21	7.60		27.0	21.0	22.5	22.0	23.0	N		
22	3.20		24.0	22.0	22.5	22.0	24.0	N		
23	2.20		24.5	22.0	25.5	23.5	24.5	W		
24										
25			24.5	22.0	25.5	25.0	24.5	W		
26	14.60		25.0	22.0	23.5	23.0	24.0	W		
27	0.00		25.0	21.0	26.5	25.5	27.5	N		
28	4.20	2.00	28.0	21.0	27.5	24.5	29.0	N		
29	2.60		23.0	21.0	23.0	22.0	25.0	N		
30	2.60		23.0	21.0	23.0	22.0	25.0	N		
Total	**155.70**									
Mean		**3.3**	**25.8**	**21.2**	**24.5**	**23.3**	**25.7**			

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2009** **Month: October**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C				
			Max.	Min.	Dry	Wet	Ordinary
1	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA
16	35.00	4.10	25.0	22.0	24.5	21.0	26.0
17	0.20	0.20	27.0	21.0	24.0	21.0	24.0
18	0.40	1.20	25.0	21.0	26.0	22.0	26.0
19	0.00	2.00	26.0	22.0	23.0	20.0	25.0
20	0.20	3.70	24.0	21.0	24.0	20.0	24.0
21	10.60	6.60	26.0	21.0	24.0	21.0	24.0
22	0.20	3.30	25.0	21.0	24.0	20.0	25.0
23	0.40	4.40	27.0	22.0	23.0	20.0	24.0
24	0.00	3.00	24.0	22.0	24.0	21.0	24.0
25	0.20	4.20	24.0	22.0	24.0	22.0	25.0
26	0.40	4.40	25.0	21.0	23.0	20.0	25.0
27	0.00	2.00	24.0	21.0	23.0	20.0	24.0
28	15.00	1.00	24.0	22.0	23.0	20.0	24.0
29	21.20	NA	24.0	21.0	22.0	20.0	24.0
30	18.40	0.40	25.0	21.0	24.0	21.0	25.0
31	3.40	3.40	26.0	21.0	24.0	21.0	25.0
Total	105.60						
Mean		2.93	25.1	21.4	23.7	20.6	24.6

CLIMATOLOGICAL DATA

Name of station: Thankamani **Year: 2009** **Month: November**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C				
			Max.	Min.	Dry	Wet	Ordinary
1	23.00	1.00	25.0	21.0	26.0	22.0	26.0
2	5.00	1.00	26.0	22.0	24.0	21.0	26.0
3	0.00	2.00	26.0	21.0	24.0	21.0	26.0
4	0.00	6.00	26.0	22.0	23.0	20.0	24.0
5	1.20	1.50	25.0	21.0	24.0	21.0	25.0
6	0.00	4.00	24.0	22.0	23.0	20.0	24.0
7	38.20	4.20	26.0	22.0	24.0	22.0	26.0
8	0.00	3.00	26.0	22.0	23.0	20.0	24.0
9	8.00	NA	25.0	22.0	23.0	21.0	25.0
10	12.00	NA	23.0	22.0	24.0	21.0	24.0
11	16.00	NA	25.0	22.0	23.0	21.0	24.0
12	0.00	6.00	25.0	21.0	24.0	21.0	25.0
13	0.60	2.60	26.0	22.0	25.0	21.0	26.0
14	0.00	0.40	25.0	22.0	25.0	22.0	25.0
15	0.20	4.20	26.0	22.0	24.0	21.0	26.0
16	0.00	2.00	25.0	21.0	25.0	22.0	23.0
17	0.20	2.20	25.0	21.0	26.0	22.0	26.0
18	0.00	1.00	24.0	20.0	24.0	21.0	23.0
19	0.20	3.20	22.0	21.0	23.0	20.0	21.0
20	0.20	2.20	23.0	22.0	NA	NA	22.0
21	0.00	3.00	26.0	21.0	NA	NA	25.0
22	0.20	2.20	24.0	20.0	24.0	21.0	24.0
23	0.60	6.60	26.0	22.0	21.0	20.0	26.0
24	0.10	3.00	22.0	21.0	NA	NA	25.0
25	0.20	4.20	26.0	20.0	24.0	23.0	26.0
26	0.20	6.20	22.0	22.0	NA	NA	21.0
27	2.20	6.20	26.0	21.0	24.0	21.0	26.0
28	0.00	4.00	26.0	22.0	26.0	22.0	26.0
29	0.00	6.00	23.0	21.0	25.0	23.0	24.0
30	0.00	1.40	25.0	21.0	27.0	22.0	26.0
31							
Total	108.30						
Mean		3.31	24.8	21.4	24.2	21.2	24.7

CLIMATOLOGICAL DATA

Name of station: Thankaman **Year: 2009** **Month: December**

Date	Rainfall in mm	Evaporation in mm	Temperature in ^{0}C				
			Max.	Min.	Dry	Wet	Ordinary
1	0	4	24	22	21	21	23
2	0	4	25	21	26	22	25
3	0	2	23	22	23	21	24
4	0	3	23	22	25	23	22
5	0	3	26	20	23	22	21
6	0	2	22	22	26	23	24
7	0	6	23	21	26	22	22
8	0	4	22	21	25	22	26
9	0	3	26	23	26	21	24
10	0	4	22	21			22
11	0	6	21	20	26	24	26
12	0	6	28	22	25	23	26
13	0	4	25	22	24	22	24
14	0	3	22	21	26	21	22
15	0	3	21	20			21
16	0	4	22	21			24
17	0	2	23	20	26	22	21
18	0	6	24	22	23	21	22
19	0	6	22	22	24	21	26
20	0	4	23	22			28
21	0	2	24	21	23	20	27
22	0	2	21	20			22
23	0	3	26	22	25	21	25
24	0	4	23	20	26	23	22
25	0	3	23	21	23	22	21
26	0	3	26	20	21	21	24
27	0	4			24	23	25
28	0	3			21	20	24
29	0	2	22	20			23
30	0	4	25	21	24	23	26
31	0	3			21	20	24
Total	0.00						
Mean		3.61	23.46	21.14	24.12	21.76	23.74

Data on Infiltration test conducted at Idinjamala on 26-04-07

Time from Start in minutes	Δt hours	Infiltration depth in cm
0		0
2	0.0333	2
6	0.0666	2
10	0.0666	2
20	0.1667	3.5
30	0.1667	3.2
60	0.5	9.3
90	0.5	7.8
120	0.5	6.5
150	0.5	5.7
180	0.5	5
210	0.5	4
240	0.5	4

MOISTURE CONTENT OF SOIL SAMPLES COLLECTED FROM ERATTAYAR WATERSHED APRIL 2007 (25th & 26th)							
Sl.No.	**Location**	**Sampling Depth from surface (m)**	**Container No**	**Weight of container+lid w1 gm**	**Wet weight of container+lid+soil sample w2 gm**	**Dry weight of container+lid+soil sample w3 gm**	**Moisture content (%) (w2-w3)/(w3-w1)**
1	**Erattayar**	0.30	14	47.01	110.62	98.68	**23.11**
2		0.60	54	43.84	120.92	107.93	**20.27**
3		0.90	176	46.29	134.42	116.45	**25.61**
4	**Nalumukku**	0.30	190	43.58	114.58	102.74	**20.01**
5		0.60	80	41.12	113.31	101.37	**19.82**
6		0.90	166	47.74	153.11	134.16	**21.93**
7	**Thankamony**	0.30	3	46.91	87.20	81.30	**17.16**
8		0.60	24	49.22	146.39	126.65	**25.49**
9		0.90	132	47.96	77.23	71.63	**23.66**
10	**Kamakshy**	0.30	10	44.4	118.24	103.52	**24.90**
11		0.60	20	46.34	141.24	119.15	**30.34**
12		0.90	4	42.19	99.40	86.04	**30.47**
13	**8th mile**	0.30	180	45.81	134.04	118.36	**21.61**
14		0.60	152	45.75	128.88	113.50	**22.70**
15		0.90	139	46.38	135.51	117.24	**25.78**
16	**Vazhavara**	0.30	70	44.43	106.64	91.99	**30.80**
17		0.60	44	50.86	121.36	106.87	**25.87**
18		0.90	186	46.01	105.25	91.16	**31.21**
19	**Idinjamala**	0.30	174	39.55	125.14	110.40	**20.80**
20		0.60	135	46.83	131.58	116.81	**21.11**
21		0.90	101	43.66	144.19	130.34	**15.98**
22	**Infiltration sample from Idinjamala**		157	43.32	114.58	101.08	**23.37**

Report on Soil Test conducted for the samples collected from the Erattayar Watershed

Soil samples from ten locations in the Erattayar watershed were collected from 60 cm depth and the analysis carried out during May 2008. Details of the test conducted are given below.

Permeability Test

The permeability test was conducted in the soil laboratory of Ground Water Divison of CWRDM. The permeability values computed are given in Table A.

Table A Permeability and Drainage Characteristics of Soils

Sl.No.	Location Name	Permeability , K (cm/sec)	Drainage
1	Nalumukku	1.3×10^{-2}	Good
2	Parakkadavu	1.2×10^{-2}	Good
3	Kamakshy	1.7×10^{-2}	Good
4	Idinjamala	1.6×10^{-2}	Good
5	IdinjamalaThodu	8.0×10^{-3}	Good
6	Pathammile	1.6×10^{-2}	Good
7	Eighth mile	1.4×10^{-2}	Good
8	Vazhavara	1.4×10^{-2}	Good
9	Thankamany Yard	8.0×10^{-3}	Good
10	Thankamany	9.0×10^{-3}	Good

Details Of Well Observation

Sl No	Station	December 2007 (28) m	January 2008 (30) m	February 2008 (26 & 27) m	March 2008 (25, 26,27 &28)
1	Thankamony	2.13	2.37	2.51	2.30
2	Kamakshy	2.15	2.74	2.85	2.20
3	Vazhavara	2.08	2.14	2.14	2.13
4	Santhigram	7.15	10.3	10.69	9.00

Sl No	Station	Latitude	Longitude
1	Thankamony		
2	Kamakshy		
3	Vazhavara		
4	Santhigram		

Thankamany

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.19	0.047
Dec-08	0.12	0.018
Jan-07	0.1	0.009
Feb-07	0	0
Apr-07	0.14	0.012
Jul-07	0.4	0.1966
Aug-07	0.17	0.071
Sep-07	0.2	0.0982
Oct-07	0.11	0.0505
Nov-07	0.205	0.1246
Dec-07	0.06	0.0143
Jan-08	0.04	0.008
Feb-08	0	0
Mar-08	0.02	0.0012
Apr-08	0.04	0.0027
May-08	0	0
Jun-08	0.22	0.15815
Jul-08	0.29	0.1688
Aug-08	0.23	0.06625
Sep-08	0.18	0.0983
Oct-08	0.16	0.0149
Nov-08	0.16	0.0295
Dec-08	0.1	0.0205
Jan-09	0.11	0.0163
Feb-09	0.04	0.0012
Mar-09	0.06	0.006
Apr-09	0	0
May-09	0	0
Jun-09	0.3	0.0861025
Jul-09	0.39	0.1825
Aug-09	0.26	0.5027
Sep-09	0.46	0.1906
Oct-09	0.28	0.1181

Parakkadavu

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.08	0.425
Dec-06	0.09	0.107
Jan-07	0.05	0.0345
Feb-07	0	0
Apr-07	0.15	0.137
Jul-07	0.77	1.9814
Aug-07	0.44	1.0583
Sep-07	0.7	2.0463
Oct-07	0.4	1.082
Nov-07	0.44	1.178
Dec-07	0.2	0.256
Jan-08	0.1	0.1186
Feb-07	0.16	0.0023
Mar-08	0.14	0.1153
Apr-08	0.02	0.0064
May-08	0	0
Jun-08	0.49	1.0771
Jul-08	0.61	1.14335
Aug-08	0.625	1.2699
Sep-08	0.57	0.9234
Oct-08	0.4	0.4146
Nov-08	0.12	0.3039
Dec-08	0.16	0.1344
Jan-09	0.13	0.0233
Feb-09	0	0
Mar-09	0.04	0.0017
Apr-09	0	0
May-09	0	0
Jun-09	0.34	0.4083
Jul-09	0.42	0.7524
Aug-09	0.45	0.5415
Sep-09	0.56	0.9856
Oct-09	0.5	1.0866

Kamakshy

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.2	0.198
Dec-06	0.15	0.07
Jan-07	0.06	0.024
Feb-07	0.015	0.001
Apr-07	0.115	0.072
Jul-07	0.44	1.1645
Aug-07	0.26	0.631
Sep-07	0.4	0.9867
Oct-07	0.24	0.4539
Nov-07	0.28	0.8003625
Dec-07	0.1	0.1044
Jan-08	0.1	0.04689
Feb-07	0.06	0.0077
Mar-08	0.1	0.024
Apr-08	0.07	0.0324
May-08	0	0
Jun-08	0.19	0.0994
Jul-08	0.45	1.0062
Aug-08	0.3	0.4519
Sep-08	0.26	0.1179
Oct-08	0.22	0.2634
Nov-08	0.15	0.1118
Dec-08	0.08	0.0317
Jan-09	0.055	0.0149
Feb-09	0	0
Mar-09	0.06	0.004
Apr-09	0	0
May-09	0	0
Jun-09	0.28	0.3777
Jul-09	0.43	0.8854
Aug-09	0.29	0.5758
Sep-09	0.46	0.8121
Oct-09	0.29	0.7323

Idinjamala

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.1	0.308
Dec-06	0.18	0.12
Jan-07	0.14	0.0441
Feb-07	0.06	0.005
Apr-07	0.06	0.155
Jul-07	0.28	2.214
Aug-07	0.22	1.311
Sep-07	0.28	2.03
Oct-07	0.2	0.9953
Nov-07	0.23	2.1659
Dec-07	0.08	0.1419
Jan-08	0.04	0.056
Feb-07	0.11	0.0113
Mar-08	0.06	0.0294
Apr-08	0.04	0.0068
May-08	0	0
Jun-08	0.125	0.2413
Jul-08	0.195	0.8075
Aug-08	0.225	0.945875
Sep-08	0.19	1.0701
Oct-08	0.14	0.2559
Nov-08	0.1	0.2934
Dec-08	0.05	0.0817
Jan-09	0.03	0.0591
Feb-09	0	0
Mar-09	0	0
Apr-09	0.04	0.0739
May-09	0	0
Jun-09	0.19	0.181
Jul-09	0.27	0.4037
Aug-09	0.17	0.291
Sep-09	0.17	0.2684
Oct-09	0.2	0.4129

Nalumukku

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.9	0.7
Dec-06	0.52	0.6778
Jan-07	0.36	0.1775
Feb-07	0	0
Apr-07	0	0
Jul-07	0.38	4.367
Aug-07	1.42	2.377
Sep-07	0.70	4.497
Oct-07	0.65	4.03
Nov-07	0.52	2.34
Dec-07	0.05	0.293
Jan-08	0.3	0.128
Feb-08	0.09	0.044
Mar-08	0.1	0.134
Apr-08	0.04	0.217
May-08	0.02	0.025
Jun-08	0.34	0.3480
Jul-08	0.62	1.941
Aug-08	0.78	1.658
Sep-08	0.655	1.5540
Oct-08	0.63	1.2345
Nov-08	0.32	0.5560
Dec-08	0.38	0.8810
Jan-09	0.36	0.2075
Feb-09	0.33	0.481
Mar-09	0.38	0.2290
Apr-09	0.28	0.272
May-09	0	0.0000
Jun-09	0.42	0.7539
Jul-09	0.92	4.2617
Aug-09	0.66	2.4542
Sep-09	0.78	3.2415
Oct-09	0.7	3.7025

8th mile

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.1	0.047
Dec-06	0.13	0.05
Jan-07	0.21	0.0161
Feb-07	0.1	0.005
Apr-07	0.04	0.014
Jul-07	0.1	0.412
Aug-07	0.12	0.342
Sep-07	0.14	0.4175
Oct-07	0.09	0.1306
Nov-07	0.11	0.23765
Dec-07	0.04	0.0363
Jan-08	0.02	0.00285
Feb-07	0.02	0.0023
Mar-08	0.02	0.007
Apr-08	0.03	0.0049
May-08	0	0
Jun-08	0.13	0.3791
Jul-08	0.04	0.0529
Aug-08	0.1	0.2419
Sep-08	0.11	0.3133
Oct-08	0.16	0.0149
Nov-08	0.016	0.0295
Dec-08	0.1	0.0205
Jan-09	0.04	0.0968
Feb-09	0	0
Mar-09	0	0
Apr-09	0	0
May-09	0	0
Jun-09	0.1	0.205
Jul-09	0.05	0.0842
Aug-09	0.1	0.16425
Sep-09	0.02	0.0305
Oct-09	0.1	0.2002

Vazhavara

MONTH	DEPTH	DISCHARGE (m^3/s)
Nov-06	0.32	0.153
Dec-06	0.23	0.05
Jan-07	0.27	0.029
Feb-07	0.11	0.032
Apr-07	0.18	0.054
Jul-07	0.215	0.6764
Aug-07	0.15	0.3841
Sep-07	0.17	0.4485
Oct-07	0.12	0.1615
Nov-07	0.175	0.30915
Dec-07	0.14	0.0787
Jan-08	0.12	0.0453
Feb-07	0.08	0.01825
Mar-08	0.1	0.032
Apr-08	0.08	0.03102
May-08	0	0
Jun-08	0.13	0.0823
Jul-08	0.2533	0.6479
Aug-08	0.205	0.30155
Sep-08	0.19	0.37655
Oct-08	0.23	0.38995
Nov-08	0.22	0.1754
Dec-08	0.21	0.0703
Jan-09	0.18	0.037
Feb-09	0.16	0.0321
Mar-09	0.12	0.034
Apr-09	0	0
May-09	0	0
Jun-09	0.18	0.17291
Jul-09	0.36	0.6336
Aug-09	0.24	0.24033
Sep-09	0.24	0.2184
Oct-09	0.28	0.3543

Monthly average flow in m^3/sec

Month	Thankamani	Kamakshy	8thmile	Parakkadavu	Vazhavara	Idinjamala
Jan-07	0.000	0.024	0.000	0.000	0.000	0.000
Feb-07	0.000	0.001	0.000	0.000	0.000	0.000
Mar-07	0.000	0	0.000	0.000	0.000	0.000
Apr-07	0.012	0.072	0.042	0.000	0.117	0.076
May-07	0.000	0.0418	0.000	0.032	0.070	0.055
Jun-07	0.045	0.5001	0.101	0.126	0.167	0.439
Jul-07	0.166	1.645	0.246	2.518	0.682	0.751
Aug-07	0.071	0.831	0.198	0.985	0.271	0.500
Sep-07	0.098	0.9867	0.221	1.210	0.361	0.540
Oct-07	0.051	0.5539	0.150	1.001	0.347	0.515
Nov-07	0.010	0.4003	0.229	0.721	0.350	0.412
Dec-07	0.014	0.1044	0.113	0.300	0.181	0.221
Jan-08	0.008	0.04689	0.021	0.140	0.119	0.079
Feb-08	0.000	0.0077	0.012	0.079	0.086	0.054
Mar-08	0.001	0.024	0.010	0.118	0.082	0.070
Apr-08	0.003	0.0324	0.005	0.037	0.052	0.052
May-08	0.000	0	0.004	0.037	0.016	0.020
Jun-08	0.158	0.0994	0.088	0.277	0.058	0.127
Jul-08	0.169	1.0062	0.163	1.429	0.340	0.351
Aug-08	0.066	0.4519	0.194	1.111	0.432	0.616
Sep-08	0.033	0.5179	0.209	1.448	0.359	0.630
Oct-08		0.334	0.037	0.578	0.299	0.374
Nov-08		0.3	0.026	0.348	0.330	0.345
Dec-08		0.0317	0.014	0.300	0.236	0.128
Jan-09		0.0149	0.004	0.003	0.023	0.060
Feb-09		0	0.000	0.000	0.009	0.008
Mar-09		0.004	0.001	0.000	0.000	0.000
Apr-09		0.0201	0.012	0.009	0.000	0.005
May-09		0.0177	0.005	0.000	0.000	0.003
Jun-09		0.2778	0.061	0.091	0.174	0.068
Jul-09		0.7854	0.245	0.980	0.459	0.366
Aug-09		0.568	0.147	0.779	0.307	0.351
Sep-09		0.67	0.101	1.157	0.335	0.427
Oct-09		0.55	0.150	0.780	0.332	0.353
Nov-09		0.36	0.041	0.661	0.366	0.345
Dec-09		0.15	0.020	0.105	0.295	0.105