KFRI Research Report No. 241 ISSN 0970-8103

ADEQUACIES OF MINERALS AND SALTS AND WATER MAPPING IN ERAVIKULAM NATIONAL PARK, WAYANAD AND ARALAM WILDLIFE SANCTUARIES AND SUGGESTIONS FOR MANAGEMENT

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July 2002

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(Final Report of the Research Project KFRI 353/2000
from April 2000 to March 2002)

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ABSTRACT OF PROJECT PROPOSAL

Project No.:	KFRI 353/2000
	Adequacies of minerals and salts & water mapping in Eravikulam National Park, Wyanad and Aralam Wildlife Sanctuaries and suggestions for management
Objectives:	To assess the adequacies and effectiveness of the management strategies and suggest measures for its improvement.
	To map the water bodies, their seasonal availability and to assess the quality of water in the Protected Areas (PAs).
	To develop location specific action plan for water management.
	To find the nutritional status of minerals and salts of selected forage species during different seasons in the above PAs.
	To study the availability of natural salts and minerals in the above PAs.
Expected outcome:	Map the water bodies in each PAs with special reference to their seasonality and suggestions for judicious water management.
	Assessment of water pollution in the above PAs and suggest control measures for water pollution.
	Assessment of the nutritional status of minerals and salts of selected forage species of major herbivores during different seasons and availability of natural salt and minerals in above PAs and suggestions to improve.
Date of commencement:	April 2000
Date of completion:	March 2002
Funding Agency:	Kerala Foretry Project (World Bank)
	Kerala Forest Department
Investigators:	K.K.Ramachandran
	S.Kumaraswamy
Project Fellow:	K.P.Naveen

Contents

ABSTRACT

A study was conducted in the three protected areas namely, Eravikulam National Park, Wayanad Wildlife Sanctuary and Aralam Wildlife Sanctuary for two years to know the adequacies of salts in soil, forage samples and water quality and suggest management strategies.

Water is available through out the year and there is no visible water scarcity in Eravikulam National Park and Aralam Wildlife Sanctuary. On the other hand, water scarcity is observed in the months between January to April especially in Tholpetty, Kurichiat and Sulthan Bathery ranges of Wayanad Wildlife Sanctuary. Creation of artificial waterholes to meet the water requirement of the animals is suggested. The quality of water in the three protected areas falls within the permissible limits of drinking water and safe for animal use; pH was near neutral in all the water samples analyzed. Water of Wayanad Wildlife Sanctuary recorded higher levels of hardness but it is within the permissible limits. There was no anthropogenic pollution of water bodies in the three protected areas except alleged pesticide residues reaching the water stream in Aralam Wildlife Sanctuary. Letting in of the effluent of coffee processing unit was noticed in the Nadudana thodu of Tholpetty range in Wayanad Wildlife Sanctuary.

In Wayanad Wildlife Sanctuary, large numbers of natural soil salt licks were seen in Muthanga and Tholpettty ranges, which contain high amounts of sodium, calcium and magnesium. These salt licks were monitored during the different seasons of the year and interestingly some of the salt licks were sloughed in and not used by the animals. There were no visible salt licks in Aralam Wildlife Sanctuary and Eravikulum National Park. Moreover, there was no sign of animals eating the soil especially near the water source. It appears that natural salt licks are not common in these two protected areas. However, surface soil samples collected from the protected areas were analyzed for the mineral element concentration. The amount of sodium, calcium and magnesium was lower in the surface soil samples as compared to the salt content recorded in the natural salt licks. No

relationship could be established on elemental composition of forage samples and natural salt licks. Forage appears to accumulate lesser amount of elements in comparison to that of soil.

1. INTRODUCTION

Management of wild animals requires the assessment of availability of natural resources for animal use in a given geographical area. Natural resource availability may vary in different ecosystems and climatic conditions and their interactions. The spatial distribution of the natural resources like water, forage and natural salt licks may be some of the constraints faced in the management of animals in Wildlife Sanctuaries (WLS) and National Parks (NP). Information is scanty on natural distribution of the water bodies, seasonal availability, water quality and also occurrence of natural saltlicks to meet the animal requirements in protected areas. This calls for mapping the distribution of water bodies and monitoring of the seasonal availability to explore the corrective measures for better management.

Information is lacking on the water availability and seasonal abundance to suggest judicious water management in the protected areas to ensure the availability of water during the lean period of the year and/or scanty rainfall years. The spatial distribution and minimum water bodies in a given protected area need to be maintained to overcome shortage of water for animal use. Moreover, the quality of available water is an important factor. Herbivorous mammals are known to eat soil deliberately from specific soil deposits rich in minerals to meet the body requirements (Ayeni, 1979; Seidensticker and McNeely, 1975; Kreulen 1985;). It is in this context a study was undertaken to assess the availability, seasonal variation and quality of water and occurrence of natural soil slat licks to suggest corrective measures for improvement in three protected areas namely, Eravikulam National Park, Wayanad Wildlife Sanctuary, Aralam Wildlife sanctuary.

1.1. Review of literature

Animal body water requirement is met from the water bodies and water-holes in the protected areas. The shortage of water may be expected during the dry seasons or in years with erratic rainfall resulting in scarcity of water for animal used leading to movement of animals to other regions (Anon, 1961; Williamson and Mbano, 1988; Western, 1975). Under these situations, creation of artificial water-holes has been suggested to be beneficial (Ayeni, 1975). Water availability throughout the different seasons of the year in the wildlife

sanctuaries is a concern, which needs to be addressed as this has direct relevance in wild animal management. However, information is limited on the spatial distribution of water bodies, seasonal abundance and water quality in the protected areas of regional importance.

The soil eating by animals is a known habit and efforts have been made to know the the elemental composition of natural salt licks to understand the reasons. However, elemental function in the biology of an animal is not clear (Stark, 1986). Few research reports indicate that natural salt licks ingested by animals had high concentrations of sodium (Weir, 1972; Stark, 1986). Ingestion of soil by wild life may be important for the acquisition of saltls, particularly those found in far higher quantities in soil than plant. In certain cases it might be possible to provide external source of mineral salts in different proportions. However, no information is available for actual body requirement of various animal species in the wild. Moreover, mineral sufficiency or deficiencies to wildlife species will vary with species, its diet and other factors including their population and distribution. In a study, spatial distribution of elephants was related to environmental sodium concentrations in soils (Weir, 1973). In the present study an attempt has been made to identify the spatial distribution of water bodies and natural salt licks in the protected areas.

1.2. Objective of the present study

1. To assess the adequacies and effectiveness of the management strategies and suggest measures for its improvement.
2. To map the water bodies, their seasonal availability and to assess the quality of water in the Protected Areas (PAs)
3. To prepare location specific action plan for water management in the above PAs and prepare map.
3. To find the nutritional status of mineral element and salts of selected forage species during different seasons in the above PAs.
5. To study the availability of natural salts and mineral elements in the above PAs.

2. STUDY AREAS

2.1. Eravikulam National Park

Eravikulam National Park lies at $10^0$05'to $10^0$20' N lat and 77^0 to $77^0$10' E long falls on the crest of the Western Ghats (Fig. 1). The total area of the park, which is in the high ranges of Idukki district in Kerala is 99.98 sq km with sholas and grasslands. The main body of national park is comprised of high rolling plateau with a base elevation of about 2000 m ASL (Jose *et al*., 1994) Mean rainfall is 5238 mm, the peak rainy period is between the months June and August. Fog and strong wind is prevalent during the rainy season with relative humidity ranging between 65 and 82 percent. This park is abode for the endangered animal Nilgiri Tahr (*Hemitragus hylocrius*).

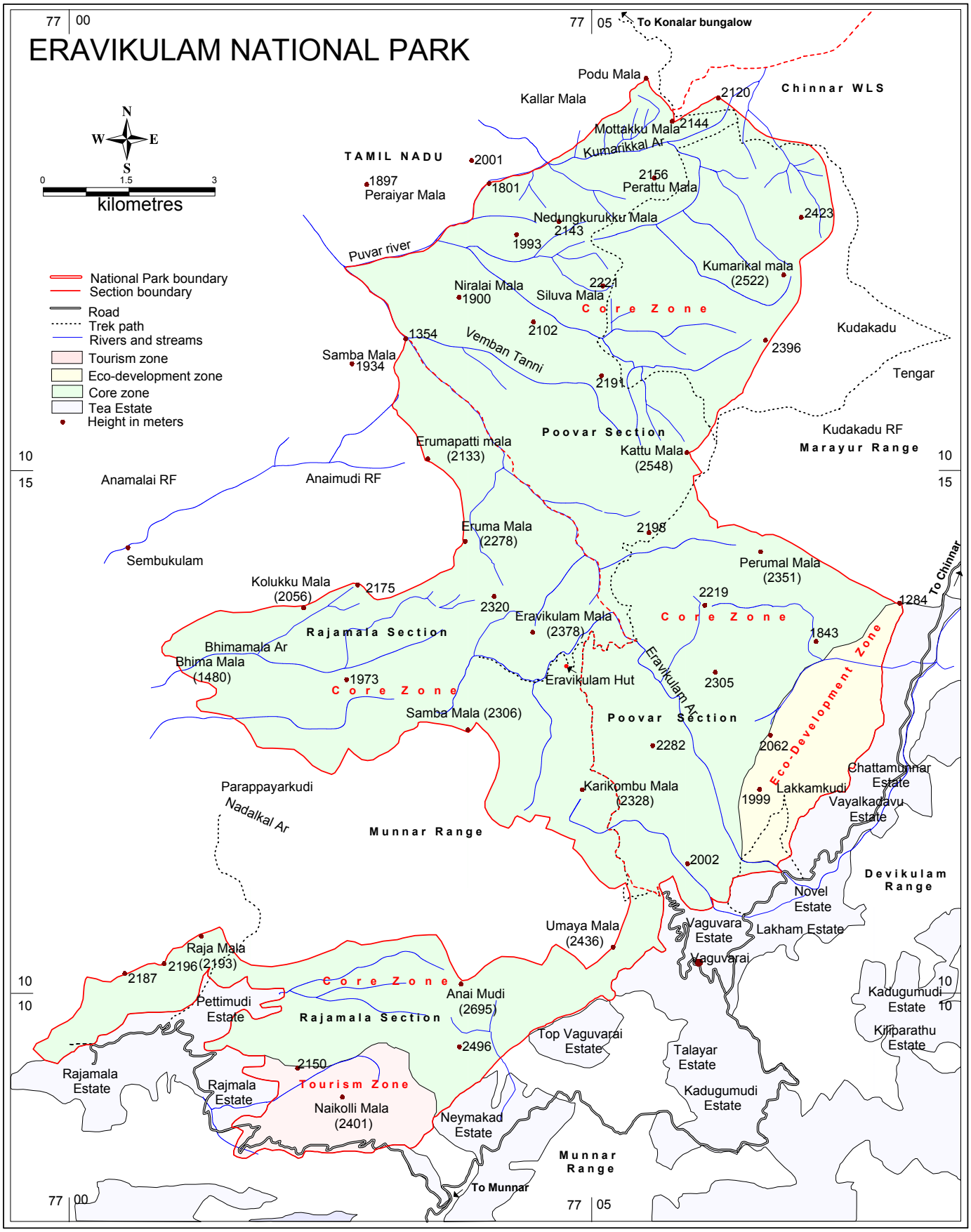

ERAVIKULAM NATIONAL PARK
77 00
77 05
To Konalar bungalow
N
W
E
S
0
1.5
3
kilometres
National Park boundary
Section boundary
Road
Trek path
Rivers and streams
Tourism zone
Eco-development zone
Core zone
Tea Estate
Height in meters
TAMIL NADU
Chinnar WLS
Podu Mala
Kallar Mala
2120
Mottakku Mala
2144
Kumarikkal Ar
2001
1897
Peraiyar Mala
1801
2156
Perattu Mala
Nedungkurukku Mala
2143
2423
1993
Puvar river
Kumarikal mala
(2522)
Niralai Mala
1900
2221
Siluva Mala
Core Zone
2102
1354
Vemban Tanni
Samba Mala
1934
2396
Kudakadu
Tengar
2191
Poovar Section
Kudakadu RF
Marayur Range
Erumapatti mala
(2133)
Kattu Mala
(2548)
10
15
Anamalai RF
Anaimudi RF
Eruma Mala
(2278)
2198
Sembukulam
Perumal Mala
(2351)
To Chinnar
Kolukku Mala
(2056)
2175
2219
1284
2320
Eravikulam Mala
(2378)
Core Zone
Rajamala Section
1843
Bhimamala Ar
Bhima Mala
(1480)
Eravikulam Ar
Eco-Development Zone
1973
Core Zone
Eravikulam Hut
2305
Samba Mala (2306)
Poovar Section
2282
2062
Chattamunnar
Estate
Parappayarkudi
Karikombu Mala
(2328)
Lakkamkudi
1999
Vayalkadavu
Estate
Nadalkal Ar
Munnar Range
2002
Devikulam
Range
Novel
Estate
Umaya Mala
(2436)
Vaguvara
Estate
Lakham Estate
Raja Mala
2196 (2193)
Vaguvarai
2187
Core Zone
Anai Mudi
(2695)
Pettimudi
Estate
Rajamala Section
Kadugumudi
Estate
Kilparathu
Estate
Top Vaguvarai
Estate
2496
Talayar
Estate
2150
Rajamala
Estate
Tourism Zone
Rajmala
Estate
Naikolli Mala
(2401)
Kadugumudi
Estate
Neymakad
Estate
Munnar
Range
To Munnar

Fig.1

2.2. Wayanad Wildlife Sanctuary

Wayanad lies between $11^0$20' to $12^0$70' N latitude and $75^0$28' to $76^0$36' E longitude. It is the part of the continuous stretch of forests including Bandipur Tiger Reserve and Ragiv Gandhi National Park of Karnataka and Madumalai WLS of Tamil Nadu which together forms the Asian elephant reserve No.7 under the Project Elehant. The total area is about 1200sq km of which 344 sq km forms the WLS (Table 1). This Sanctuary is located in two blocks (Figs. 2 and 3) separated by revenue lands and reserve forests. Vegetation types include wet evergreen forests confined to the northern part and deciduous forests along the state border.

Table 1. Ranges of Wayanad Wildlife Sanctuary

Range	Natural forest km^2	Plantation km^2	Total km^2
Tholpetty	37.57	40.10	77.67
Kurichiyat	77.20	29.25	106.45
Sulthan Bathery	70.97	15.06	86.03
Muthanga	57.22	17.07	74.29
Total area	242.96	101.48	344.44

*Source: Gopinathan (1990)

2.2.1. Drainage

The Kabini river originate as many streams in the Wayanad Plateau in Kerala, which join to form the Mananthavady puzha and Panamaram puzha, Bavelipuzha and Noolpuzha.

2.2.2. Rainfall

The average annual rainfall received in the Wyanad Plateau is around 2000mm. The rainfall varies considerably and shows a sharp gradient of rainfall from west to east. The pattern of rainfall in the four ranges of the sanctuary for five years are provided in the figures 4 to 7.

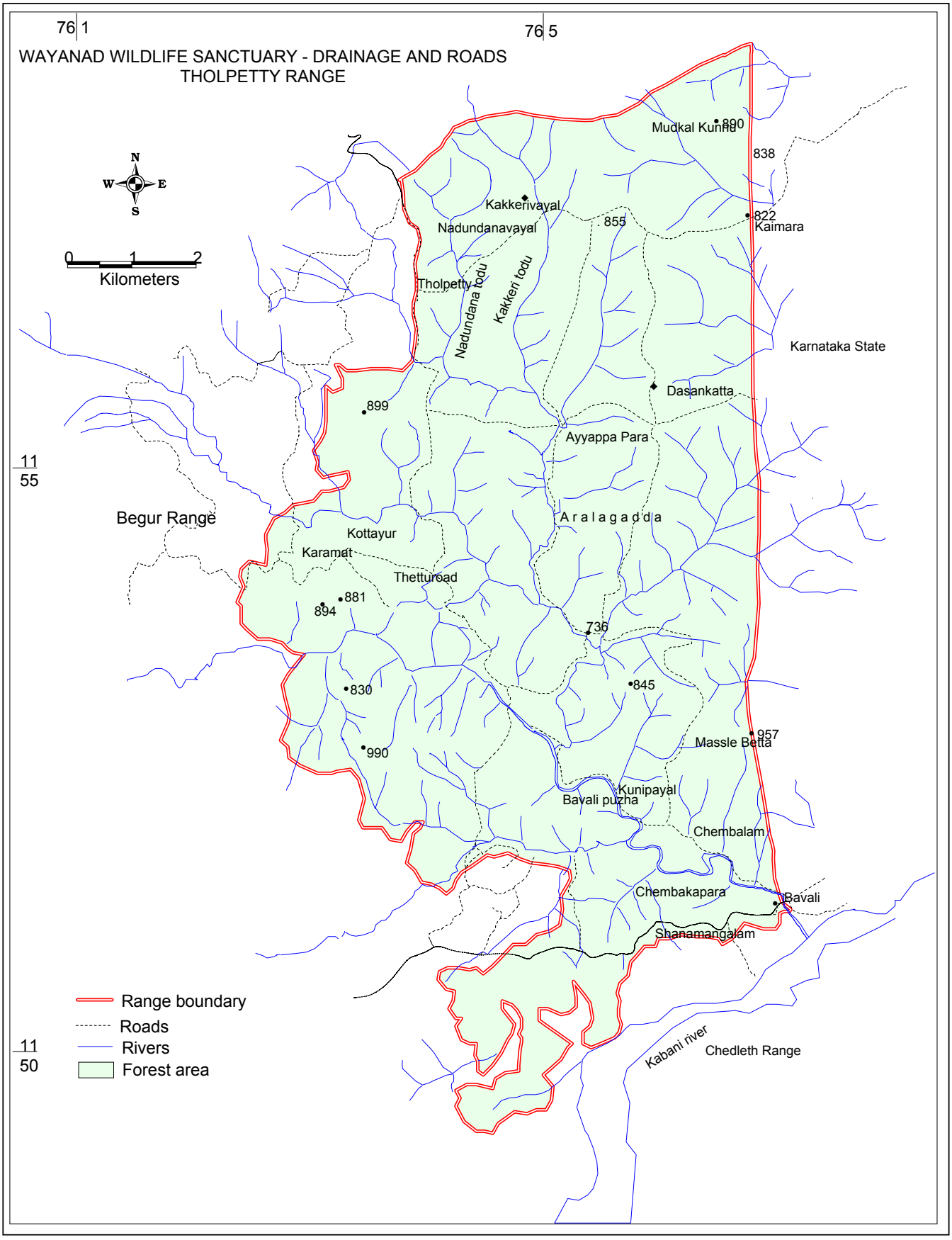

76 1
76 5
WAYANAD WILDLIFE SANCTUARY - DRAINAGE AND ROADS
THOLPETTY RANGE
N
W
E
S
0
1
2
Kilometers
Mudkal Kunnu
890
838
Kakkerivayal
Nadundanavayal
855
822
Kaimara
Tholpetty
Nadundana todu
Kakkeri todu
Karnataka State
Dasankatta
899
Ayyappa Para
11
55
Begur Range
A r a l a g a d d a
Kottayur
Karamat
Thetturoad
881
894
736
830
845
957
Massle Betta
990
Kunipayal
Bavali puzha
Chembalam
Chembakapara
Bavali
Shanamangalam
Range boundary
Roads
Rivers
Forest area
11
50
Kabani river
Chedleth Range

Fig. 2□

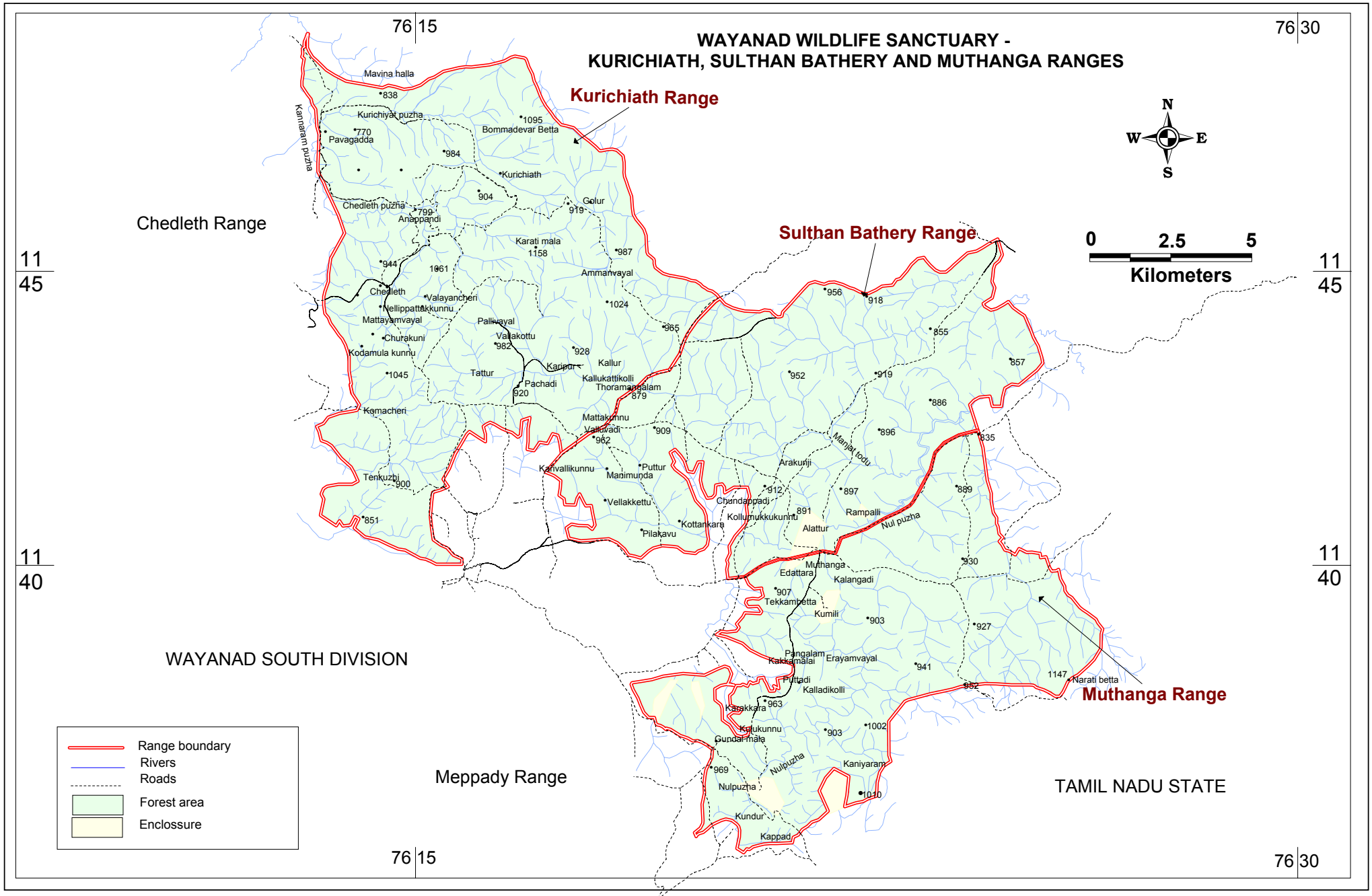

WAYANAD WILDLIFE SANCTUARY -
KURICHIATH, SULTHAN BATHERY AND MUTHANGA RANGES
Kurichiath Range
Sulthan Bathery Range
Muthanga Range
Chedleth Range
WAYANAD SOUTH DIVISION
Meppady Range
TAMIL NADU STATE
76 15
76 30
11 45
11 40
N
W
E
S
0 2.5 5
Kilometers
Range boundary
Rivers
Roads
Forest area
Enclossure
Mavina halla
Kurichiyat puzha
Pavagadda
Bommadevar Betta
Kannaram puzha
Kurichiath
Chedleth puzha
Anappandi
Golur
Karati mala
Ammanvayal
Chedleth
Valayancheri
Nellippattakkunnu
Mattayamvayal
Pallivayal
Churakuni
Vallakottu
Kodamula kunnu
Kallur
Karipur
Tattur
Pachadi
Kallukattikolli
Thoramangalam
Komacheri
Mattakunnu
Valluvadi
Tenkuzhi
Kanvallikunnu
Manimunda
Puttur
Vellakkettu
Kottankara
Pilakavu
Arakunji
Manjal todu
Chundappadi
Kollumukkukunnu
Rampalli
Alattur
Nul puzha
Muthanga
Edattara
Kalangadi
Tekkambetta
Kumili
Pangalam
Kakkamalai
Erayamvayal
Puttadi
Kalladikolli
Narati betta
Karakkara
Kulukunnu
Gundal mala
Nulpuzha
Kaniyaram
Kundur
Kappad

Fig. 3

2.3.Aralam Wildlife Sanctuary

The Aralam WLS covers the area of 55.59 km^2 and has the rich diversity of flora and fauna. This Wildlife Sanctuary is situated in the southeastern side of the Kannur district of Kerala. The area lies between $11^0$50' to $11^0$59' N latitude, and $75^0$45' to $75^0$59' E longitude (Fig. 8). The study area supports two distinct forest type viz west coast tropical evergreen forest and west coast semi-evergreen forest. The soil type with in the sanctuary is mainly of red and lateritic in nature.

3. MATERIALS AND METHODS

Reconnaissance survey was conducted in the Eravikulam National Park ,Wayanad Wild Life Sanctuary and Aralam Wildlife Sanctuary for water bodies and natural saltlick spots. Water and soil saltlick samples were collected from respective locations (Figures 9 to 13) during different seasons of the year.

3.1. Water mapping

Water mapping is done after locating the perennial sources of water, which is available to wildlife. The location of the water bodies is located in a digitized base map in 1:50,000 scale using MapInfo software. The information on the seasonality/permanence is collected from local field staff/residents and also personal verification in the field. Survey of perennial and non-perennial sources of water is noted separately. The streams are classified according to the permanence, type and access. Periodic observation of water bodies is done to know whether it is drying up in the summer. Water availability is related to the total rainfall in the area for the purpose of comparison as inferred from the previous few years of rainfall record of the area.

Fig 4. Rainfall data of Tholpetty range during 1997 - 2001

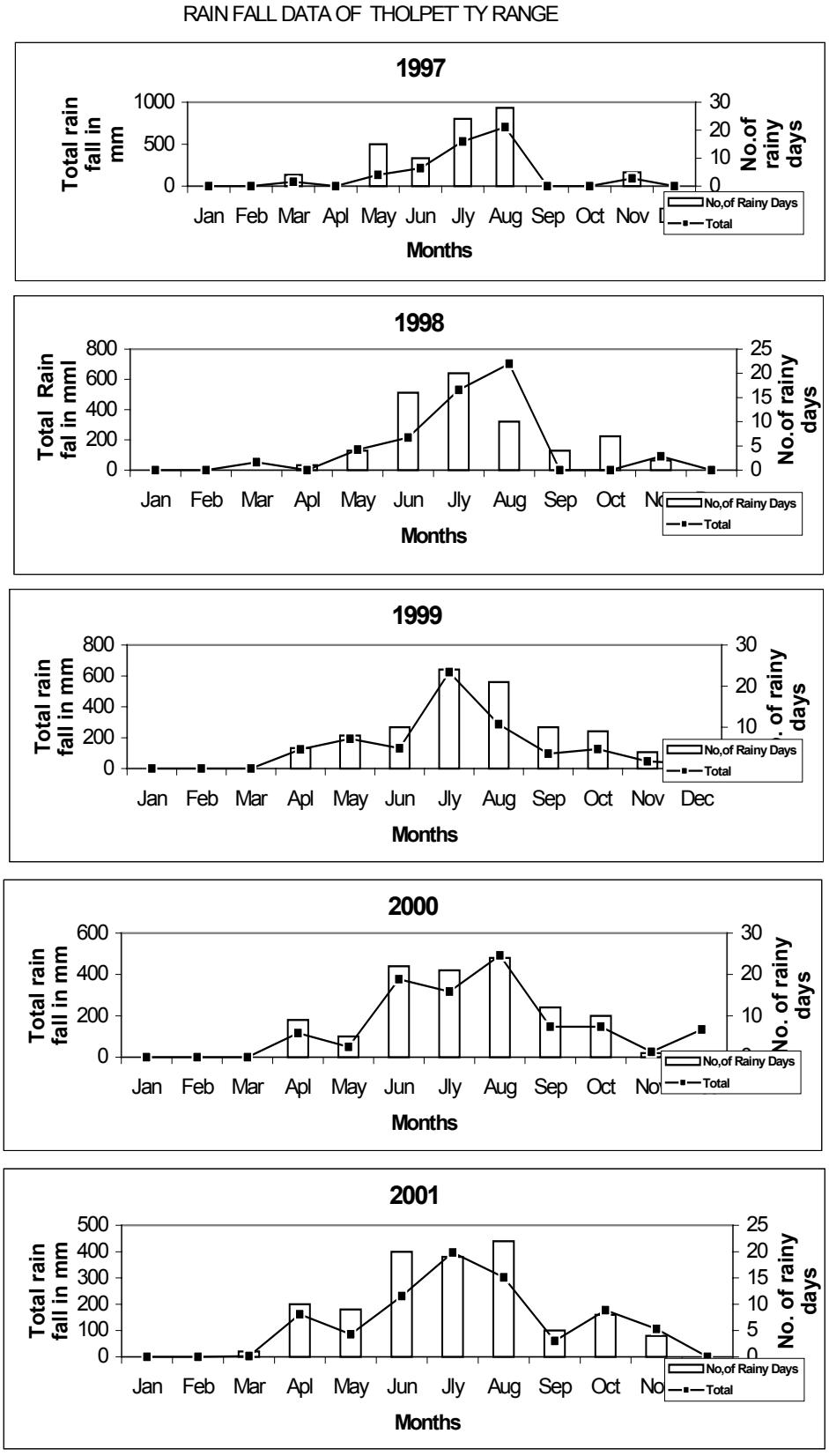


Fig 5. Rainfall data of Kurichiat range during 1997 - 2001

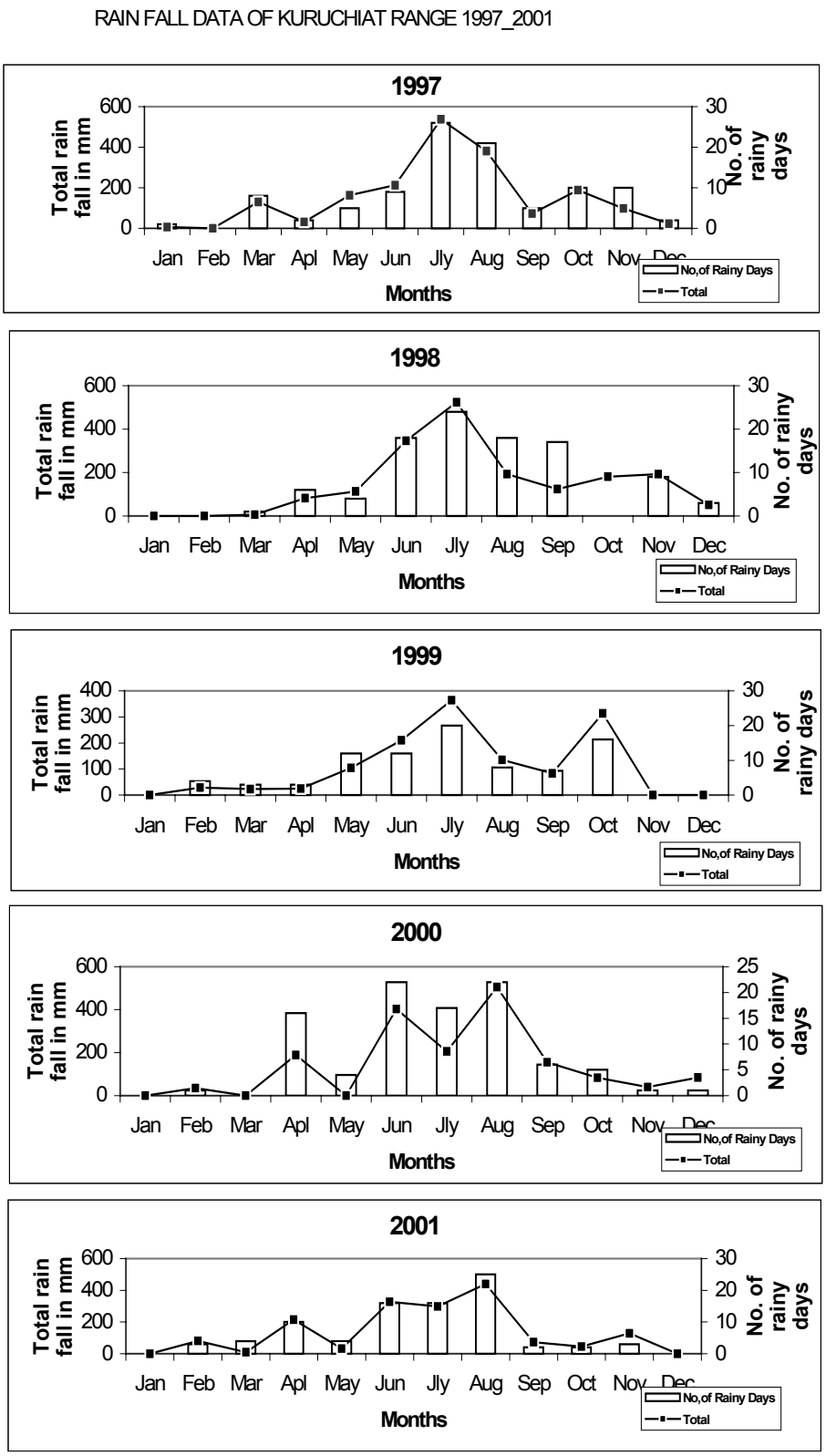
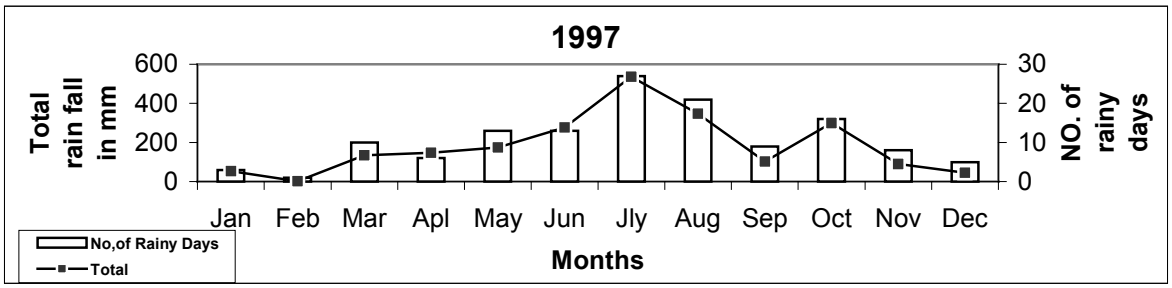
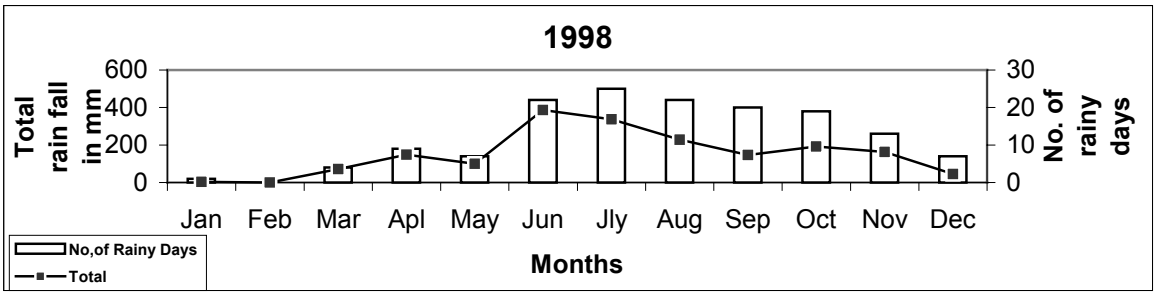
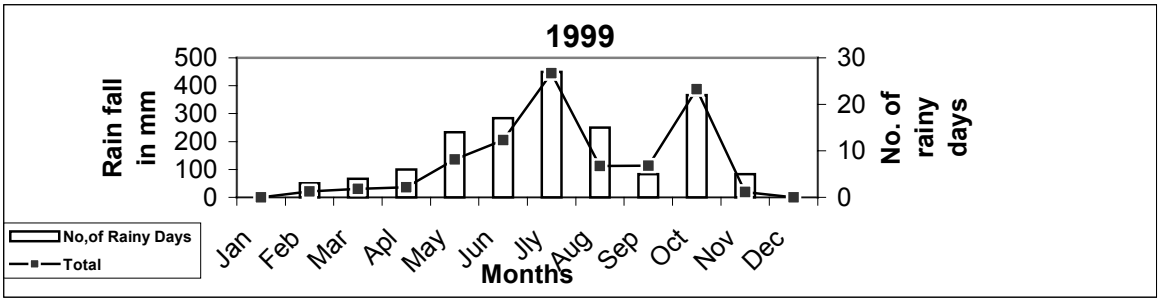


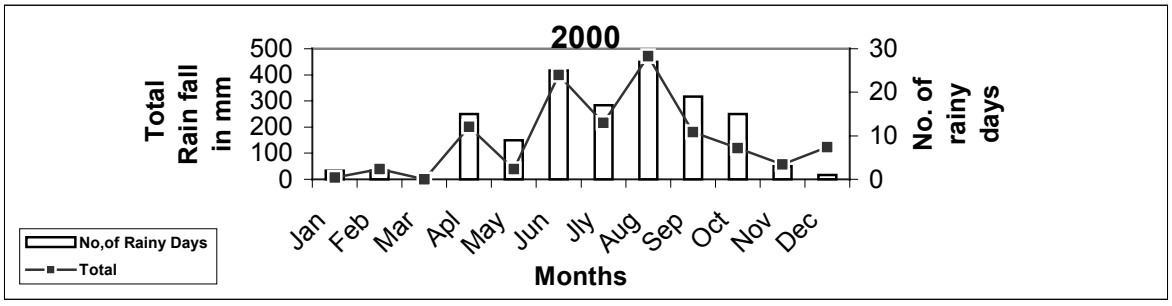
Fig 6. Rainfall data of Sulthan Bathery range during 1997 - 2001

A RAIN FALL DATA OFSULTHANS BATHERY RANGE1997_20001









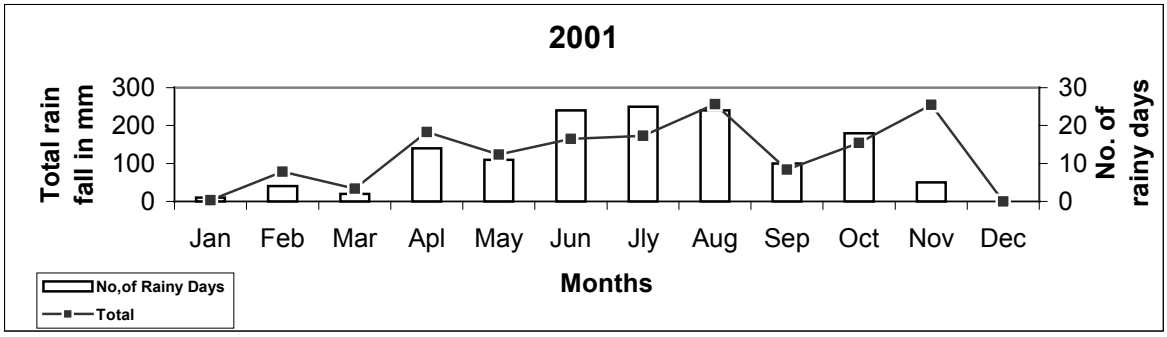
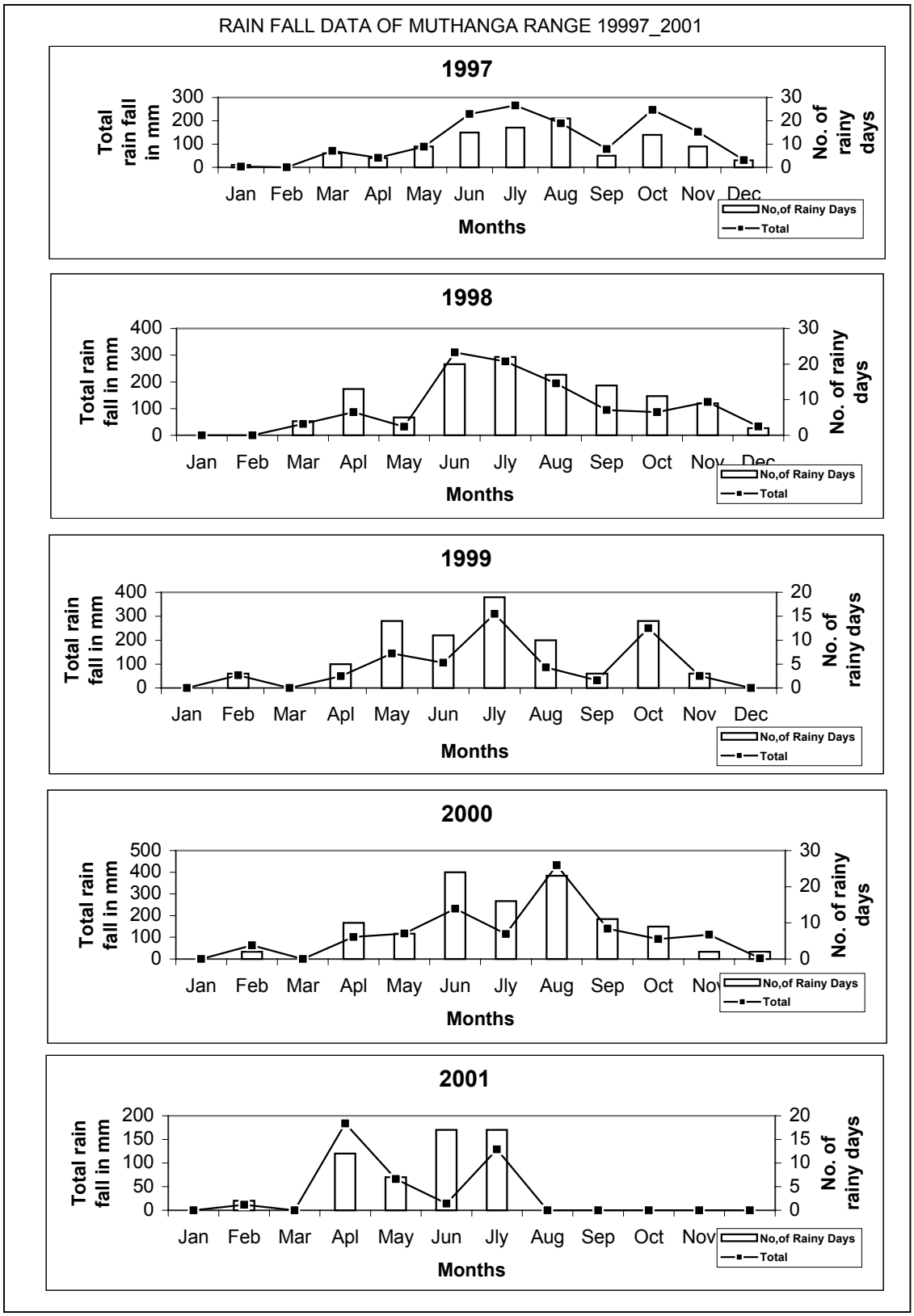


Fig 7. Rainfall data of Muthanga range during 1997 - 2000



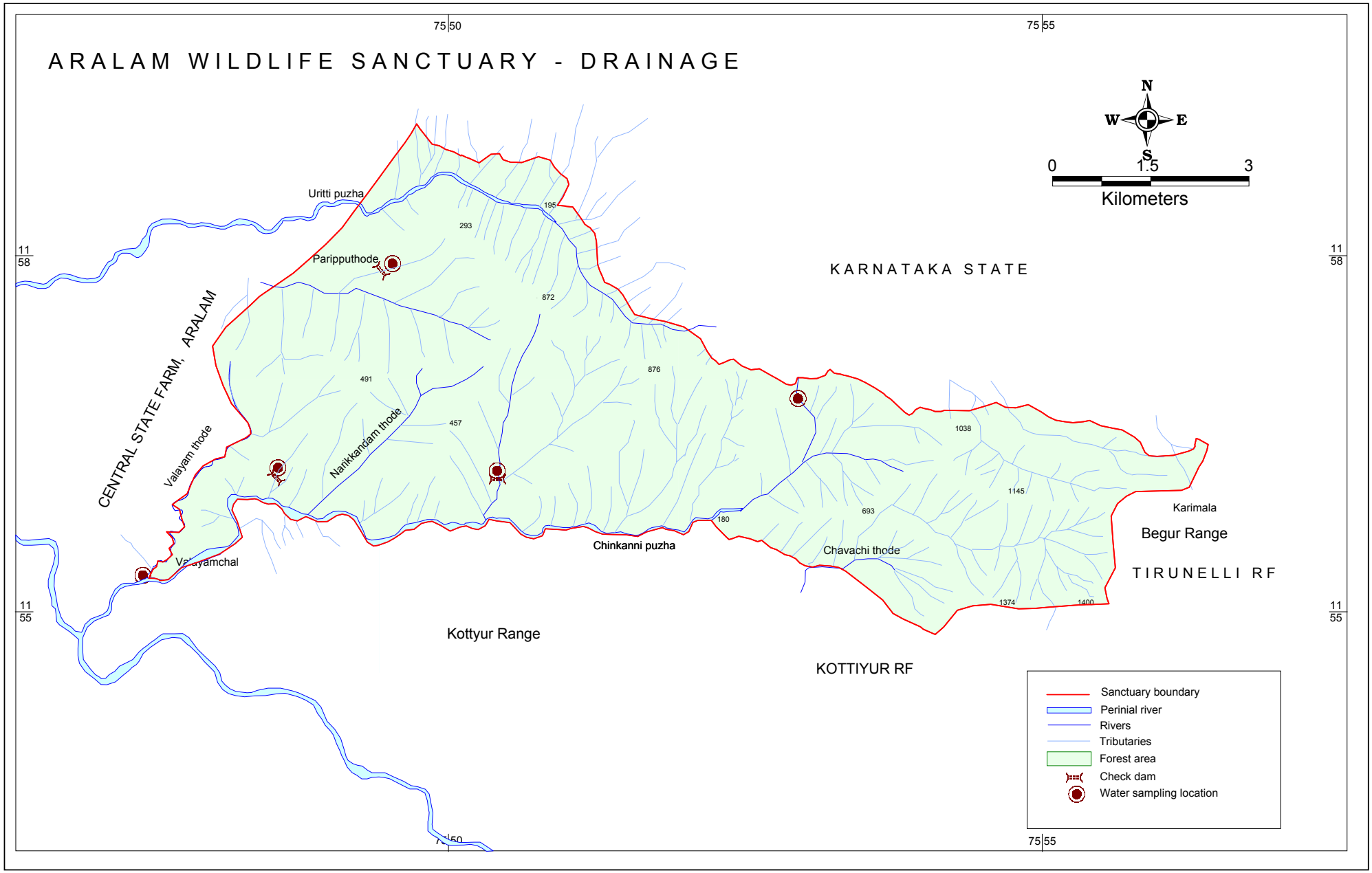

ARALAM WILDLIFE SANCTUARY - DRAINAGE
75 50
75 55
11 58
11 55
N
W
E
S
0
1.5
3
Kilometers
Uritti puzha
Paripputhode
195
293
872
876
491
457
1038
1145
693
180
1374
1400
CENTRAL STATE FARM, ARALAM
Valayam thode
Narikkandam thode
Chinkanni puzha
Chavachi thode
Karimala
Begur Range
TIRUNELLI RF
KARNATAKA STATE
Kottyur Range
KOTTIYUR RF
Sanctuary boundary
Perinial river
Rivers
Tributaries
Forest area
Check dam
Water sampling location

Fig. 8

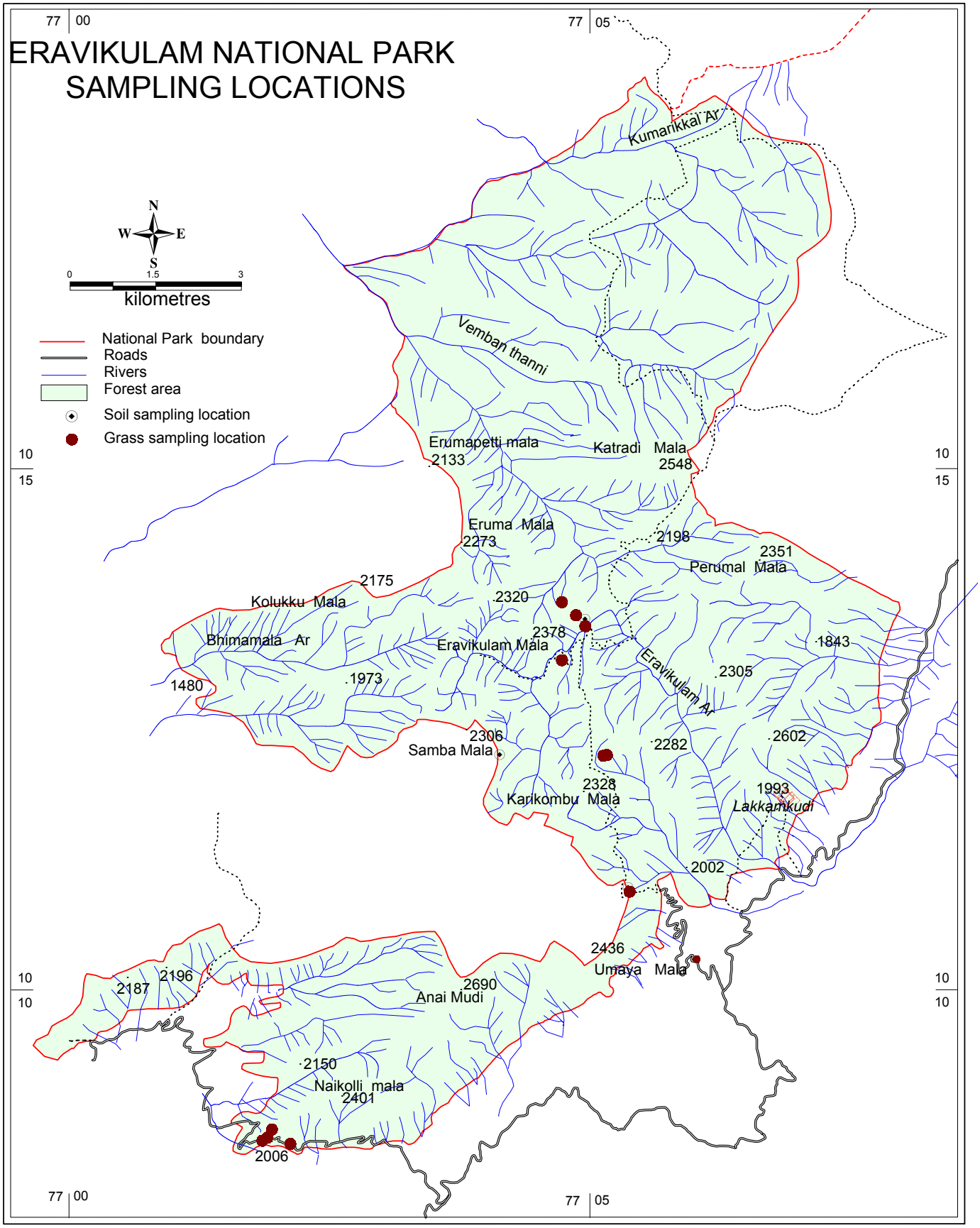

ERAVIKULAM NATIONAL PARK
SAMPLING LOCATIONS
77 00
77 05
10 15
10 10
N
W
E
S
0
1.5
3
kilometres
National Park boundary
Roads
Rivers
Forest area
Soil sampling location
Grass sampling location
Kumarikkal Ar
Vembanthanni
Erumapetti mala
2133
Katradi Mala
2548
Eruma Mala
2273
2198
2351
Perumal Mala
2175
Kolukku Mala
2320
Bhimamala Ar
2378
Eravikulam Mala
1843
1480
1973
Eravikulam Ar
2305
2306
Samba Mala
2282
2602
2328
Karikombu Mala
1993
Lakkamkudi
2002
2436
Umaya Mala
2196
2187
2690
Anai Mudi
2150
Naikolli mala
2401
2006

Fig.9

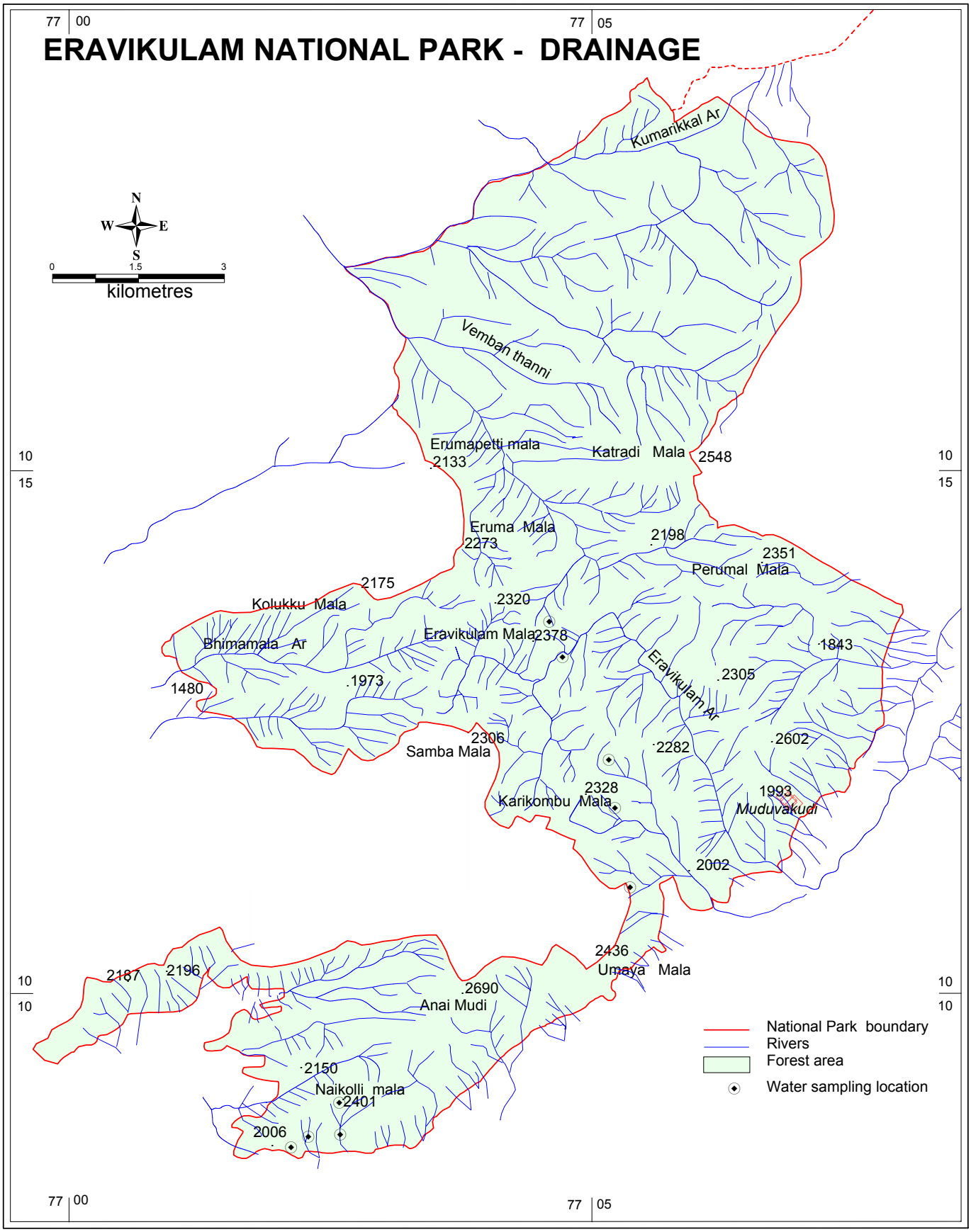

ERAVIKULAM NATIONAL PARK - DRAINAGE
77 00
77 05
10 15
10 10
N
W
E
S
0
1.5
3
kilometres
Kumarikkal Ar
Vembanthanni
Erumapetti mala
2133
Katradi Mala
2548
Eruma Mala
2273
2198
2351
Perumal Mala
2175
Kolukku Mala
2320
Bhimamala Ar
Eravikulam Mala
2378
1843
1480
1973
Eravikulam Ar
2305
2306
Samba Mala
2282
2602
2328
Karikombu Mala
1993
Muduvakudi
2002
2436
Umaya Mala
2187
2196
2690
Anai Mudi
2150
Naikolli mala
2401
2006
National Park boundary
Rivers
Forest area
Water sampling location

Fig.9a

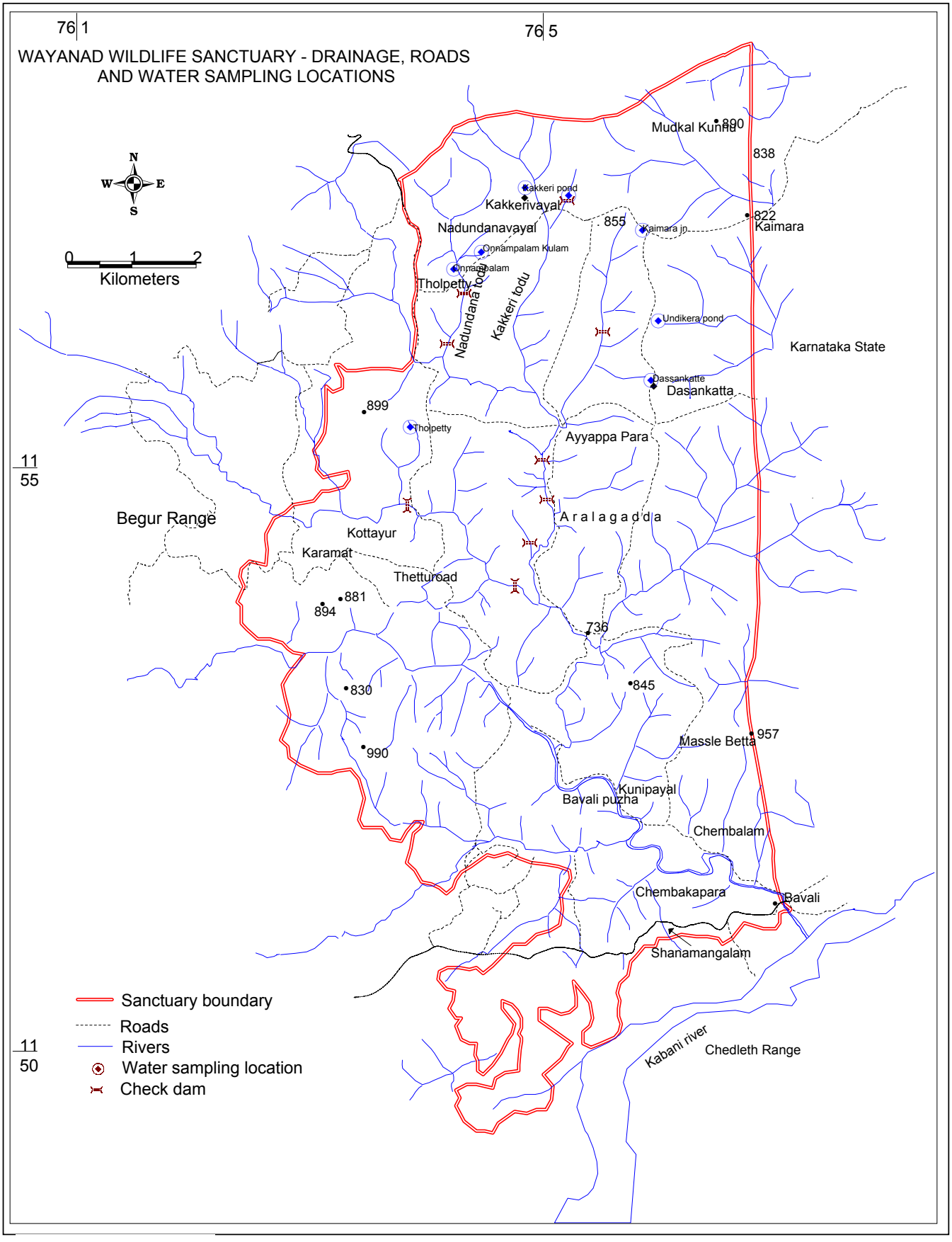

76 1
76 5
WAYANAD WILDLIFE SANCTUARY - DRAINAGE, ROADS AND WATER SAMPLING LOCATIONS
N
W
E
S
0
1
2
Kilometers
Mudkal Kunnu
890
838
Kakkeri pond
Kakkerivayal
Nadundanavayal
855
Kaimara jn
822
Kaimara
Onnampalam Kulam
Onnampalam
Tholpetty
Nadundana todu
Kakkeri todu
Undikera pond
Karnataka State
Dassankatte
Dasankatta
899
Tholpetty
Ayyappa Para
11
55
Begur Range
A r a l a g a d d a
Kottayur
Karamat
Thetturoad
881
894
736
830
845
957
Massle Betta
990
Kunipayal
Bavali puzha
Chembalam
Chembakapara
Bavali
Shanamangalam
Sanctuary boundary
Roads
Rivers
Water sampling location
Check dam
11
50
Kabani river
Chedleth Range

Fig.10

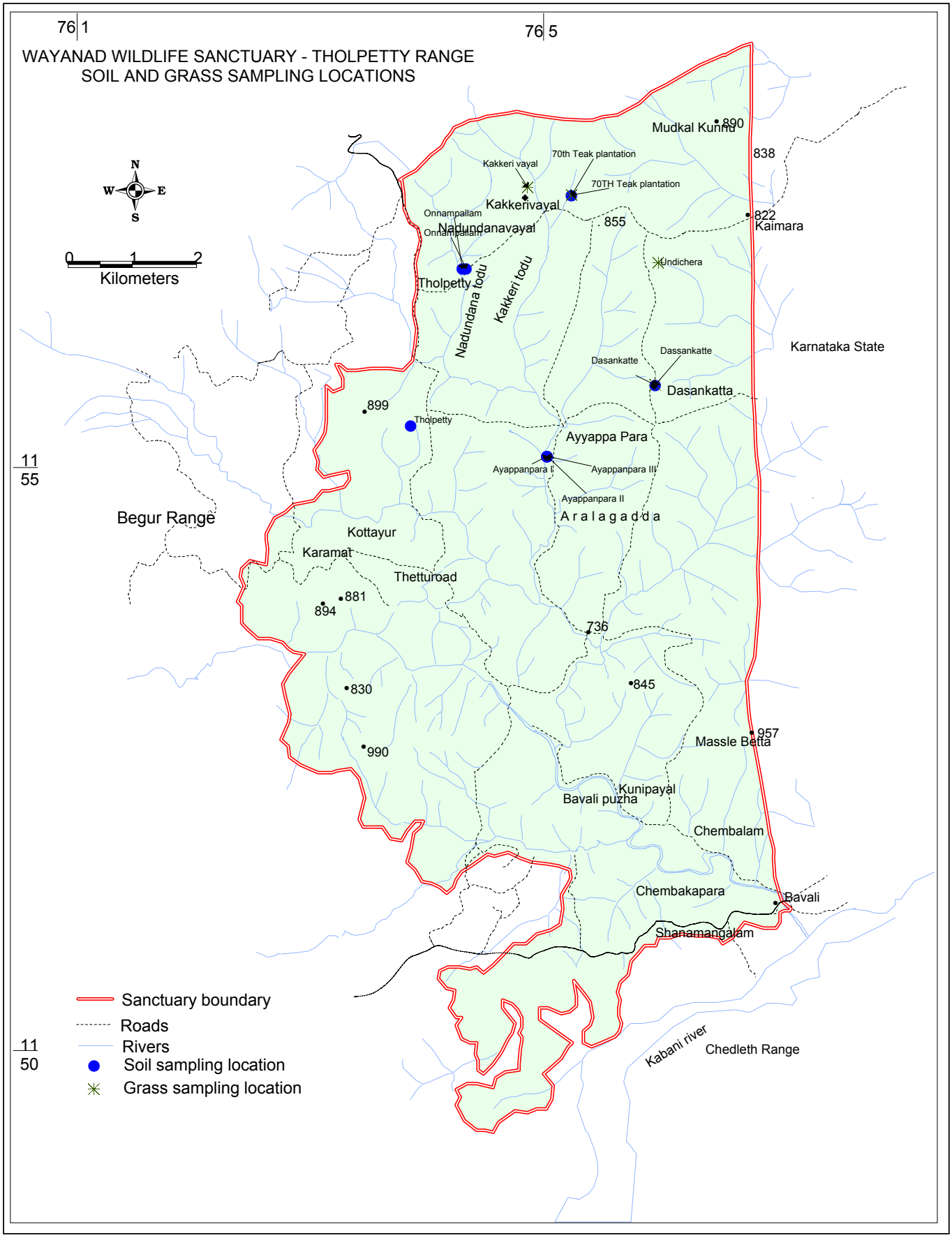

76 1
76 5
WAYANAD WILDLIFE SANCTUARY - THOLPETTY RANGE
SOIL AND GRASS SAMPLING LOCATIONS
N
W
E
S
0
1
2
Kilometers
Mudkal Kunnu
890
838
Kakkeri vayal
70th Teak plantation
70TH Teak plantation
Kakkerivayal
Onnampallam
Onnampallam
Nadundanavayal
855
822
Kaimara
Undichera
Tholpetty
Nadundana todu
Kakkeri todu
Karnataka State
Dassankatte
Dasankatte
Dasankatta
899
Tholpetty
Ayyappa Para
11
55
Ayappanpara I
Ayappanpara III
Ayappanpara II
A r a l a g a d d a
Begur Range
Kottayur
Karamat
Thetturoad
881
894
736
830
845
957
Massle Betta
990
Kunipayal
Bavali puzha
Chembalam
Chembakapara
Bavali
Shanamangalam
Sanctuary boundary
Roads
Rivers
11
50
Soil sampling location
Grass sampling location
Kabani river
Chedleth Range

Fig. 11

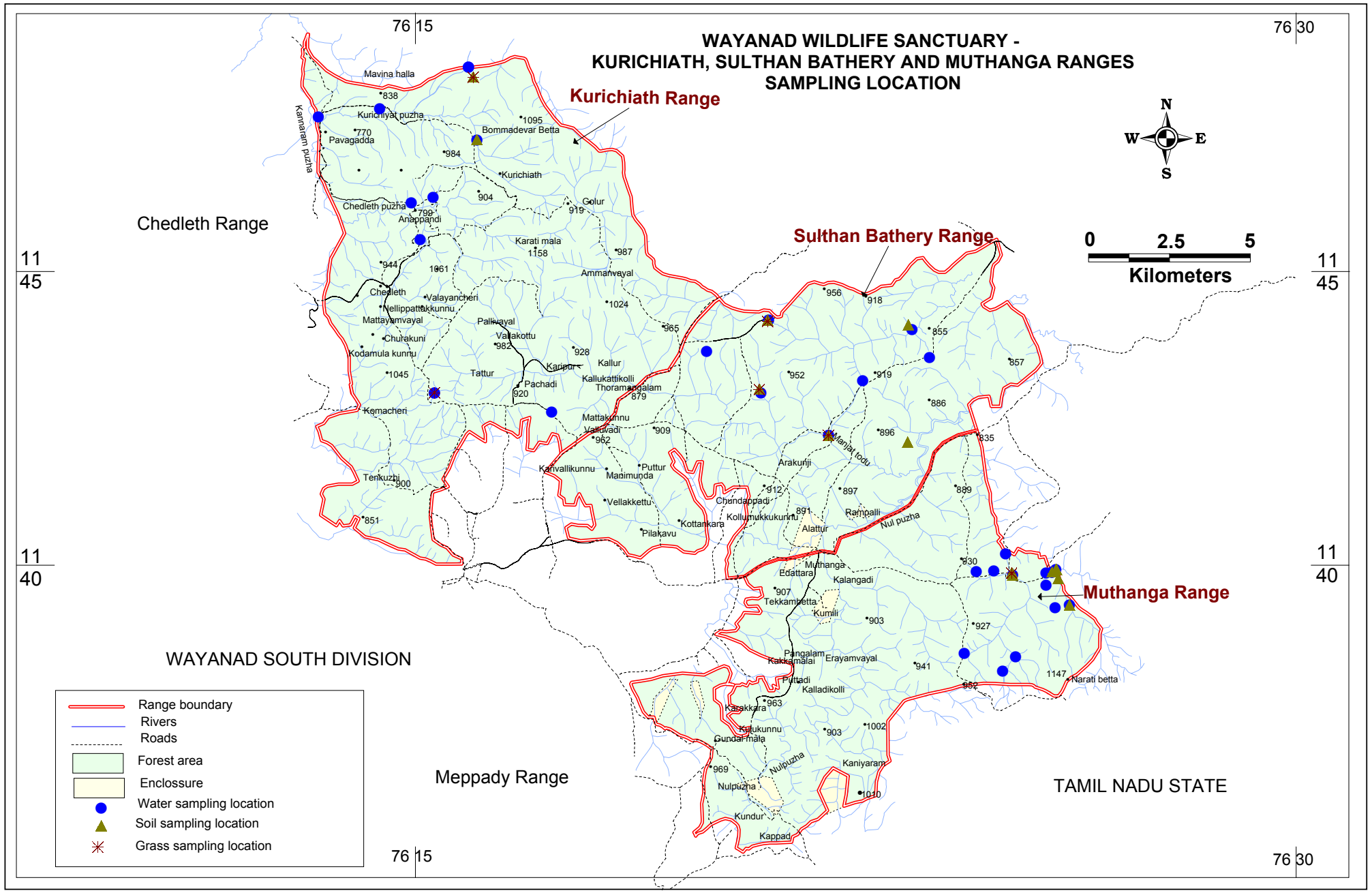

WAYANAD WILDLIFE SANCTUARY -
KURICHIATH, SULTHAN BATHERY AND MUTHANGA RANGES
SAMPLING LOCATION
Kurichiath Range
Sulthan Bathery Range
Muthanga Range
Chedleth Range
Meppady Range
WAYANAD SOUTH DIVISION
TAMIL NADU STATE
76 15
76 30
11 45
11 40
N
W
E
S
0 2.5 5
Kilometers
Range boundary
Rivers
Roads
Forest area
Enclosure
Water sampling location
Soil sampling location
Grass sampling location
Mavina halla
Kurichiyat puzha
Pavagadda
Bommadevar Betta
Kamaram puzha
Kurichiath
Chedleth puzha
Anappandi
Golur
Karati mala
Ammanvayal
Chedleth
Valayancheri
Nellippattakkunnu
Mattayamvayal
Churakuni
Kodamula kunnu
Palvayal
Vallakottu
Kallur
Karipur
Tattur
Kallukattikolli
Thoramangalam
Pachadi
Komacheri
Mattakunnu
Valluvadi
Kanivallikunnu
Manimunda
Puttur
Tenkuzhi
Vellakkettu
Pilakavu
Kottankara
Arakunji
Manjat todu
Chundappadi
Kollumukkukunnu
Alattur
Nul puzha
Rampalli
Muthanga
Edattara
Kalangadi
Tekkambetta
Kumili
Pangalam
Kakkamalai
Erayamvayal
Puttadi
Kalladikolli
Narati betta
Karakkara
Kulukunnu
Gundal mala
Nulpuzha
Kaniyaram
Kundur
Kappad

Fig. 12

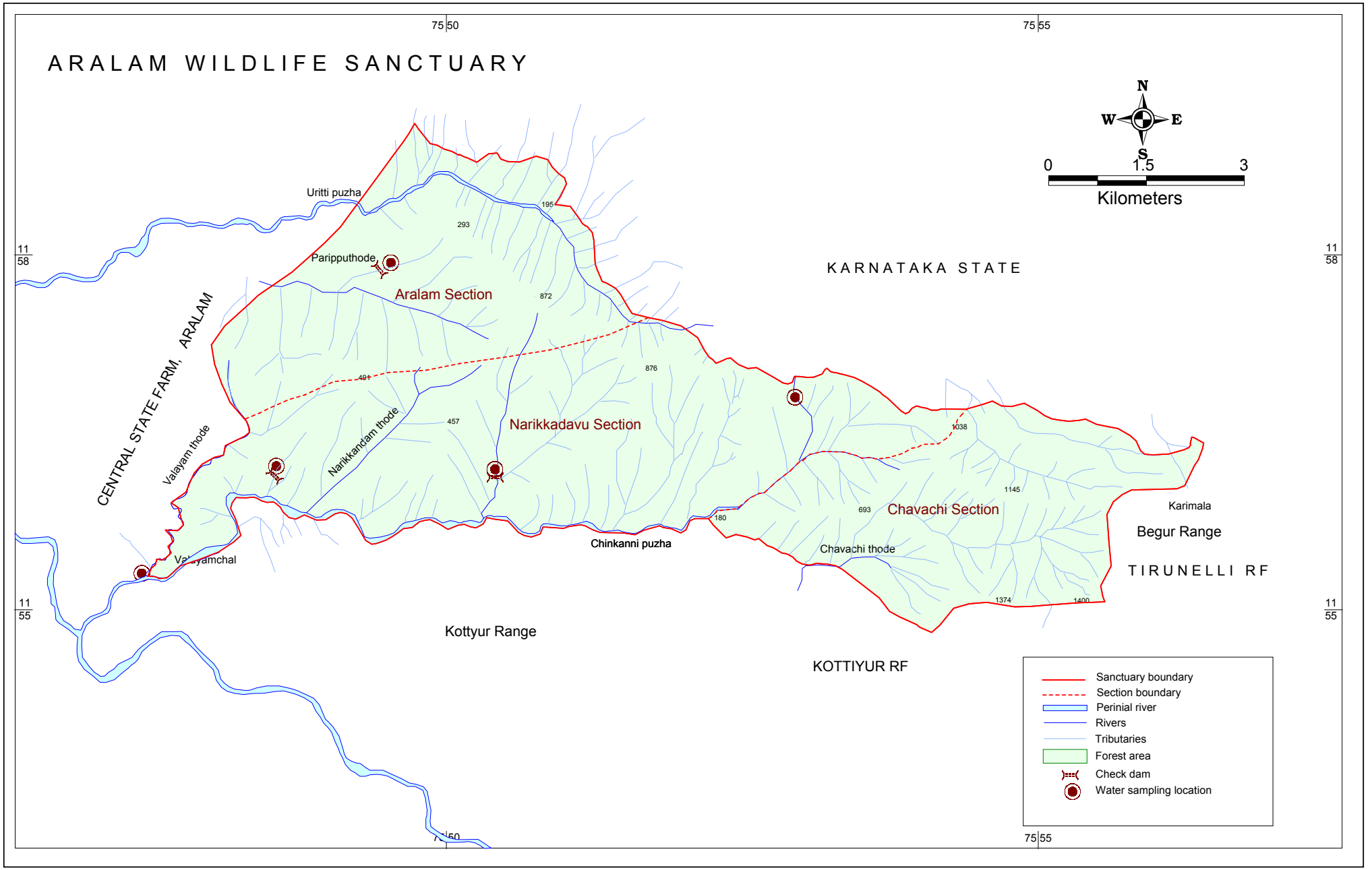

ARALAM WILDLIFE SANCTUARY
75 50
75 55
11 58
11 55
N
W
E
S
0
1.5
3
Kilometers
Uritti puzha
Paripputhode
Aralam Section
KARNATAKA STATE
CENTRAL STATE FARM, ARALAM
Valayam thode
Narikkandam thode
Narikkadavu Section
Chavachi Section
Karimala
Begur Range
TIRUNELLI RF
Chinkanni puzha
Chavachi thode
Kottyur Range
KOTTIYUR RF
195
293
872
876
491
457
1038
1145
693
180
1374
1400
Sanctuary boundary
Section boundary
Perinial river
Rivers
Tributaries
Forest area
Check dam
Water sampling location

Fig. 13

The streams are classified into four categories as follows and digitized as separate layers with separate colour coding.
July – September in Green color
July – December in Blue color
July to June (which is the perennial source) in Red.

Analysis was done using a combination of scenarios with natural availability during the dry period and the degree of disturbance, etc. Circular buffer of one kilometer area were created around each water source. The areas outside the buffer represent the areas where water shortage may be there for wildlife.

During the study period seasonal availability of water and spatial distribution of water bodies were analyzed in all the three PAs. The spatial distribution of each of the water bodies was located using GPS. Natural water bodies, newly constructed water holes and check dams were monitored for water storage and conditions during the different seasons to suggest management strategies.

3.2. Water sampling

Water samples were collected in clean bottles with permanent marker labels and sealed. The water samples were stored in deep freeze condition until chemical analysis was completed.

3.3. Chemical analysis of water

Appropriate aliquots of sub samples were used in analysis of different water quality parameters *viz* pH, chlorides, hardness, Calcium, alkalinity, total dissolved solids, total suspended solids, organic carbon and phosphates.

3.3.1. Organic carbon

The organic carbon in the water samples was estimated by potassium permanganate titration method (Welcher, 1975).

3.3.2. Suspended solids and dissolved solids

Total solids, suspended and dissolved solids in the water samples were estimated by gravimetric method. The difference between the total solids and suspended solids was accounted as dissolved solids (Purohit, 1985).

3.3.3. Chlorides

Chloride concentration in the water samples was analyzed in filtered (Whatman 42) water samples by silver nitrate titrimetric method (Welcher, 1975)

3.3.4. Hardness

Total hardness of the water was estimated by complexometric method using standard EDTA (Welcher, 1975)

3.3.5. Calcium

Calcium of the water was estimated by complexometric method using standard EDTA (Welcher, 1975)

3.3.6. Alkalinity

Phenolphthalein Alkalinity was estimated by titrimetry (Welcher, 1975).

3.3.7. Phosphates

Phosphate content in the water was estimated by molybdophosphoric acid blue colour method (Welcher, 1975).

3.4. Soil saltlick sampling

Soil salt lick and surface soil samples were collected from the Protected Areas to depth of 0-10 cm using clean trowel and transferred to clean poly bags. Soil samples were air dried under shade for 15-20 days and ground to pass through 2 mm mesh sieve. Samples

were analyzed for pH, sodium, calcium and magnesium, total nitrogen and total phosphorus.

3.5. Chemical Analysis of soil salt lick

3.5.1.Soil reaction (pH)

Soil pH was measured in 1:1.25 soil to water suspension using glass electrode pH meter (Jackson, 1973).

3.5.2. Exchangeable bases

The exchangeable bases Na^{+}, Ca^{2+} and Mg^{2+} were determined in the neutral N ammonium extract using Atomic Absorption Spectrometer with respective halo-cathode lamps.

3.5.3. Total Nitrogen and Phosphorus in the soil

Nitrogen and Phosphorus in soil samples was estimated by digesting 0.3-0.5 g of air-dried soil (passed through 2 mm sieve) with concentrated sulfuric acid in presence of digestion mixture (K_2SO_4: $CuSO_4$: Se in 100:20:1 ratio). The Nitrogen and Phosphorus content in the digested sample was then determined by salysilate-hypochlorite and ascorbic acid reduced molybdophosphoric acid blue color method, respectively, using autoanalyser.

3.6. Forage sampling

Forage grass samples common in the study area were collected. The grass samples were dried and powdered. Powdered plant samples were used for chemical anlalysis.

3.7. Chemical analysis of forage

Powdered forage samples (0.3-0.5 g) were pre-digested with 5 ml of concentrated sulfuric acid and a pinch of Sodium salysilate for overnight. The pre-digested samples were then digested for 3 hours at 350 ^{0}C in presence of hydrogen peroxide (Jackson, 1973). The nitrogen and phosphorus contents in the digest were estimated following respective analytical methods using autoanalyser.

3.4.4. Organic carbon

The organic carbon in the water samples was estimated by potassium permanganate titration method (Welcher, 1975).

4. RESULTS

4.1. Water availability in the Protected areas

4.1.1. Eravikulam National Park

Eravikulam National Park has perennial rivers and there is abundant water. The National Park gets lots of rainfall and there is plenty of water in the park. There are enough water spreads like the Bhimanoda water spread, Eravikulam lake area. There is no visible water scarcity during the summer months. This is revealed while making one kilometre buffer all around all the perennial rivers. In fact, all the areas are covered by the buffer, indicating that there is sufficient water through out the National Park.

As all the streams are perennial, there is no need for constructing additional check dams or water holes in Eravikulam National Park for the animals, because the focal species is the Nilgiri tahr, which is associated with the grasslands and cliffs.

4.1.2. Wayanad Wildlife Sanctuary

There are 29 check dams existing in the Wayanad Wildlife Sanctuary. The distribution of the check dams in different ranges are shown in Table 2. Tholpetty range is having 10 checkdams and Muthanga range has nine. . Sulthan Bathery and Kurichiat ranges have five check dams each. The check dams existing in the main streams, are having water in the summer also. The check dams seen in the farther north of the sanctuary has less water in the summer. These check dams require maintenance. All the check dams and some waterholes are perennial. The check dams built earlier in the Nellur thodu do not require management, as sufficient waterholes are present in that range. All the artificial waterholes in the Muthanga range are perennial. There is necessity of maintaining them to increase their water storage. Some of the waterholes require desilting. Some of the broken check dams require repair.

4.1.3. Aralam Wildlife Sanctuary

Aralam Wildlife Sanctuary has perennial rivers and there is no scarcity of water in the summer season. The sanctuary has three check dams. All the check dams require maintenance. The check dam at Parupputhodu is full of silt accumulated and there is very little water stored in summer months. Lot of elephant activity is noted around the check dam at Parupputhodu. The Chullikandam weir does not have have the stopper for retaining water in the summer.

The newly constructed check dam at PothanPlavu does not store enough water in the summer. This is due to the water seeping below the dam. Measures should be taken to increase the storage level, so that more water is retained in the check dam so that animals such as elephants and sambar deer can come wallow in the summer.

The water availability and seasonal variation in the Wayanad Wildlife Sanctuary is provided in Table 2. The spatial distribution and conditions of the water bodies were analyzed and suggestions for management have been drawn up based on the condition of the water body/water-hole for further maintenance and/or create further water-hole in the areas to alleviate the shortage of water in the dry periods of the year. The spatial distribution of water bodies/water-holes in Eravikulam National Park (Fig. 14), Wyanad Wildlife Sanctuary (Figs. 15 to 17) and Aralam Wildlife Sanctuary (Fig. 18) is indicated on the respective maps.

4.2. Water Quality parameters

Water samples collected from the study areas were characterized for parameters like pH, chlorides, hardness, calcium, alkalinity, dissolved solids, suspended solids, organic carbon and phosphorus.

In Eravikulum National Park, there was no appreciable variation in the water quality parameters analyzed in the water samples collected during different seasons (Table 3 and Appendix 1 a-i).

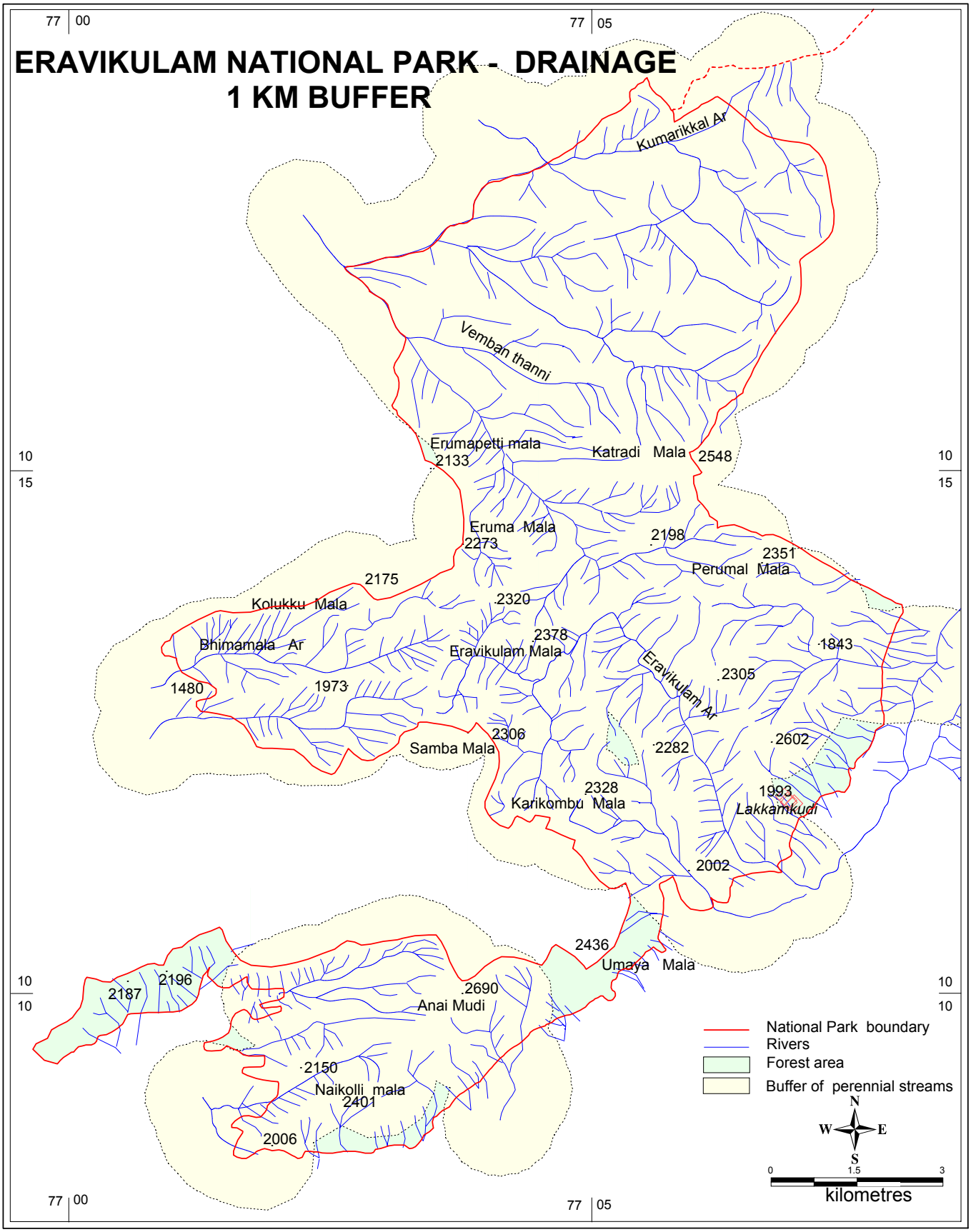

ERAVIKULAM NATIONAL PARK - DRAINAGE
1 KM BUFFER
77 00
77 05
10 15
10 10
Kumarikkal Ar
Vemban thanni
Erumapetti mala
2133
Katradi Mala
2548
Eruma Mala
2273
2198
2351
Perumal Mala
2175
Kolukku Mala
2320
Bhimamala Ar
2378
Eravikulam Mala
1843
1480
1973
Eravikulam Ar
2305
2306
Samba Mala
2282
2602
2328
Karikombu Mala
1993
Lakkamkudi
2002
2436
Umaya Mala
2187
2196
2690
Anai Mudi
2150
Naikolli mala
2401
2006
National Park boundary
Rivers
Forest area
Buffer of perennial streams
N
W
E
S
0
1.5
3
kilometres

Fig.14

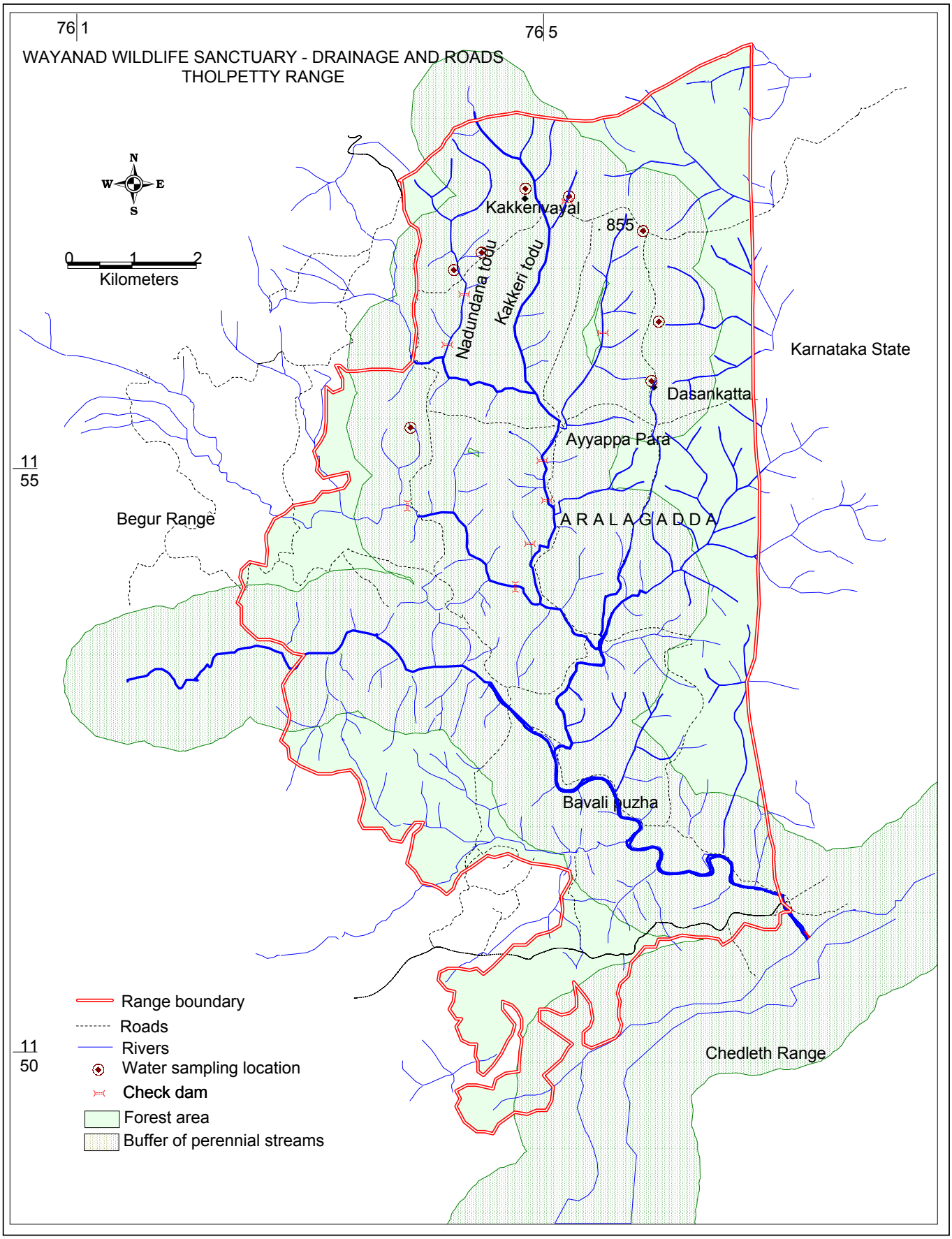

76 1
76 5
WAYANAD WILDLIFE SANCTUARY - DRAINAGE AND ROADS
THOLPETTY RANGE
N
W
E
S
0
1
2
Kilometers
Kakkenvayal
855
Nadundana todu
Kakkeri todu
Karnataka State
Dasankatta
Ayyappa Para
11
55
Begur Range
A R A L A G A D D A
Bavali puzha
Range boundary
Roads
Rivers
Water sampling location
Check dam
Forest area
Buffer of perennial streams
11
50
Chedleth Range

Fig. 15

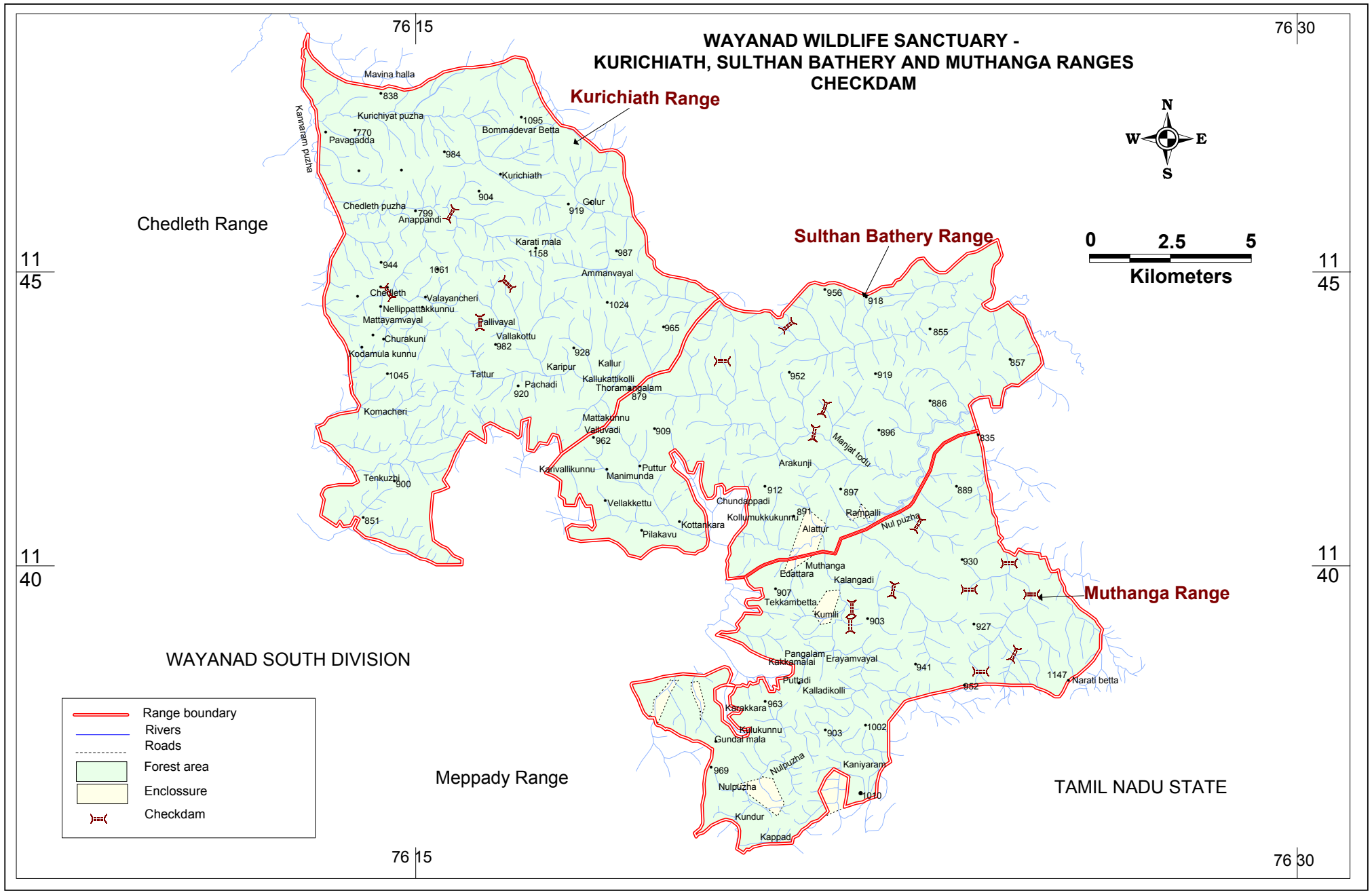

WAYANAD WILDLIFE SANCTUARY -
KURICHIATH, SULTHAN BATHERY AND MUTHANGA RANGES
CHECKDAM
Kurichiath Range
Sulthan Bathery Range
Muthanga Range
Chedleth Range
Meppady Range
WAYANAD SOUTH DIVISION
TAMIL NADU STATE
76 15
76 30
11 45
11 40
N
W
E
S
0 2.5 5
Kilometers
Range boundary
Rivers
Roads
Forest area
Enclosure
Checkdam
Mavina halla
Kurichiyat puzha
Pavagadda
Bommadevar Betta
Kannaram puzha
Kurichiath
Chedleth puzha
Anappandi
Golur
Karati mala
Ammanvayal
Chedleth
Valayancheri
Nellippattakkunnu
Mattayamvayal
Pallivayal
Churakuni
Vallakottu
Kodamula kunnu
Karipur
Kallur
Tattur
Pachadi
Kallukattikolli
Thoramangalam
Komacheri
Mattakunnu
Valluvadi
Kanivallikunnu
Puttur
Manimunda
Tenkuzhi
Vellakkettu
Kottankara
Pilakavu
Arakunji
Manjal todu
Chundappadi
Kollumukkukunnu
Alattur
Rampalli
Nul puzha
Muthanga
Edattara
Kalangadi
Tekkambetta
Kumili
Pangalam
Kakkamalai
Erayamvayal
Puttadi
Kalladikolli
Narati betta
Karakkara
Kilukunnu
Gundal mala
Nulpuzha
Kaniyaram
Kundur
Kappad

Fig. 16

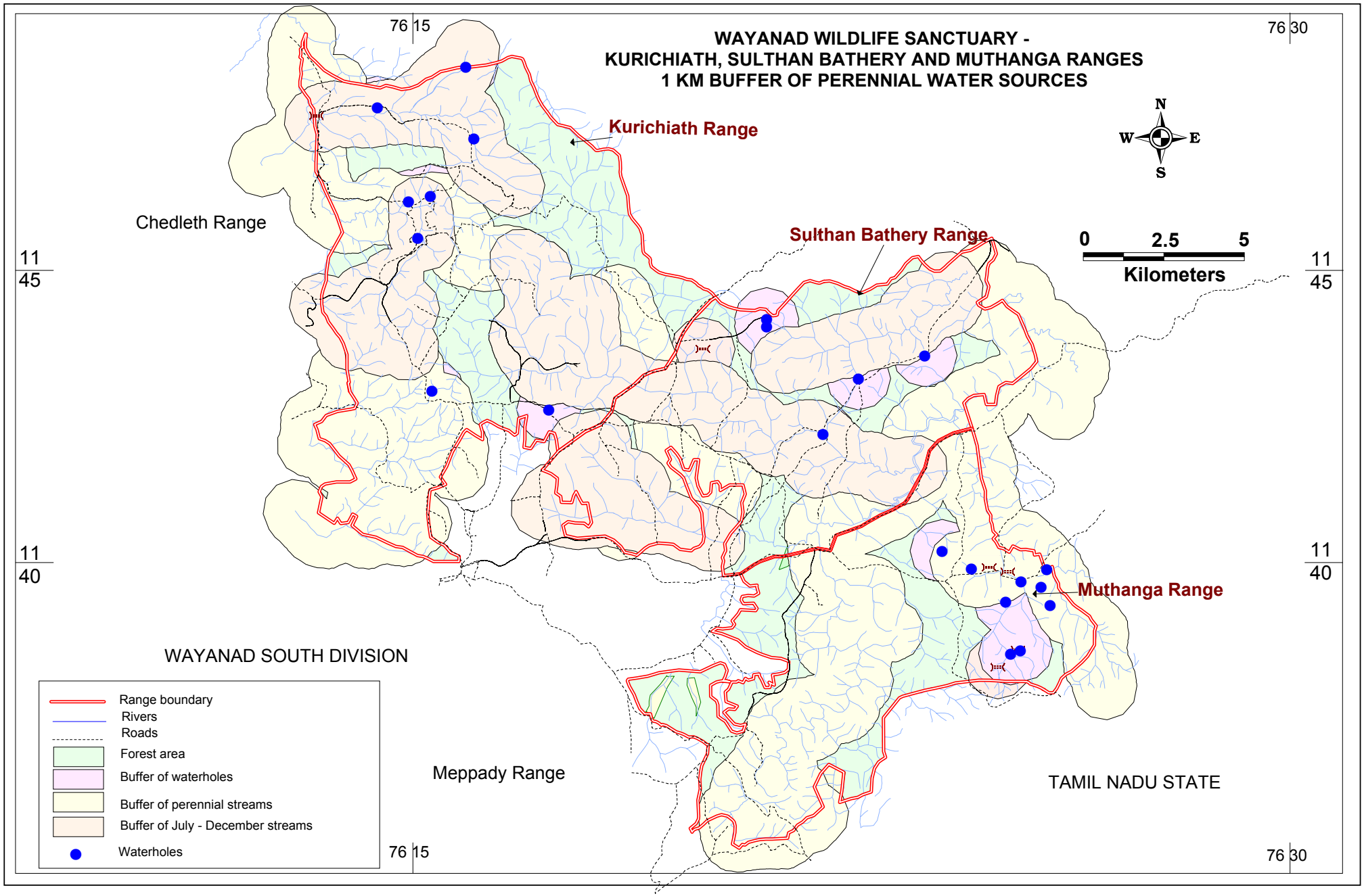

WAYANAD WILDLIFE SANCTUARY -
KURICHIATH, SULTHAN BATHERY AND MUTHANGA RANGES
1 KM BUFFER OF PERENNIAL WATER SOURCES
76 15
76 30
11 45
11 40
N
W
E
S
0 2.5 5
Kilometers
Kurichiath Range
Chedleth Range
Sulthan Bathery Range
Muthanga Range
WAYANAD SOUTH DIVISION
Meppady Range
TAMIL NADU STATE
Range boundary
Rivers
Roads
Forest area
Buffer of waterholes
Buffer of perennial streams
Buffer of July - December streams
Waterholes

Fig. 17

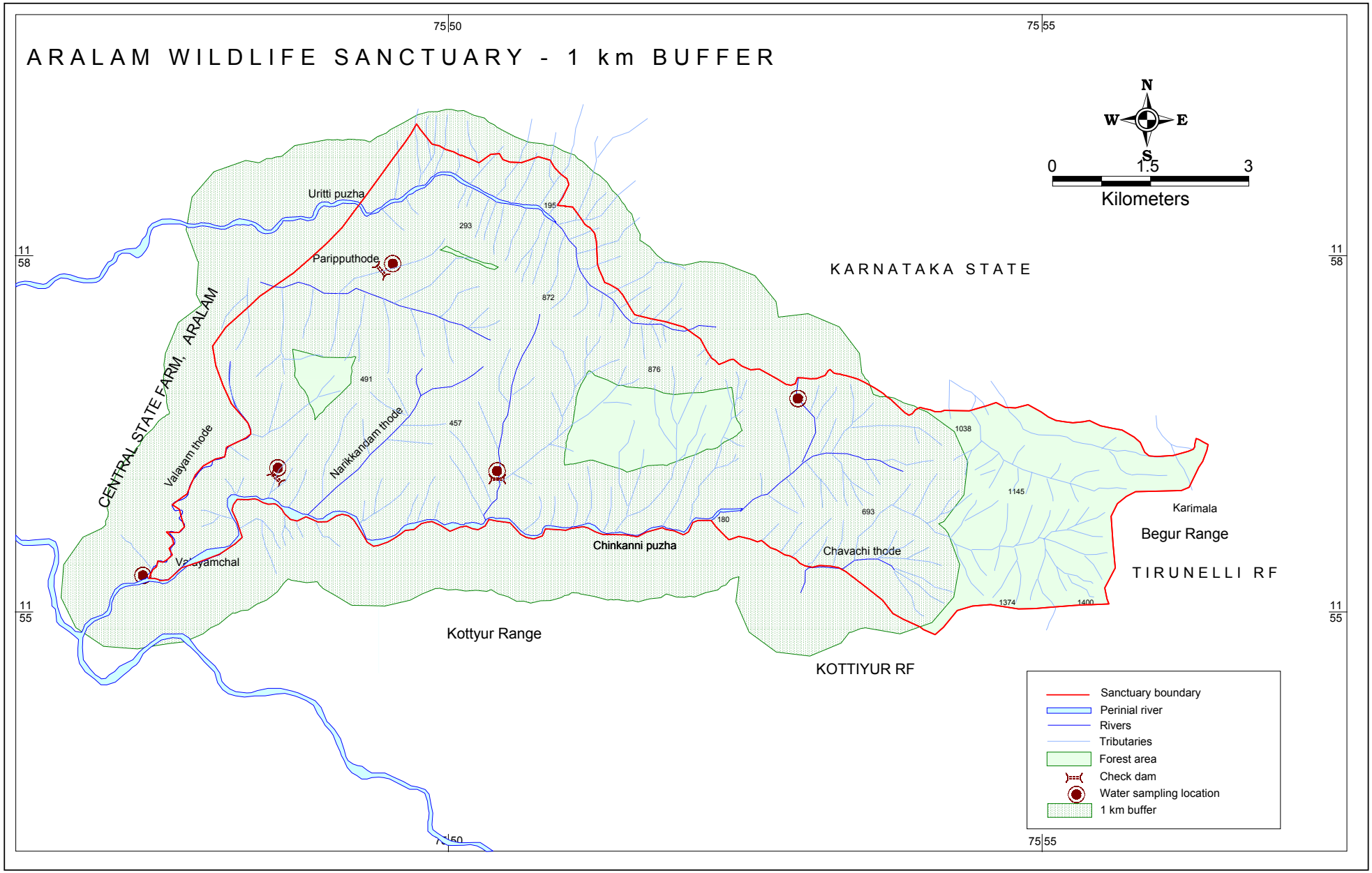

ARALAM WILDLIFE SANCTUARY - 1 km BUFFER
75 50
75 55
11 58
11 55
N
W
E
S
0
1.5
3
Kilometers
Uritti puzha
Paripputhode
KARNATAKA STATE
CENTRAL STATE FARM, ARALAM
Valayam thode
Narikkandam thode
Chinkanni puzha
Chavachi thode
Karimala
Begur Range
TIRUNELLI RF
Kottyur Range
KOTTIYUR RF
195
293
872
491
876
457
1038
1145
693
180
1374
1400
Sanctuary boundary
Perinial river
Rivers
Tributaries
Forest area
Check dam
Water sampling location
1 km buffer

Fig. 18

Table 2. Check dams and waterholes in the different ranges of Wayanad Wildlife Sanctuary

Place& Range	Type of water hole	Longitude	Latitude	Permanence	Nature of Management Required
THOLPETTY RANGE					
Tholpetty	Check dam	76.079332	11.899794	Perennial	
Tholpetty	Check dam	76.081406	11.905929	Perennial	
Tholpetty	Check dam	76.083850	11.912112	Perennial	
Tholpetty	Check dam	76.083177	11.917747	Perennial	
Tholpetty	Check dam	76.063905	11.911318	Perennial	
Tholpetty	Check dam in Nadunthana thodu	76.069748	11.934442	Perennial	
Tholpetty	Check dam in Nadunthana thodu	76.072024	11.941563	Perennial	
Tholpetty	Check dam	76.086740	11.941563	Perennial	
70^{th} teak plantation	Check dam	76.0876740	11.954794	Water retention is not enough, dries up in summer	Check dam broken. Needs repair
Dasankatte	Check dam	76.091838	11.936060	Perennial	
Onnampalam	Artificial Water hole	76.07055000	11.94508333	Perennial	Check pollution of Nadunthana thodu from coffee berry processing season (January to April)

….. continued

Thirulkunu section, Tholpetty	Artificial waterhole	76.06435000	11.92258333	Dries up in March and April	Water storage area needs to be increased so that water is available in summer
Onampalam kulam, Tholpetty	Artificial waterhole	76.07451667	11.94758333	Perennial	Desilting once in three years is needed
Kakkeri pond, Tholpetty	Artificial waterhole	76.08106667	11.95671667	Water dries up duing Feb to April	Increase water storage area so that water is available in summer
70th teak plantation, Tholpetty	Artificial waterhole	76.08700000	11.95560000	Water shortage during Feb to April	Depth should be increased. Broken water retention wall should be rebuilt.
Kaimara Junction, Tholpetty	Artificial waterhole	76.09755000	11.95066667	Perennial, covered with azola	Desilting every three years
Undichira pond, Tholpetty	Natural stagnant	76.09980000	11.93771667	Perennial	Desilting every three years
Dassankatte, Tholpetty	Artificial stagnant	76.09876667	11.92923333	Perennial	Increase depth of water storage

….. continued

KURICHIAT RANGE					
Chedleth, Kurichiat	Check dam	76.24347	11.744293		
Chedleth, Kurichiat	Check dam	76.25980	11.766495		
Chedleth, Kuruchiat	Check dam	76.276100	11.746634		
Chedleth , (Pallivayal)	Check dam	76.268296	11.735708		
Anapandhi , Kuruchiat	Check dam	76.22250000	11.79403333	Water available from July to October	
Doddapalam , Kuruchiat	Stream	76.24880000	11.766973333	Running water Available till October	
Pavagadha, Kuruchiat	Artifical waterhole	76.23988333	11.79641667	Water available till December	
Doddakulasi, Kuruchiat	Artifical waterhole	76.26506667	11.80811667	Water available throughout but less in summer	
Kuruchiat vayal, Kuruchiat	Artifical waterhole	76.26743333	11.78751667	Stagnant water	
Alathur puzha, Kuruchiat	Stream	76.25501667	11.77128333	Perennial	
Chethalayam, Kuruchiat	Stream, waterfall	76.25138333	11.75920000	Perennial	

….. continued

5th mile water pond, Kuruchiat	Artificial waterhole	76.25541667	11.76973333	Perennial water flowing	Not a suitable location for waterhole as it is near the road, cattle grazing and human disturbance
SULTHAN BATHERY RANGE					
Sulthan Bathery	Check dam	76.336944	11.724600	Perennial	
Panthankolly	Check dam	76.33265000	11.72571667	Perennial	Requires desilting.
Nallathanni	Check dam	76.355587	11.734606	No storage of water Down stream also water is less.	Requires concreting of the floor of the water storage area. Ideal location for check dam
	Check dam	76.366006	11.711272	Perennial	Requires desilting once in three years
Manjal Thodu	Check dam	76.363074	11.704219	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.350283	11.736367	Perennial	Requires desilting once in three years

….. continued

	Artificial Waterhole	76.332650	11.725170	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.348067	11.715733	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.367267	11.703650	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.376938	11.719167	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.391000	11.733700	Perennial	Requires desilting once in three years
	Artificial Waterhole	76.395933	11.725733	Perennial	Requires desilting once in three years
MUTHANGA RANGE					
Muthanga	Check dam	76.392517	11.678313	Perennial	Requires desilting once in three years
Muthanga	Check dam	76.418263	11.667271	Perennial	Requires desilting once in three years

….. continued

Muthanga	Check dam	76.385480	11.659823		Requires desilting once in three years
Muthanga	Check dam	76.406942	11.659833		Requires desilting once in three years
Muthappan kolly	Check dam	76.424695	11.658507		Requires desilting once in three years
Maragadha	Check dam	76.373770	11.654672	Dry period February to May standing water	Depth should be incresed
Muthanga	Check dam	76.373373	11.649907		Requires desilting once in three years
Muthanga	Check dam	76.419805	11.641543	Perennial	Requires desilting once in three years
Muthanga	Check dam	76.410242	11.636774	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.420383	11.640633	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.420367	11.654633	Perennial	Requires desilting once in three years

Muthanga	Artificial waterhole	76.431633	11.654633	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.43568	11.655433	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.429050	11.661217	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.430717	11.664917	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.419533	11.663983	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.414217	11.665250	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.409217	11.664883	Perennial	Requires desilting once in three years
Muthanga	Artificial waterhole	76.417533	11.669983	Perennial	Requires desilting once in three years

The pH was near neutral in all the water samples indicating no harmful effects on the animal usage. There was no visible pollution of water was noticed in the protected area. The contents of dissolved solids and suspended solids analyzed in the water samples indicate that water is clear. The other water quality parameters *viz* chlorides, phosphates and alkalinity studied in the water samples are in negligible level (250 mg/l chlorides; Phosphates-not available; Alkalinity-not available; Kudesia, 1992) as compared to guidelines of permissible limits for the drinking water. Likewise similar results were obtained in water samples collected from the Aralam Wildlife Sanctuary (Table 6; Appendix 3). There may be possibilities of pesticides sprays reaching the water from the adjacent agricultural farm in Aralam Wildlife Sanctuary. It needs to be monitored during the crop management activities in the farm to ascertain the level of pesticide reaching the water stream and their persistence in the water body.

In case of water samples from Wayanad Wildlife Sanctuary, pH was near neutral in all the water samples with slight seasonal variation among the water samples analyzed (Table 5; Appendix 2). Hardness in the water samples of Wayanad Wildlife Sanctuary recorded higher levels however; it is below the permissible limits. Water samples from water stream in Maragadha of Muthaga Range, Onnampalam water hole in Tholpetty Range and Machikudi canal in Bathery Range recorded high hardness. Calcium content in the water appear to be higher against negligible level of chlorides, alkalinity. Water samples contain negligible level of suspended solids, dissolved solids and organic carbon content in the water. The visible observations indicated that water will be turbid during the rainy season and muddy during the summer depending up on the water level in the water hole and water bodies however; the parameters contributing to the turbidity are far below the permissible limits (suspended solids 250 mg/l; total solids <500 mg/l; US Public Health Service Drinking Water Standards 1961; APHA, 1976; Welcher, 1975) for drinking water.

In general, all the water quality parameters studied in water sample collected from the study Protected areas during the different season indicate that there was no visible water pollution and water is safe for animal use.

Table 3 Water Quality parameters studied in samples collected from different water bodies occurring in Ervikulum National Park

Location	pH	Chlorides (mg/l)	Hardness (mg/l)	Calcium (mg/l)	Alkalinity (mg/l)	Dissolved solids (mg/l)	Suspended solids (mg/l)	Organic carbon (mg/l)	Phosphates (mg/l)
Sankumalai	6.15 ± 0.41	1.95 ± 0.61	8.50 ± 1.91	1.6 ± 0.20	**0.11± 0.05**	0.023 ± 0.01	0.05 ± 0.03	0.35 ± 0.04	1.37 ± 0.49
Rajamalai flowing water	6.86 ± 0.29	2.30 ± 0.36	5.00 ± 0.34	2.1± 0.80	0.11± 0.05	0.019 ± 0.01	0.02 ± 0.01	0.39 ± 0.04	1.58 ± 0.54
Naykolli malla	7.16 ± 0.39	1.95 ± 0.20	6.75 ± 0.96	4.18 ± 2.80	0.11± 0.02	0.029 ± 0.01	0.01 ± 0.00	0.38 ± 0.05	1.26 ± 0.75
Eravikulam thodu- hut area 1	6.91 ± 0.48	1.95 ± 0.20	4.50 ± 1.91	2.60 ± 1.30	0.11± 0.03	0.022 ± 0.01	0.05 ± 0.03	0.45 ± 0.08	1.24 ± 0.19
Eravikulam thodu-hut area 2	6.93 ± 0.29	1.86 ± 0.34	7.00 ± 3.82	2.40 ± 1.20	0.11± 0.05	0.020 ± 0.02	0.03 ± 0.01	0.41 ± 0.00	1.47 ± 0.66
Vattachadambu	6.56 ± 0.51	2.74 ± 0.45	8.50 ± 1.00	2.80 ± 0.60	0.09± 0.04	0.022 ± 0.01	0.02 ± 0.00	0.46 ± 0.05	1.07 ± 0.26
Bhemanode	7.00±0.00	1.86 ± 0.00	10.0 ± 0.00	1.60 ± 0.00	0.07± 0.00	0.027 ± 0.01	0.01 ± 0.00	0.41 ± 0.00	1.18 ± 0.21
MPCA plot	6.86 ± 0.54	2.21 ± 0.34	8.20 ± 1.91	1.37 ±0 .00	0.09± 0.00	0.024 ± 0.01	0.09 ± 0.05	0.30 ± 0.08	1.09 ± 0.39

Data are mean of three replicate analyses summed over three sampling period.

Table 4. Water Quality parameters studied in samples collected from different water bodies occurring in Aralam Wildlife Sanctuary

Location	pH	Chlorides mg/l	Hardness mg/l	Calcium mg/l	Alkalinity mg/l	Dissolved solids mg/l	Suspended solids mg/l	Organic carbon mg/l	Phosphate mg/l
Chullikandam	7.44 ± 0.51	2.00 ± 0.33	13.0 ± 4.16	2.71 ± 0.88	0.18 ± 0.11	0.021 ± 0.01	0.09 ± 0.02	0.35 ± 0.17	1.58 ± 0.77
Valanchal thodu	7.22 ± 0.29	2.59 ± 1.48	12.7 ± 3.06	3.40 ± 0.28	0.14 ± 0.06	0.016 ± 0.00	0.11 ± 0.01	0.37 ± 0.06	1.24 ± 0.17
Panthalplave check dam	7.14 ± 0.28	1.90 ± 0.84	18.7 ± 4.16	4.00 ± 0.00	0.23 ± 0.11	0.013 ± 0.01	0.01 ± 0.00	0.39 ± 0.21	1.41 ± 0.4
Meenmatti	7.13 ± 0.00	3.10 ± 0.00	10.0 ± 0.00	2.40 ± 0.00	0.37 ± 0.00	0.032 ± 0.00	0.01 ± 0.00	0.41 ± 0.00	1.63 ± 0.00
Paripthodu	6.71 ± 0.55	1.32 ± 0.33	11.3 ± 1.15	2.60 ± 0.35	0.12 ± 0.02	0.018 ± 0.01	0.002 ± 0.00	0.27 ± 0.09	1.52 ± 0.21

Data are mean of three replicate analyses summed over three sampling period.

Table 5 Water Quality parameters studied in samples collected from different water bodies occurring in Wayanad Wildlife Sanctuary

Location	PH	Chlorides (mg/l)	Hardness (mg/l)	Calcium (mg/l)	Alkalinity (mg/l)	Dissolved solids (mg/l)	Suspended solids (mg/l)	Organic carbon (mg/l)	Phosphates (mg/l)
Muthanga range									
Nellur vayal checkdam	7.67 ± 0.26	2.21 ± 0.45	37.70 ± 18.1	10.0 ± 1.38	0.7 ± 0.46	0.02 ± 0.01	0.12 ± 0.05	0.24 ± 0.20	1.5 ± 0.59
Nellur vayal-water stream	7.80 ± 0.45	1.94 ± 0.68	46.00 ± 8.25	12.6 ± 1.65	0.7 ± 0.52	0.02 ± 0.00	0.02 ± 0.00	0.29 ± 0.08	1.64 ± 0.80
Maragadha Water body 1	7.03 ± 0.53	2.12 ± 0.00	14.50 ± 3.42	6.75 ± 0.98	0.5 ± 0.34	0.05 ± 0.00	0.28 ± 0.15	0.52 ± 0.33	2.86 ± 0.83
Maragadha – Water body 2	7.45 ± 0.25	3.80 ± 0.62	25.00 ± 12.5	5.55 ± 2.91	1.06 ± 0.69	0.03 ± 0.01	0.11± 0.05	0.32 ± 0.07	2.86 ± 0.63
Maragadha thodu water stream	7.92 ± 0.36	2.10 ± 0.50	55.50 ± 14.0	13.0 ± 2.64	0.8 ± 0.64	0.02 ± 0.00	2.19 ± 0.26	0.47 ± 0.04	1.50 ± 0.23
Karadimunda - check dam	7.26 ± 0.33	2.85 ± 0.76	36.00 ± 16.2	8.60 ± 4.54	0.7 ± 0.49	0.01 ± 0.00	0.07 ± 0.02	0.31± 0.10	1.25 ± 0.27
Karadimunda check dam	7.32 ± 0.60	2.49 ± 1.48	28.00 ± 20.3	10.6 ± 3.65	0.5 ± 0.31	0.01± 0.00	0.30 ± 0.01	0.29 ± 0.10	1.26 ± 0.66
Karadimunda-stagnant waterbody	6.97 ± 0.36	2.70 ± 1.56	23.50 ± 7.00	4.80 ± 0.66	0.5 ± 0.38	0.01 ± 0.00	0.14 ± 0.06	0.25 ± 0.07	1.38 ± 1.02
Bagagadha check dam	7.62 ± 0.11	2.47 ± 0.65	17.30 ± 10.1	4.80 ± 2.12	0.5 ± 0.18	0.01± 0.00	0.32 ± 0.12	0.27 ± 0.12	1.52 ± 0.55
Muthappankolli water body	7.53 ± 0.53	1.96 ± 0.65	32.00 ± 13.1	8.60 ± 2.30	0.4 ± 0.28	0.02 ± 0.01	0.13 ± 0.07	0.25 ± 0.08	1.47 ± 0.57

Kurichiyath range									
Kurichiyat Waterhole	7.36 ± 0.54	3.95 ± 1.68	41.50 ± 30.0	8.35 ± 6.23	0.97 ± 0.27	0.01± 0.00	0.09 ± 0.04	0.31± 0.01	1.71 ± 1.09
Anapandhi check dam	6.95 ± 0.04	3.33 ± 1.30	32.00 ± 17.0	8.40 ± 2.82	0.94 ± 0.05	0.02± 0.01	0.07 ± 0.03	0.39 ± 0.12	1.5 ± 0.45
5th mile water hole	7.18 ± 0.32	2.59 ± 1.48	33.00 ± 8.72	6.00 ± 1.06	0.5 ± 0.25	0.05± 0.04	0.04 ± 0.01	0.19 ± 0.05	1.32 ± 0.11
Doddakulasy - waterhole	7.08 ± 0.40	2.69 ± 0.75	42.50 ± 21.6	11.2 ± 6.09	0.67 ± 0.41	0.15± 0.02	0.12 ± 0.06	0.25 ± 0.14	1.44 ± 0.92
Bathery range									
Machikudi canal	7.48 ± 0.62	2.90 ± 1.33	52.00 ± 11.2	13.0 ± 4.64	1.34 ± 0.79	0.03 ± 0.01	0.38 ± 0.19	0.55 ± 0.26	1.73 ± 0.88
Tholpetty range									
Onnampalam waterhole	7.66 ± 0.45	2.63 ± 0.91	51.50 ± 18.8	11.80 ± 4.94	0.85 ± 0.60	0.02 ± 0.01	0.25 ± 0.10	0.66 ± 0.28	1.89 ± 0.92
Kakkeripond waterhole	7.47 ± 0.56	2.77 ± 0.95	45.00 ± 41.6	10.60 ± 6.71	0.79 ± 0.61	0.02 ± 0.00	0.07 ± 0.02	0.33 ± 0.18	1.58 ± 0.18
Dasankatte/Kaimara Jn: waterhole	7.48 ± 0.48	2.64 ± 0.27	44.80 ± 19.6	12.30 ± 4.78	0.78 ± 0.33	0.01 ± 0.00	0.06 ± 0.02	0.23 ± 0.10	1.29 ± 0.23
Dasankatte – udichira waterhole	7.67 ± 0.64	3.56 ± 1.10	46.00 ± 20.1	10.80 ± 3.60	0.62 ± 0.45	0.06 ± 0.02	0.12 ± 0.03	0.25 ± 0.12	1.55 ± 0.62
Dasankatte waterhole	7.54 ± 0.44	2.85 ± 0.42	35.00 ± 14.4	12.10 ± 4.08	0.85 ± 0.41	0.01± 0.00	0.10 ± 0.08	0.37 ± 0.16	1.84 ± 0.68

Data are mean of three replicate analyses summed over three sampling period.

Table 6. Prominent natural saltlick areas monitored in Wayanad Wildlife Sanctuary

Sl. No	Place name of Salt lick spots	Latitude	Longitude
	Muthanga range		
1	Maragadha	11.65463333	75.79073333
2	Trijunction 1	11.66556667	76.43181667
3	Trijunction 2	11.65543333	76.43568333
4	Nallur stream salt lick.	11.66465000	76.41933333
	Kurichiat Range		
1	Doddakulasi vayal	11.80530000	76.26638333
2	Kurichiat vayal	11.78751667	76.26743333
	Bathery Range		
1	Manjal thodu salt lick	11.70365000	76.36726667
2	Machikudi vayal under the mango tree	11.71670000	76.34760000
3	Nallathani	11.73636667	76.35000000
4	Kumalla halla.	11.70173333	76.38975000
	Tholpetty Range		
1	Tholpetty	11.92265000	76.06433333
2	Onnampallam 1	11.94511667	76.07226667
3	Onnampallam 2	11.94510000	76.07171667
4	Dassankatte	11.92846667	76.09928333
5	Ayappanpara 1	11.91828333	76.08383333
6	Ayappanpara 2	11.91828333	76.08383333

Table 7 pH and mineral element contents of soil salt licks collected from Wayanad Wildlife Sanctuary

Location	pH	Mg (%)	Ca (%)	Na (%)	TN (%)	TP (%)
Muthanga Range						
Nellur vayal under bamboo clump soil salt lick	7.33 ± 0.97	2.11 ± 1.33	2.11 ± 1.52	2.11 ± 1.77	2.10± 0.16	2.11 ± 0.06
Nellur thodu	6.76 ± 0.13	1.50 ± 0.09	5.05 ± 3.41	14.6 ± 6.23	0.80 ± 0.27	0.03 ± 0.01
Nellur thodu under bamboo clump	6.35 ± 0.13	1.19 ± 0.16	2.82 ± 0.66	12.0 ± 6.20	0.30 ± 0.01	0.03 ± 0.01
Maragadha thodu soil salt lower portion	6.80 ± 0.94	5.91 ± 4.90	8.80 ± 5.62	17.8 ± 5.20	0.50 ± 0.2	0.05 ± 0.02
Maragadha thodu soil salt lick 1	6.47 ± 0.55	2.27 ± 0.70	7.26 ± 4.66	11.4 ± 4.70	0.90 ± 0.37	0.11 ± 0.03
Maragadha thodu soil salt lick 2	8.60 ± 0.10	2.76 ± 1.26	5.71 ± 2.52	12.7 ± 9.30	0.40 ± 0.25	0.07 ± 0.07
Maragadha thodu soil salt lick 3	6.40 ± 0.17	4.84 ± 4.41	9.65 ± 6.31	13.4 ± 5.80	1.30 ± 0.00	0.13 ± 0.10
Maragadha thodu soil salt lick 4	8.11 ± 0.41	2.44 ± 0.46	4.23 ± 2.51	15.5 ± 2.40	0.10± 0.06	0.12 ± 0.10
Maragadha thodu soil salt 5	7.22 ± 0.34	1.89 ± 0.84	2.38 ± 1.19	11.2 ± 8.50	0.20 ± 0.08	0.12 ± 0.06
Maragadha trijunction Maragadha (upper portion)	5.83 ± 0.49	2.48 ± 0.28	8.34 ± 1.60	9.44 ± 10.70	1.40 ± 1.02	0.10 ± 0.03
Surface Soil	5.43 ± 0.40	1.54 ± 0.39	4.26 ± 2.52	5.70 ± 2.40	0.13 ± 0.07	0.09 ± 0.05
Bathery Range						
Nallathanni soil salt lick	6.20 ± 0.54	1.85 ± 0.63	2.30 ± 1.03	23.00 ± 4.15	0.20 ± 0.05	0.04 ± 0.02
Malchikudi vayal, soil under the mango tree	8.06 ± 0.59	3.87 ± 2.08	11.40 ± 3.59	9.22 ± 5.20	0.50 ± 0.15	0.03 ± 0.01
Manjal Vayal	6.65 ± 0.78	2.09 ± 0.18	7.29 ± 2.49	15.70 ± 3.10	0.70 ± 0.49	0.02 ± 0.01
Varalam	8.80 ± 0.20	5.64 ± 0.00	7.20 ± 0.74	4.54 ± 0.10	0.60 ± 0.05	0.08 ± 0.02
Kumallihalla (visible evidence of Elephants activity)	8.75 ± 0.21	6.40 ± 0.86	26.20 ± 2.9	12.50 ± 4.90	0.70 ± 0.54	0.22 ± 0.02

Surface Soil	7.70 ± 0.52	7.80 ± 0.76	2.70 ± 0.21	2.6 ± 1.1	0.3 ± 0.07	0.09 ± 0.03
Kurichiyath Range						
Kummichi vayal soil salt lick (previously artificial salt licks were provided)	5.80 ± 0.31	0.86 ± 0.11	2.47 ± 0.11	9.16 ± 3.90	0.20 ± 0.03	0.06 ± 0.01
Udimaran vayal	7.90 ± 0.16	9.49 ± 0.71	7.71± 0.41	7.96 ± 0.90	0.12 ± 0.01	0.02 ± 0.00
Doddakulasi Vayal	5.30 ± 0.12	1.10 ± 0.23	7.70 ± 0.34	18.50 ± 4.30	0.03 ± 0.01	0.05 ± 0.00
Mavinthal vayal near flowing water	7.00 ± 0.19	4.71 ± 0.30	4.13 ± 0.38	0.55 ± 0.18	0.10 ± 0.02	0.01 ± 0.00
Surface Soil	6.90 ± 0.26	1.10 ± 0.30	2.87 ± 0.34	2.89 ± 1.15	0.10 ± 0.03	0.01 ± 0.00
Tholpetty Range						
Onnampalam	6.35 ± 0.47	2.58 ± 1.30	7.22 ± 2.19	12.10 ± 6.80	0.52 ± 0.29	0.10 ± 0.04
Onnampalam surface soil	7.76 ± 0.64	6.67 ± 3.61	11.30 ± 1.63	17.00 ± 7.50	0.10 ± 0.04	0.08 ± 0.05
Onnampalam soil salt lick 1	6.83 ± 0.77	3.52 ± 1.61	8.99 ± 4.17	15.60 ± 6.80	0.80 ± 0.76	0.11± 0.08
Onnampalam soil salt lick 2	6.75 ± 0.71	2.46 ± 0.65	5.29 ± 0.45	12.90 ± 5.20	0.30 ± 0.09	0.11± 0.05
Kakkeri Vayal	6.75 ± .0.99	3.02 ± 1.72	5.80±0.38	9.15 ± 4.50	0.40 ± 0.28	0.19 ± 0.03
Ayyappanpara soil salt lick (near animal pass)	7.86 ± 0.64	10.2 ± 4.86	13.70 ± 3.79	48.00 ± 45.30	0.80 ± 0.28	0.17 ± 0.11
Ayyappanpara rocky area	6.90 ± 0.12	2.85 ± 0.06	8.42 ± 1.22	4.68 ± 2.86	0.90 ± 0.52	0.38 ± 0.31
Dasanakatte	5.60 ± 0.31	1.43 ± 0.29	5.97 ± 1.28	18.50 ± 0.41	0.30 ± 0.16	0.29 ± 0.15
Surface Soil	6.40 ± 0.70	2.60 ± 1.42	3.80 ± 0.38	9.15 ± 4.60	0.38 ± 0.15	0.08 ± 0.03

Data are mean of three replicate analyses summed over three sampling period.

Table 8. pH and mineral element contents of surface soil collected form Aralam Wildlife Sanctuary

Location	pH	Mg (%)	Calcium (%)	Na (%)	TN (%)	TP (%)
Chullikandam	5.55 ± 0.10	1.45 ± 0.23	4.23 ± 1.49	16.5 ± 3.18	0.98 ± 1.37	0.07 ± 0.00
Ponthanplave 1	5.93 ± 0.12	1.60 ± 0.06	5.65 ± 2.70	14.0 ± 0.42	0.49 ± 0.28	0.09 ± 0.05
Ponthanplave 2	5.83 ± 0.00	1.38 ± 0.00	2.06 ± 0.00	14.9 ± 0.00	2.75 ± 0.00	0.17 ± 0.00
Ponthanplave 3	5.65 ± 0.14	1.38 ± 0.26	2.98 ± 0.43	12.2 ± 7.79	1.65 ± 1.13	0.07 ± 0.00
Meen matti (upper area)	6.43 ± 0.00	1.00 ± 0.00	2.5 ± 0.00	2.6 ± 0.00	1.04 ± 0.00	0.018 ± 0.00
Meen matti (lower area)	5.90 ± 0.00	1.28 ± 0.00	3.50 ± 0.00	4.9 ± 0.00	2.97 ± 0.00	0.16 ± 0.00
Paripthodu	5.50 ± 0.00	1.06 ± 0.00	6.00 ± 0.00	15.5 ± 0.00	0.23 ± 0.00	0.12 ± 0.00

Data are mean of three replicate analyses summed over three sampling period.

Table 9. pH and mineral element contents of surface soil collected form Eravikulam National Park

Location	pH	Mg (%)	Ca (%)	Na (%)	TP (%)	TN (%)
Sankumalli	4.83 ± 0.42	0.88 ± 0.56	2.19 ± 1.60	4.72 ± 2.45	0.18 ± 0.07	7.6 ± 4.23
Rajamalai	4.86 ± 0.32	0.74 ± 0.44	2.39 ± 1.15	1.76 ± 0.78	0.22 ± 0.10	7.9 ± 4.7
Soil under grass near wire less station	5.09 ± 0.78	0.96 ± 0.93	5.09 ± 3.62	1.61 ± 1.53	0.17 ± 0.03	6.5 ± 3.94
Soil sample below the ferns	4.70 ± 0.37	0.71± 0.52	1.40 ± 1.29	3.08 ± 1.99	0.22 ± 0.07	3.0 ± 1.04
Eravikulam hut area						
Eravikulammala surface soil	5.19 ± 0.44	0.72 ± 0.38	2.18 ± 1.10	3.02 ± 1.76	0.19 ± 0.01	5.5 ± 3.35
Eravikulammala-Upper portion (fire occurred last Jan 2000)	4.62 ± 0.25	0.07 ± 0.03	0.8 ± 0.18	0.11 ± 0.04	0.14 ± 0.06	12 ± 0.93
Eravikulammala-Lower portion (fire occurred last Jan 2000)	5.17 ± 0.44	0.57 ± 0.32	0.96 ± 0.28	2.14 ± 1.40	0.26 ± 0.01	0.2 ± 0.12
Eravikulammala-Unburnt	4.87 ± 0.70	0.58 ± 0.35	3.54 ± 0.00	3.34 ± 0.44	0.18 ± 0.00	0.4 ± 0.22

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Hut area- Soil from enclosure upper area	5.66 ± 2.15	0.11± 0.05	1.64 ± 0.00	0.07 ± 0.02	0.04 ± 0.02	6.8 ± 1.77
Hut area- Soil from enclosure lower area	4.78 ± 0.45	0.86 ± 0.53	2.14 ± 1.43	1.90 ± 0.09	0.12 ± 0.09	3.5 ± 1.91
Eravikulammala	4.85 ± 0.21	3.19 ± 3.01	1.29 ± 0.55	3.29 ± 2.49	0.12 ± 0.11	3.9 ± 0.76
Vattachathuppu (experimental plots outside)	4.78 ± 0.54	0.72 ± 0.59	1.54 ± 1.44	3.29 ± 0.44	0.16 ± 0.04	3.9 ± 0.89
Vattachathuppu (experimental plots inside)	5.00 ± 0.41	0.71 ± 0.59	1.76 ± 1.58	2.09 ± 1.12	0.14 ± 0.03	7.2 ± 4.7
MPCA Plot	4.80 ± 0.38	0.65 ± 0.63	1.83 ± 0.93	3.32 ± 0.90	0.15 ± 0.04	3.7 ± 2.02

Data are mean of three replicate analyses summed over three sampling period.

Table 10. Nutrient content analysis in the grass samples collected from Eravikulam National Park

Location	Grass Species	TN (%)	TP (%)	Na (%)	Mg (%)	Ca (%)
Sankumalai area	Chrysopogon hackeli	0.50 ± 0.39	0.06 ± 0.03	0.60	011	0.06
	Chrysopogon hackeli	0.45 ± 0.15	0.05 ± 0.03	0.30	0.09	0.10
	Chrysopogon hackeli	0.26 ± 0.00	0.01 ± 0.00	0.28	0.10	0.05
	Dicanthium oliganthum	1.05 ± 0.38	0.11± 0.05	0.38	0.17	0.04
Burnt area	Andropogan polyptychus	1.04 ± 0.82	0.10 ± 0.02	0.60	0.31	0.07
Hut area						
Ervikulamala	Apluda mutica	0.57 ± 0.28	0.06 ± 0.01	0.93	0.21	0.33
	Eulalia phacothrix	0.65 ± 0.00	0.03 ± 0.00	1.15	0.08	0.02
-Upper portion.	Chrysopogon hackeli	0.50 ± 0.28	0.30 ± 0.52	0.67	0.13	0.03
-Lower portion	Chrysopogon hackeli	0.55 ± 0.31	0.31± 0.04	1.25	0.16	0.06
Vattachadambu (experimental plots in side)	Chrysopogon hackeli	0.53 ± 0.24	0.26 ± 0.04	0.28	0.14	0.06
(experimental plots outside)	Apocorposis caurtallumensis	0.62 ± 0.37	0.06 ± 0.02	0.82	0.31	0.12
MPCA Plot.	Andropogan polyptychus	0.69 ± 0.33	0.06 ± 0.03	0.64	0.19	0.06
	Apluda mutica Eulalia phacothrix	0.29 ± 0.00	0.02 ± 0.00	0.98	0.11	0.08

Data are mean of three replicate analyses summed over three sampling period.

Table 11 Nutrient content analysis in the grass sample Collected from Wayanad Wildlife Sanctuary and Aralam Wildlife Sanctuary

Location	Grass Species	Mg (%)	Ca (%)	Na (%)	TN (%)	TP (%)
Wayanad Wildlife Sanctuary						
Muthanga Range						
Muthappankolii	*Themeda tremula*	0.24	0.32	0.81	0.55 ± 0.17	0.10 ± 0.00
Nellur thodu	*Apluda mufics, Eragostis sp*	0.25	0.34	1.14	0.76 ± 0.29	0.24 ± 0.00
Nellur thodu (Near check dam)	*Eragrostic japenics*	0.21	0.33	1.04	0.29 ± 0.23	0.09 ± 0.04
Nellur thodu (Near check dam)	*Eragrostic japenics*	0.16	0.26	0.95	0.50 ± 0.00	0.13 ± 0.00
Maragadha thodu	*Themeda tremula*	0.23	0.40	0.98	0.56 ± 0.10	0.11 ± 0.05
Maragadha thodu		0.21	0.38	0.85	0.87 ± 0.49	0.15 ± 0.03
Trijunction Maragadha	*Digitaria bicornis*	0.23	0.40	0.96	0.75 ± 0.24	0.15 ± 0.07
	Imperata cylindrica	0.20	0.41	1.02	0.60 ± 0.00	0.22 ± 0.00
	Themeda cymbaria	0.21	0.35	0.57	0.70 ± 0.00	0.20 ± 0.00
Kurichiyat Range						
Kumachi vayal	*Imperata Cylindrica*	0.19	0.28	0.76	0.74 ± 0.00	0.14 ± 0.00
Kumachi Vayal	*Imperata Cylindrica*	0.16	0.32	0.85	0.56 ± 0.00	0.10 ± 0.00
Udimaran vayal	**Digitaria bicornis**	0.18	0.30	0.78	0.72 ± 0.00	0.06 ± 0.00
Doddakulasi vayal	*Axonopus compresses*	0.23	0.42	1.30	0.70 ± 0.00	0.10 ± 0.00
	Themida triandra	0.11	0.30	0.66	0.56 ± 0.16	0.12 ± 0.09

Tholpatty Range						
Kakkari area	*Imparata cylindrica*	0.12	0.01	0.23	0.30 ± 0.26	0.08 ± 0.00
	Imparata cylindrica	0.41	0.49	0.44	0.76 ± 0.00	0.04 ± 0.00
Undichera	*Imparata cylindrica*	0.17	0.33	0.20	0.78 ± 0.00	0.12 ± 0.00
Dassankatte	*Imparata cylindrica*	0.24	0.30	1.13	0.44 ± 0.00	0.08 ± 0.00
Bathery range						
Manjal thodu	*Chrysopogon fulvus*	0.17	0.34	0.29	1.04 ± 0.00	0.08 ± 0.00
Machikudi vayal	*Apluda mufics*	0.24	0.30	0.49	0.48 ± 0.00	0.06 ± 0.00
Aralam Wildlife Sanctuary						
Chullikandam	*Isachne setosa*	0.68	0.21	1.56	0.72 ± 0.00	0.05 ± 0.00
Ponthan plave	*Brachiaria miliformis*	0.54	0.08	0.88	0.87 ± 0.00	0.04 ± 0.00

Data are mean of three replicate analyses summed over three sampling period.

4.3. Natural occurrence of soil salt licks and mineral salt contents

The occurrence of natural salt licks in the three protected area was analyzed during the study period. Wayanad Wildlife sanctuary has large number of natural soil saltlick spots especially near the riverbanks and natural water bodies (Table 3). Maragadha thodu in Muthanga range (Fig. 19) Ayyappapara in Tholpetty range (Fig. 20), Cave like saltlick area at Varlam in Bathery Range (Fig. 21) are some of the prominent saltlicks frequently visited by herbivores. Visible salt deposition (white specks of salt) (Fig. 22) was observed in salt lick at Ayyappapara and Varalam. It is worthwhile to mention here that some of the natural salt licks observed during the first field trip were sloughed-in and not used by animals. Ayyappapara had highest concentration of exchangeable bases like Sodium Calcium and Magnesium. Surface soil samples collected in the salt lick were also analyzed for Sodium, Calcium and Sodium, surface soil contain lower level of these minerals as compared to salt licks. There was no appreciable differences in the total Nitrogen and total Phosphorus content in the salt lick and surface soil (Table 7; Appendix 5). In Aralam Wildlife Sanctuary (Table 9) and Eravikulum National Park (Table 8; Appendix 4), no natural salt lick spots were observed. However, surface soil samples collected were analyzed for mineral element contents. The mineral contents were lower in all the soil samples and no appreciable quantity of Sodium was recorded as seen in salt licks of Wayanad Wildlife Sanctuary. In general, Sodium was the dominant mineral in the salt lick. Sodium and Calcium contents of natural salt lick spots was however lower than in the artificial saltlick prescribed for (Indian Standard, 1992) domestic animals, which is 22% of Na as NaCl salt and Ca as $CaCO_3$, respectively. In the present study the Sodium content in the natural salt lick soil was in the range of 2-18% and 2.11-13.7% of Ca in most of the salt licks except salt licks at Ayyapapara (48%) and Dasankatta (18.5%). It appears that artificial salt lick need to be kept in the area preferably near natural salt lick spots, which are most frequented by herbivores to supplement the additional salt for the animals. However, it is difficult to specify the composition of the different mineral contents in the artificial salt lick as information lacks on the animal requirement and the physiological functions of the minerals in animal body. Furthermore, various herbivores eat the soil salt lick and their body requirement may vary making it difficult to assess quantity required. It warrants further

study to correlate the mineral content in the soil salt lick and herbivore requirement based on the record of feeding habits of animals.

Forage samples were also collected from the protected area and analyzed for total Nitrogen and Phosphorus content. Grass samples contain lower levels of exchangeable bases like Sodium. Calcium and Magnesium and Nitrogen and Phosphorus as compared to their content in soil. Grass samples collected during the different areas at different sampling dates showed negligible seasonal variation in mineral content in the plant biomass both at Eravikulum National Park (Table 10), Wayanad Wildlife Sanctuary and Aralam Wildlife Sanctuary (Table 11). Soil samples were also collected from the burnt (fire occurred in January 2000) and un-burnt area in Eravikulam National Park. There was no appreciable change in the mineral content of the soil in burnt and un-burnt area. (Table 8).

5. DISCUSSION

5.1. Water Quality

Water is the most important in gradient of the living organisms and act as medium for metabolic process. Water quality plays a crucial role in the natural water bodies for assessing its suitability for drinking purpose. In the natural ecosystems the quality of water may be influenced by array of unknown factors. Thus, quality of water in the natural conditions needs to be assessed for its suitability to animal use. In the present study an attempt has been made to characterize the quality of water occurring in the protected areas during the different seasons of the year.

Water samples collected from the different Protected areas were analyzed for different water quality parameters. In general water quality parameters studied fall below the permissible limit of the drinking water prescribed by US Public Health Service Drinking Water Standards (Welcher, 1975). The pH of the water was near neutral during all seasons of the year. There were small variations in the hardness of the water occurring in the different eco-region of the Protected areas, which is again within the permissible limit of drinking water quality. Water samples collected during the rainy season of the year showed certain degree of turbidity due to soil washed through runoff. However, the level

of turbidity falls below the level notified for the quality of drinking water. The relationship between animal usage and quality of the water cannot be established. There was no anthropogenic pollution of water bodies in the Protected areas studied except suspected pesticide residues reaching the water stream in Aralam Wildlife Sanctuary. Plant production practices like pesticide and fertilizer application in the adjacent farm may be one of the probable sources of contamination. However, it needs to be confirmed during the spray period and possible toxicity to animals.

In general, water quality of water bodies occurring in the different Protected areas appears to fall below the permissible limit of drinking water and safe for animal usage. There were no visible source of water pollution activities in the Wayanad Wildlife Sanctuary and Eravikulum National Park. However, probability of pesticide residues reaching the water stream in Aralam Wildlife sanctuary need to be analyzed coinciding the pesticide spray schedule in the adjacent farm. It may be mentioned here that most of the pesticides are biodegradable and their pesticide effect will be lost with in a short period (Bollag and Liu, 1990). It makes difficult to assign any ill effects of the pesticide residues reaching the water stream long after its application. It would be useful to analyze the effect, if any on wild animals, immediately after the pesticide application. The evidence of letting in of the effluent of coffee processing unit was noticed in the Nadudan thodu of Tholpetty range in Wayanad Wildlife Sanctuary. The down stream of this river reaches the Onnampalam check dam. A suggestion to coffee processing unit to find alternative way of disposal would solve the problem. We also analyzed the coffee effluent as done for water samples collected from the study area. Coffee effluent appears to be high in Calcium content (30.45 mg/l), total hardness (142 mg/l) and free chlorides (7.940 mg/l).

5.2. Soil salt lick and animal consumption

The salt lick spots are the prominent salt deposit areas, which are used/ingested by the animals to meet the body requirements. The soil licking habit of animals has been reported for many large herbivores and omnivores. Ingestion of soil by wildlife may be important for acquisition of minerals particularly those found in far higher quantities in soil than in plants (Maskall and Thornton, 1989). The relationship between mineral deficiencies in

domestic animals and mineral nutrition has been reported elsewhere (Thornton, 1983). However, there is no information available on the nutritional requirement of animals. Moreover, it is difficult to assess the nutritional requirements of the animals in the wild to derive a suitable elemental composition and provide them supplement.

In Wayanad Wildlife Sanctuary, large numbers of natural soil salt lick spots were seen in Muthanga and Tholpettty ranges, which always contained high amounts of sodium, calcium and magnesium. Artificial salt licks may need to be placed in certain locations preferably near water sources to meet animal requirements. It would be difficult to specify the proportion of salt mixtures in the artificial salt licks as the animal community is mixed and difficult to assess the body requirement.

There were no visible salt lick spots in Aralam Wildlife Sanctuary and Eravikulam National Park. Moreover, no sign of animals eating the soil especially near the water source as seen in the Wayanad Wildlife Sanctuary. It appears that natural slat licks are not common in these two Protected areas. However, surface soil samples collected from the Protected areas were analyzed for the mineral salt concentration. The amount of Sodium, Calcium and Magnesium were lower in the surface soil samples as compared to the salt content recorded in the natural slat lick spots.

In the present study, we collected soil salt licks and surface soil samples and analyzed for some of the mineral nutrient contents. Soil salt lick samples always contained high amounts of Sodium, Calcium and Magnesium in that order (Tables 7, 8 and 9). This in confirmation with the results reported for Benoue National Park (Stark 1986) wherein natural salt licks always contained high levels of sodium as compared to surface soil. Several researchers have concluded that soil supplements the need for sodium by the animals (Weir, 1972; Maskall and Thornton, 1989). There was no clear indication between the nutrient levels in the forage and mineral contents of the salt licks. Moreover, it is difficult to correlate the animal requirement of mineral salts and it requires the prudent analysis of animal requirement in detail. Furthermore, it would be difficult to assess the body requirements of minerals of animals in the wild. In a study, Henshaw and Ayeni (1971) could not assign natural salt lick use to any one specific element. Under these

situations it calls for comparison of mineral concentration of artificial saltlicks provided to animals in captivity. It appears that natural salt licks contain lower levels of Sodium as compared to ingredient in the artificial salt lick specified for domestic animals. Artificial salt lick provided to the captive animals contains various levels and mixtures of minerals depending up on the target animals. It is worthwhile to mention here that captive animals are fed with limited type of fodders as compared to choice of forages in the wild. Thus it forms unrealistic comparison to arrive at mineral requirement of animals in the wild. However, it forms the basis for comparison of the mineral salt concentration in the natural salt licks for formulation of salt mixture to be provided as artificial salt licks in the wild conditions.

In most of the cases, natural salt licks were seen near the riverbanks and/or streams. Indirect evidence of licking activities of animals was recorded near the river banks/near tree trunks/bamboo clumps near river basins. It suggests that any artificial salt lick management aspects should be carried out near the water source. Surface soil samples collected 2 meter away and on the upper slope of the salt lick spots recorded low levels of minerals like Sodium, Calcium and Magnesium. Analyses of salt licks indicate that Sodium was consistently high in all the salt lick soil samples.

5.3. Forage and Mineral Content

Forage of animals may be one of the other sources of mineral nutrients. The nutrient contents of the forage may vary depending upon the soil nutrient status and uptake rate of plants. In various ecosystems, sources of inputs of the major nutrients are unknown and the processes that determine the exchanges of nutrients within systems are not clearly quantified. Thus, analyzing the nutrient contents of the dominant forage species would be another option to know the changes in the contents of the mineral salts.

Dominant forage (grass) samples were also collected from the study area and analyzed for major nutrients like Nitrogen, Phosphorus, Sodium, Calcium and Magnesium. There was no difference in the nutrient concentration of the forage during the different seasons. However, forage samples collected from the Eravikulam National Park contain very high

levels of Nitrogen. Soil also contained high levels of nitrogen, it could be one of the reasons for high levels of Nitrogen accumulation in the biomass of the grass. In a study, multiple regression analysis to identify the dependant factors, indicate that no physiological benefit was apparent for ingesting lick soils but increased lick use towards the end of the dry season may indicate poorer quality grass forage (Stark, 1986). Moreover, during dry season due to non-availability of forage animals may tend to use soil salt licks to meet the body requirement. In the present study there was no appreciable differences in the mineral content of the forage during the different season of the year. The requirement of a particular salt by various herbivores might vary and therefore it becomes difficult to identify specific salt deficiency or sufficiency. Moreover, physiological function of a mineral is not clear and it requires detailed information on dietary composition/contents of feed provided to an animal.

The relationship between dietary habits, the mineral status in the soil and water play an important role in meeting the minerals requirement of herbivores in a locality. In some cases, intensive use of an area naturally leads to deficiencies; these deficiencies can usually be corrected by supplementation of animals with the appropriate mineral rich feeds. However, results of the present study are insufficient to draw up mineral composition for the animals in the wild. Moreover, the animal composition and their variable body requirement further complicate the prescription of mineral composition in artificial salt lick. Few number of artificial mineral mixtures prescriptions are available for domestic animals and birds (Singh, 1995) however, there are no specific mineral mixture formulation is available for herbivores in the wild because little is known about their metabolic function (Stark, 1986; Maskall and Thornton, 1989). A detailed study is warranted to link the body requirement of animals and nutritional habits through integrating the mineral content of artificial lick.

6. SUMMARY

Water availability was monitored in the protected areas and suggestions have been drawn up based on the spatial distribution and water availability during the different seasons.

Water bodies in the Wayanad Wildlife Sanctuary are spread across different ranges and additional water bodies need to be created to meet animal requirement of water during dry periods of the year. Most of the check dams constructed to reduce runoff are damaged and need maintenance at least once in three years.

Eravikulam National Park has abundant water with lot of perinneal streams. The ungulate population in the Park is mainly the Nilgiri tahr which is associated with the cliff like areas and grasslands. For the other animals like sambar, gaur and elephant there are enough perinneal water sources in the Park.

In Aralam Wildlife Sanctuary most of the streams are perennial and water scarcity was not observed. As the sanctuary is more wooded and less open grassland is found the herbivore number is not much except elephants and sambar deer.

In general, water quality examined indicates that water is safe for animal used. No observable pollution was noticed in Eravikulam National park however, effluent from a coffee processing unit reaching stream in Wayanad Wildlife Sanctuary is observed. Pesticide residue reaching the stream in Aralam Wildlife Sanctuary is suspected.

Wayanad Wildlife Sanctuary has good number of natural salt licks, which are regularly used by the animals. No natural salt lick spots were observed in the Eravikulam National Park and Aralam Wildlife Sanctuary. Sodium is the dominant element in the salt licks followed by calcium and magnesium.

7. SUGGESTIONS FOR MANAGEMENT

7.1. Eravikulam National Park:

1. As there is enough water, there is no need for making manmade structures like check dams for animals.
2. As the area is of great scenic value, and water being plentiful during all the months, care should be taken not to make any construction which will be an eye sore for the unique landscape.

7.2. Wayanad Wildlife Sanctuary:

1. This sanctuary requires special attention as the area forms part of the Elephant Reserve No. 7 under the Project Elephant.

2. Water management should be mainly focused on the water availability for the large mammals during the pinch period (January to April) when the water shortage is felt in the field.

3. Construction of water holes is needed in Tholpetty, Kurichiat and Bathery ranges where there is shortage of water during January to April.

4. Waterholes should be constructed only in areas where there is less human presence and it should be sufficiently away from settlements for avoiding the possible human-wildlife conflict.

5. There is need for maintenance and desilting of existing water holes/check dams at least every three years.

6. Construction of smaller weirs will be useful for retaining water rather than big check dams which were constructed earlier (as seen in Nellur vayal).

7. Check dams should be constructed only at first/second order streams and should not block the free flow of water.

8. The evidence of letting in of the effluent of coffee processing unit was noticed in the Nadundana thodu of Tholpetty range in Wayanad Wildlife Sanctuary. A suggestion to coffee processing unit to find alternative way of disposal would solve the problem.

7.3. Aralam Wildlife Sanctuary:

1. There is no need for making check dams in the perinneal streams in the sanctuary as water scarcity is not observed.
2. The newly built checkdam at Pothanplavu may require maintenance to have more water storage, as there is seepage underneath.
3. The Chullikandam weir should have the stopper replaced in the summer for storing water.

PLATE 1

A. Natural salt lick at Trijunction area, in Muthanga range of Wayand WLS

B. Natural salt lick in Tholpetty range, Wayanad WLS

C. Cave like salt lick in Sulthan Bathery range of Wayanad WLS

D. Closer view to show the salt

PLATE 2

A natural soil salt lick spot monitored at Maragadha stream bank, Muthanga range Wayanad WLS (A & B), Closer view of the lower portion of the saltlick (C)

PLATE 3

Broken check dam in Nellur thodu (Muthanga range- Wayanad WLS

Water body in Doddakulasi (Kurichiat range- Wayanad WLS) with growth azola

A tusker at Onnampala pond in (Tholpetty range)

PLATE 4

Wayanad WLS

A prominent salt lick at Ayyappapara (Tholpetty range) and its usage during successive visits

ACKNOWLEDGMENTS

I am extremely grateful to Dr. J.K. Sharma, Director, KFRI, for constant encouragement. Interest shown by Sri. P.K. Surendranathan Asari, IFS, Principal Chief Conservator of Forests is gratefully acknowledged. Sri. OmPrakash Kaler, IFS, Conservator of Forests (BDC) is acknowledged for sharing the water mapping, which he had attempted during 1995-96. Several forest department staff helped in the field in getting information on the water seasonality especially the range officers and deputy range officer Sri. Hydrose Kutty.

Thanks are due to Dr. P. Vijayakumaran Nair for assisting in preparing the map using MapInfo software. Thanks are also due to Dr. N.Sasidharan, Scientist, KFRI for identifying grass species collected.

Thanks are also due to Sri. Sudheesh, data entry operator, FIS unit for his help in MapInfo layouts.

The help by the local assistants in three protected areas is also remembered with gratitude.

8. REFERENCES

American Public Health Association, 1976. American Water Works Association, Water Pollution Control Federation, 'Standard methods for the Examination of waters and waste waters' 14th edition APHA, Washington.

Anonymous. 1961. Mounting death toll follows severe drought. *Wildlife* **3**: 22

Ayeni, J.S.O. 1975. Utilization of water holes in Tsavo National Park (East). *E. Afr. Wildl. J.* **13**: 305-323.

Ayeni, J.S.O. 1979. Big game utilization of natural mineral licks. In S.S. Ajayi and L.B. Halstead (Eds.) *Wildlife Management in Savannah Woodland*, pp. 85-95. Taylor and Francis, London.

Bollag, J.M. and S.Y.Liu. 1990. Biological transformation processes of pesticides. P.169-211. In: H.H. Chang (Ed.) Pesticides in the soil environment: Processes, impacts and modeling. SSSA Book Ser. 2. SSSA, Madison, WI.

Deshmukh, V.R and Dhore, M. A 1994. Nutritive values of some lesser-known herbivore foods from Melghat Tiger Reserve (Maharashtra). *Indian Forester*. Special issue on biodiversity - II. 120 (10): 920-923.

Gopinathan, V. 1990. The First management plan for Aralam Widlife Sanctuary 1990-91 to 1999-2000.

Gopinathan, V. 1990. The First management plan for Wayanad Widlife Sanctuary 1990-91 to 1999-2000.

Henshaw, J and A.S.O.Ayeni, 1971. Some aspects of big game utilization of mineral licks in Yankari Game Reserve, Nigeria. East Afr.Wildll J., 9: 73-82.

Indian Standard. 1992. Mineral Mixtures for supplementing cattle feeds – specification (Third Revision)- IS No. 1664: 1992

Jackson, M.L. 1973. Soil Chemical Analysis. Printice Hall of India Pvt. Ltd., New Delhi.

Jose, K., Sreepathy, A., Mohankumar, B., and Venugopal, V.K. 1994. Structural and floweristic and edaphic attributes of grassland shola forests of Eravikulam in peninsular India. *For. Ecol. Manage* **65:** 279-291.

Karunakaran, P.V. 1997. Ecological Studies on the Grassland of Eravikulam National Park, Kerala, India. Doctoral thesis, Saurashtra University.

Kotwal, P.C. 1987. Vegetational studies in Noradehi Sanctuary, Madhya Pradesh with reference to wildlife management. *Journal of Tropical Forestry*. 3 (3): 254-367.

Kreulen, D.A. 1985. Lick use by large herbivores: a review of benefits and banes of soil consumption. *Mammal Review*, 15 (3): 107-123.

Kreulen,D.A. and J. Jagger, 1984. Significance of soil ingestion in the utilization of arid rangelands by large herbivores, with special reference to natural licks on the Kalhari plains. In: Herbivore Nutrition in the Subtropics and Tropics. F.M.C.Gulchrist and R.I.Mackie (Eds.) The Science press, Johannesburg.

Kudesia, V.P. 1992. Water Pollution. Pragathi Prakashan, Meerut, India.

Maskall, J.E. and J.Thornton, 1989. The mineral status of Lake Nakuru National Park, Kenya: a reconnaissance survey. *Afr.J.Ecol.* 27: 191-200

Muoghalu,I and A.O.Isichei. 1987. Seasonal cycling of Nitrogen, Phosphorus and potassium in isolated vegetation mats on an inselberg in southwestern Nigeria. *Afr.J.Ecol.* 25: 265-278.

Purohit, S.K. 1985. Chemical and Biological methods of water and air pollution control (A practical Hygiene Manual). Agro-Botanical Publishers (India), Daryagunj, New Delhi.

Ramachandran, K.K. Balagopalan, M. and Nair, P.V. 1995. Use pattern and chemical characterisation of the natural salt licks in Chinnar Wildlife Sanctuary. KFRI Research Report No. 94, 1-18.

Rameshan, R. The First management plan for Eravikulam National Park. 1990-91 to 1999-2000.

Seidensticker, J. and McNeely, J. 1975. Observations on the use of natural licks by ungulates in the Huai Kha Khaeng Wildlife Sanctauary, Thailand. *Nat. Hist. Bull. Siam. Soc.* 26: 25-34.

Singh, G.P. 1995. Urea-Molasses-Mineral lick: A multi-nutirent and economic feed supplement for ruminant animals. In: *Bioprocessing of feeds and crop residues to improve their nutritive value.* (Proc. Of Summer Institute, National Diary Research Institute, Karnol (Haryana) India.

Stark, M.A. 1986. Analysis of five natural soil licks, Benoue National Park, Cameroon, West Africa. *Afr. J. Ecol.* 24: 181-187.

Thornton, I. 1983. Geochemistry applied to agriculture. In: *Applied Environmental Geochemistry* (Ed. I.Thornton), Academic Press, London.

Welcher, F.J. 1975. Satandard methods of chemical analysis. R.E. Krieger Publishing Company, Huntington, New York.

Western, D. 1975. Water availability and its influence on the structure and dynamics of a savannah large mammal community. *E. Afr. Wildl. J.* **13**: 265-286.

Weir, J.S. 1972. Spatial distribution of elephants in an African national park in relation to environmental sodium. *Oikos* **23**: 1-13.

Williamson, D.T. and Mbano, B. 1988. Wildebeest mortality during 1983 at Lake Xau, Botswana. *Afr. J. Ecol*. **26**: 341-344.

APPENDIX 1 a

Variation in pH of the water samples collected from Eravikulam National Park

Locations	PH				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	5.72	6.70	6.10	6.10	6.15± 0.41
Rajamalai flowing water	6.74	7.30	6.70	6.70	6.86± 0.29
Naikollimala	6.74	7.50	7.20	7.20	7.16± 0.39
Eravikulam thodu- hut area	6.47	7.60	6.80	6.80	6.91± 0.48
Eravikulam hut thodu	7.03	7.30	6.70	6.70	6.93± 0.29
Vattachathumbu	6.14	7.30	6.40	6.40	6.56± 0.51
Bhimanoda	6.90	7.40	6.80	6.80	7.00± 0.00
MPCA plot	7.37	7.30	6.40	6.40	6.86± 0.54

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 b

Variation in Chlorides of the water samples collected from Eravikulam National Park

Locations	Chlorides mg/L				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	1.06	2.48	2.12	2.12	1.95± 0.61
Rajamalai flowing water	2.48	1.77	2.48	2.48	2.3± 0.36
Naikollimala	2.12	2.12	1.77	1.77	1.95± 0.2
Eravikulam thodu- hut area	1.77	1.77	2.12	2.12	1.95± 0.2
Eravikulam hut thodu	1.41	1.77	2.12	2.12	1.86± 0.34
Vattachathumbu	3.19	2.12	2.83	2.83	2.74± 0.45
Bhimanoda	1.13	2.12	1.70	1.32	1.86± 0.00
MPCA plot	1.77	2.12	2.48	2.48	2.21± 0.34

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 c

Variation in Hardness in the water samples collected from Eravikulam National Park

Locations	Hardness mg/L				
	I*	II*	III*	IV*	Average
Sankumalai	6	8	10	10	8.50± 1.91
Rajamalai flowing water	2	2	8	8	5.00± 3.46
Naikollimala	7	8	6	6	6.75± 0.96
Eravikulam thodu- hut area	2	4	6	6	4.50± 1.91
Eravikulam hut thodu	2	6	10	10	7.00± 3.82
Vattachathumbu	10	8	8	8	8.50± 1.00
Bhimanoda	12	10	11	9	10.0± .00
MPCA plot	8	6	10	10	8.20± 1.91

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 d

Variation in Calcium content in the water samples collected from Eravikulam National Park

Locations	Calcium mg/L				
	I*	II*	III*	IV*	Average± SD
Sankumalai	1.8	1.6	1.6	1.6	1.6± 0.2
Rajamalai flowing water	3.2	1.4	1.4	2.4	2.1± 0.8
Naikollimala	2.3	6.4	6.4	1.6	4.2± 2.8
Eravikulam thodu- hut area	5.6	0.8	0.8	3.2	2.6± 2.3
Eravikulam hut thodu	5.6	0.8	0.8	2.4	2.4± 2.2
Vattachathumbu	6.4	0.8	0.8	3.2	2.8± 2.6
Bhimanoda	1.6	1.6	1.6	1.6	1.6± 0.0
MPCA plot	2.3	0.8	0.8	1.6	1.4± 0.0

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 e

Variation in Alkalinity in the water samples collected from Eravikulam National Park

Locations	Alkalinity mg/L				
	I*	II*	III*	IV*	Average± SD
Sankumalai	0.18	0.07	0.10	0.10	0.11± 0.05
Rajamalai flowing water	0.14	0.07	0.01	0.01	0.11± 0.05
Naikollimala	0.14	0.14	0.18	0.18	0.11± 0.02
Eravikulam thodu- hut area	0.10	0.14	0.07	0.07	0.11± 0.03
Eravikulam hut thodu	0.18	0.10	0.07	0.07	0.11± 0.05
Vattachathumbu	---	0.14	0.07	0.07	0.09± 0.04
Bhimanoda	---	0.1	0.07	0.07	0.07± 0.00
MPCA plot	0.07	0.07	0.07	0.07	0.09± 0.00

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 f

Variation in dissolved solids of the water samples collected from Eravikulam National Park

Locations	Dissolved solids mg/L				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.01	0.02	0.03	0.03	0.023 ± 0.01
Rajamalai flowing water	0.02	0.01	0.03	0.03	0.019 ± 0.01
Naikollimala	0.02	0.02	0.04	0.04	0.029 ± 0.01
Eravikulam thodu-hut area	0.01	0.02	0.04	0.04	0.022 ± 0.01
Eravikulam hut thodu	0.02	0.01	0.03	0.03	0.020 ± 0.02
Vattachathumbu	0.02	0.02	0.03	0.03	0.022 ± 0.01
Bhimanoda	---	0.02	0.03	0.03	0.027 ± 0.01
MPCA plot	0.01	0.02	0.04	0.04	0.024 ± 0.02

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 g

Variation in suspended solids of the water samples collected from Eravikulam National Park

Locations	Suspended solids mg/L				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.07	0.01	004	0.05	0.03 ± 0.02
Rajamalai flowing water	0.08	0.02	0.01	0.02	0.04 ± 0.02
Naikollimala	---	0.01	0.02	0.01	0.01 ± 0.00
Eravikulam thodu- hut area	0.07	0.03	0.02	0.01	0.03 ± 0.02
Eravikulam hut thodu	0.06	0.02	0.01	0.01	0.03 ± 0.01
Vattachathumbu	0.04	0.02	0.01	0.02	0.02 ± 0.02
Bhimanoda	---	0.01	0.02	0.01	0.01± 0.00
MPCA plot	0.18	---	0.01	0.01	0.09 ± 0.05

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 h

Variation in organic carbon content of the water samples collected from Eravikulam National Park

Locations	Organic carbon %				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.41	0.33	0.33	0.33	0.35 ± 0.04
Rajamalai flowing water	0.41	0.41	0.33	0.41	0.39 ± 0.04
Naikollimala	---	0.33	0.41	0.41	0.38 ± 0.05
Eravikulam thodu- hut area	0.58	0.41	0.41	0.41	0.45 ± 0.08
Eravikulam hut thodu	0.41	0.41	0.41	0.41	0.41± 0.00
Vattachathumbu	0.50	0.50	0.41	0.41	0.46 ± 0.05
Bhimanoda	---	0.41	0.41	0.41	0.41 ± 0.00
MPCA plot	0.41	0.28	0.25	0.25	0.30 ± 0.08

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 1 i

Variation in phosphate content of the water samples collected from Eravikulam National Park

Locations	Phosphates mg/l				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.68	1.86	1.46	1.46	1.37 ± 0.49
Rajamalai flowing water	1.17	2.38	1.38	1.38	1.58 ± 0.54
Naikollimala	---	0.39	1.69	1.69	1.26 ± 0.75
Eravikulam thodu- hut area	0.97	1.22	1.38	1.38	1.24 ± 0.19
Eravikulam hut thodu	0.69	2.3	1.44	1.44	1.47 ± 0.66
Vattachathumbu	0.81	0.9	1.37	1.2	1.07 ± 0.26
Bhimanoda	---	0.96	1.2	1.37	1.18 ± 0.21
MPCA plot	0.97	0.6	1.4	1.4	1.09 ± 0.39

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 2 a

Variation in pH of the water samples collected from Wayanad Wildlife Sanctuary

Locations	pH				
	I*	II*	III*	IV*	Average±SD
Muthanga range					
Nellur vayal checkdam	7.76	7.44	8.00	7.50	7.675 ± 0.26
Nellur vayal check dam flowing water					
Newly built dam	7.7	7.44	8.30	8.12	7.89 ± 0.39
Nellur vayal- water stream	7.42	7.44	8.35	7.99	7.8 ± 0.45
Maragadha Water Body	6.99	6.34	7.60	7.20	7.03 ± 0.53
Maragadha water body	6.84	7.15	7.74	7.30	7.25 ± 0.37
Maragadha – water sample 2	7.23	7.30	7.78	7.49	7.45 ± 0.25
Maragadha thodu water stream	7.58	7.70	8.38	8.04	7.92 ± 0.36
Karadimunda - check dam	6.97	7.07	7.70	7.32	7.26 ± 0.33
Karadimunda check dam	6.89	6.82	7.46	8.12	7.32 ± 0.6
Karadimunda- stagnant waterbody	6.72	6.61	7.32	7.24	6.97 ± 0.36
Bagagadha check dam	7.67	7.50	---	7.70	7.62 ± 0.11
Muthappankolli water body	6.78	7.62	8.00	7.73	7.53 ± 0.53
Kurichiyth range					
Waterhole	6.66	7.23	7.72	7.85	7.36 ± 0.54
Anapandhi check dam	6.98	6.93	---	---	6.95 ± 0.04
Nalimali water body	---	---	8.32	---	8.32 ± 0.00
5th mile water hole	6.82	---	7.30	7.42	7.18 ± 0.32
Doddakullasy - waterhole	6.64	7.10	6.99	7.60	7.082 ± 0.4
Bore well water	---	6.70	7.50	7.58	7.26 ± 0.49
Bathery range					
Malachikundu canal	8.00	6.65	7.35	7.92	7.48 ± 0.62
Tholpetty range					
watehole Onnampalam	7.25	7.30	8.00	8.10	7.66 ± 0.45
Onampalam check dam flowing water	---	---	8.36	8.15	8.25 ± 0.15
Kakkeripond waterhole	6.97	7.02	8.00	7.92	7.47 ± 0.56
Dasankatte/Kaimara Jn: waterhole	7.33	6.87	7.84	7.90	7.48 ± 0.48
Dasankatte - undichira waterhole	6.82	7.62	7.90	8.35	7.67 ± 0.64
Dasankatte waterhole	6.96	7.45	7.95	7.80	7.54 ± 0.44

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 b

Variation in chlorides content of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Chlorides mg /L				
	I*	II*	III*	IV*	Average± SD
Muthanga range					
Nellur vayal checkdam	1.77	2.12	2.83	2.12	2.21± 0.45
Nellur vayal check dam flowing water					
Newly built dam	1.77	1.41	2.48	1.70	1.84 ± 0.45
Nellur vayal- water stream	1.41	2.12	2.83	1.41	1.94 ± 0.68
Maragadha Water Body	2.12	2.12	2.12	2.12	2.12 ± 0.00
Maragadha water body	1.77	1.77	2.12	2.77	2.10 ± 0.47
Maragadha - water sample 2	9.57	1.77	2.48	1.70	3.80 ± 1.62
Maragadha thodu water stream	2.12	2.48	2.48	1.41	2.10 ± 0.50
Karadimunda - check dam	3.90	2.12	2.83	2.55	2.85 ± 0.76
Karadimunda check dam	4.60	2.12	2.12	1.13	2.49 ± 1.48
Karadimunda- stagnant waterbody	4.96	1.41	2.83	1.98	2.70 ± 1.56
Bagagadha check dam	6.73	1.77	---	1.41	2.47 ± 0.65
Muthappankolli water body	2.48	1.77	2.48	1.13	1.96 ± 0.65
Muthappankolli -Checkdam overflowing	---	2.12	2.48	2.12	2.24 ± 0.21
Kurichiyth range					
waterhole	5.67	3.19	4.96	1.98	3.95± 1.68
Anapandhi check dam	4.25	2.41	---	---	3.33 ± 1.30
Nalimali water body	---	---	2.12		
5th mile water hole	4.25	---	2.12	1.41	2.59 ± 1.48
Doddakullasy - waterhole	3.19	2.41	1.77	3.4	2.69± 0.75
Bore well water	---	1.77	2.12	1.41	1.76± 0.36
Bathery range					
Malachikundu canal	4.60	2.48	3.12	1.41	2.90 ± 1.33
Tholpetty range					
watehole Onnampalam	2.48	2.48	3.89	1.70	2.63 ± 0.91
Onampalam check dam flowing water	---	---	1.77	3.97	2.87 ± 1.56
Kakkeripond waterhole	1.77	3.19	3.89	2.26	2.77 ± 0.95
Dasankatte/Kaimara Jn: waterhole	2.65	2.83	2.83	2.26	2.64 ± 0.27
Dasankatte - undichira waterhole	3.90	2.83	4.96	2.55	3.56 ± 1.10
Dasankatte waterhole	3.12	2.83	3.19	2.26	2.85 ± 0.42

Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 c

Variation in hardness of the water samples collected from Wayanad Wildlife anctuary

Locations	Hardness mg/L				
	I*	II*	III*	IV*	Average ± SD
Muthanga range					
Nellur vayal checkdam	24	22	60	45	37.70 ± 18.1
Nellur vayal check dam flowing water Newly built dam	38	22	54	44	39.50 ± 13.4
Nellur vayal- water stream	38	46	58	46	46.00 ± 8.25
Maragadha Water Body	18	14	10	16	14.50 ± 3.42
Maragadha water body	10	16	16	20	15.00 ± 4.12
Maragadha - water sample 2	10	40	28	22	25.00 ± 12.5
Maragadha thodu water stream	46	42	72	62	55.50 ± 14
Karadimunda - check dam	38	58	22	26	36.00 ± 16.2
Karadimunda check dam	2.3	22	40	48	28.00 ± 20.3
Karadimunda- stagnant waterbody	34	20	20	20	23.50 ± 7.0
Bagagadha check dam	8	16		28	17.30 ± 10.1
Muthappankolli water body	16	48	32	32	32.00 ± 13.1
Muthappankolli -Checkdam overflowing	---	28	28	26	27.30 ± 1.15
Kurichiyth range					
Waterhole	14	18	60	74	41.50 ± 30
Anapandhi check dam	20	44	---	---	32.00 ± 17
Nalimali water body	---	---	22	---	22.00 ± 0.00
5th mile water hole	12	---	28	26	33.00 ± 8.72
Doddakullasy - waterhole	22	58	26	64	42.50 ± 21.6
Bore well water	---	160	148	80	97.00 ± 43.1
Bathery range					
Malachikundu canal	68	42	48	50	52.00 ± 11.2
Tholpetty range					
watehole Onnampalam	24	66	56	60	51.50 ± 18.8
Onampalam check dam flowing water	---	---	130	100	115.00 ± 21.2
Kakkeripond waterhole	12	80	6	82	45.00 ± 41.6
Dasankatte/Kaimara Jn: waterhole	22	36	66	55	44.80 ± 19.6
Dasankatte – undichira waterhole	16	56	58	54	46.00 ± 20.1
Dasankatte waterhole	14	46	42	38	35.00 ± 14.4

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 d

Variation in calcium content of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Calcium mg/L				
	I*	II*	III*	IV*	Average ± SD
Muthanga range					
Nellur vayal checkdam	8.81	9.61	9.61	12.00	10.00 ± 1.38
Nellur vayal check dam flowing water Newly built dam	10.10	9.61	15.20	11.20	11.50 ± 2.54
Nellur vayal- water stream	14.40	11.20	13.60	11.20	12.60 ± 1.65
Maragadha Water Body	4.80	3.70	2.40	3.80	3.85 ± 2.24
Maragadha water body	4.00	3.20	3.20	4.80	3.80 ± 0.77
Maragadha - water sample 2	3.00	8.81	7.21	3.20	5.55 ± 2.91
Maragadha thodu water stream	14.40	11.20	10.40	16.00	13.00 ± 2.64
Karadimunda - check dam	11.20	13.60	4.00	5.61	8.60 ± 4.54
Karadimunda check dam	14.40	6.41	8.81	12.80	10.60 ± 3.65
Karadimunda- stagnant waterbody	5.61	4.00	4.80	4.80	4.80 ± 0.66
Bagagadha check dam	2.40	6.41	---	5.61	4.80 ± 2.12
Muthappankolli water body	8.00	12.00	7.20	7.21	8.60 ± 2.30
Muthappankolli -Checkdam overflowing	---	4.80	5.60	7.10	5.83 ± 1.17
Kurichiyth range					
Waterhole	2.40	3.80	12.00	15.20	8.35 ± 6.23
Anapandhi check dam	6.41	10.40	---	---	8.40 ± 2.82
Nalimali water body	---	---	3.20	---	3.20 ± 0.00
5th mile water hole	4.80		6.80	6.41	6.00 ± 1.06
Doddakullasy - waterhole	12.00	14.40	2.40	16.00	11.20 ± 6.09
Bore well water	---	38.00	36.00	29.60	34.00 ± 4.39
Bathery range					
Malachikundu canal	20.80	12.80	11.00	11.20	13.90 ± 4.64
Tholpetty range					
watehole Onnampalam	8.81	16.00	6.41	16.00	11.80 ± 4.94
Onampalam check dam flowing water	---	---	21.60	19.20	10.20 ± 1.70
Kakkeripond waterhole	4.80	16.80	4.80	16.00	10.60 ± 6.71
Dasankatte/Kaimara Jn: waterhole	9.61	7.21	17.60	15.00	12.30 ± 4.78
Dasankatte - undichira waterhole	5.61	13.60	12.80	11.20	10.80 ± 3.60
Dasankatte waterhole	17.60	12.80	9.61	8.50	12.10 ± 4.08

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 e

Variation in alkalinity of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Alkalinity mg/l				
	I*	II*	III*	IV*	Average ± SD
Muthanga range					
Nellur vayal checkdam	0.09	1.11	0.93	0.93	0.70 ± 0.46
Nellur vayal check dam flowing water Newly built dam	0.65	1.00	0.57	0.32	0.60 ± 0.28
Nellur vayal- water stream	1.51	0.75	0.54	0.32	0.70 ± 0.52
Maragadha Water Body	0.64	0.93	0.18	0.29	0.50 ± 0.34
Maragadha water body	0.43	0.50	0.72	0.68	0.50 ± 0.14
Maragadha - water sample 2	1.66	1.08	0.28	0.21	0.89± 0.59
Maragadha thodu water stream	1.54	1.15	0.54	0.10	0.80 ± 0.64
Karadimunda - check dam	0.72	1.47	0.39	0.46	0.70 ± 0.49
Karadimunda check dam	1.00	0.72	0.39	0.28	0.50 ± 0.31
Karadimunda- stagnant waterbody	1.08	0.64	0.32	0.25	0.50 ± 0.38
Bagagadha check dam	0.64	0.64	---	0.32	0.50 ± 0.18
Muthappankolli water body	0.25	0.82	0.28	0.25	0.40 ± 0.28
Muthappankolli -Checkdam overflowing	---	0.72	0.32	0.68	0.50 ± 0.22
Kurichiyath range					
Kurichiyath Waterhole	0.25	0.27	0.46	0.39	0.47 ± 0.27
Anapandhi check dam	0.97	0.90	---	---	0.94 ± 0.05
Nalimali water body	---	---	0.36	---	0.36 ± 0.00
5th mile water hole	0.75	---	0.5	0.25	0.50 ± 0.25
Doddakullasy- waterhole	0.39	1.22	0.75	0.32	0.67 ± 0.41
Bore well water	---	3.09	1.22	0.54	1.62 ± 1.32
Bathery range					
Malachikundu canal	2.08	1.36	1.68	0.25	1.34 ± 0.79
Tholpetty range					
watehole Onnampalam	0.46	1.72	0.75	0.46	0.85 ± 0.60
Onampalam check dam flowing water	---	---	0.93	0.32	0.63 ± 0.43
Kakkeripond waterhole	0.32	1.65	0.79	0.39	0.79 ± 0.61
Dasankatte/Kaimara Jn: waterhole	1.15	0.97	0.54	0.46	0.78 ± 0.33
Dasankatte - undichira waterhole	0.25	1.26	0.57	0.39	0.62 ± 0.45
Dasankatte waterhole	1.29	1.11	0.54	0.46	0.85 ± 0.41

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 f

Variation in dissolved solids of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Dissolved Solids(mg/L)				
	I*	II*	III*	IV*	Average ± SD
Muthanga range					
Nellur vayal checkdam	0.02	0.04	0.03	0.03	0.02 ± 0.01
Nellur vayal- water stream	0.003	0.04	0.03	0.01	0.02 ± 0.02
Maragadha Water Body	0.01	0.16	0.02	0.02	0.05 ± 0.00
Maragadha - water sample 2	0.04	0.04	0.03	0.03	0.03 ± 0.01
Maragadha thodu water stream	0.00	0.04	0.03	0.01	0.02 ± 0.02
Karadimunda - check dam	0.01	0.04	0.02	0.01	0.01 ± 0.01
Karadimunda check dam	0.01	0.02	0.02	0.02	0.01± 0.01
Karadimunda- stagnant waterbody	0.00	0.01	0.03	0.04	0.01± 0.00
Bagagadha check dam	0.00	0.02	---	0.02	0.01± 0.01
Muthappankolli water body	0.03	0.03	0.02	0.01	0.02± 0.01
Kurichiyath range					
Waterhole	0.004	0.04	0.02	0.01	0.01± 0.00
Anapandhi check dam	0.002	0.06	0.06	0.04	0.03± 0.03
5th mile water hole	0.002	--	0.07	0.09	0.05± 0.04
Doddakullasy - waterhole	0.005	0.54	0.03	0.04	0.15± 0.02
Bathery range					
Malachikundu canal	0.004	0.08	---	0.05	0.04± 0.02
Tholpetty range					
watehole Onnampalam	0.02	0.03	0.04	0.03	0.02± 0.01
Kakkeripond waterhole	0.003	0.03	0.03	0.05	0.02± 0.02
Dasankatte/Kaimara Jn: waterhole	0.001	0.04	0.03	0.01	0.01± 0.00
Dasankatte - undichira waterhole	0.004	0.05	0.03	0.19	0.06± 0.02
Dasankatte waterhole	0.003	0.01	0.03	0.01	0.01± 0.01

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 g

Variation in suspended solids of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Suspended solids (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Muthanga range					
Nellur vayal checkdam	0.42	0.03	0.01	0.01	0.12 ± 0.05
Nellur vayal- water stream	---	0.03	0	0.01	0.02 ± 0.00
Maragadha Water Body	1.04	0.05	0.01	0.01	0.28 ± 0.15
Maragadha water body	0.38	0.02	0.01	0.01	0.11 ± 0.05
Maragadha - water sample 2	6.48	0.08	---	---	2.19 ± 0.26
Maragadha thodu water stream	0.24	0.01	0.01	---	0.07 ± 0.02
Karadimunda - check dam	0.3	0.06	0.002	---	0.3 ± 0.14
Karadimunda check dam	0.54	0.01	---	---	0.14 ± 0.06
Karadimunda- stagnant waterbody	1.28	0.01	---	0.01	0.32 ± 0.16
Bagagadha check dam	0.38	0.01	---	0.01	0.13 ± 0.12
Muthappankolli water body	0.82	0.03	0.02	0.003	0.28 ± 0.07
Kurichiyath range					
Waterhole	0.28	0.03	0.05	0.01	0.09 ± 0.04
Anapandhi check dam	0.20	0.03	0.03	0.03	0.07 ± 0.03
5th mile water hole	0.10	---	0.01	0.01	0.04 ± 0.01
Doddakullasy – waterhole	0.36	0.03	0.07	---	0.12 ± 0.06
Bathery range					
Malachikundu canal	1.08	0.07	---	0.01	0.38 ± 0.19
Tholpetty range					
watehole Onnampalam	0.96	0.01	0.02	0.01	0.25 ± 0.10
Kakkeripond waterhole	0.22	0.02	0.03	0.01	0.07 ± 0.02
Dasankatte/Kaimara Jn: waterhole	0.22	0.02	0.01	0.01	0.06 ± 0.02
Dasankatte – undichira waterhole	0.42	0.05	0.01	0.01	0.12 ± 0.03
Dasankatte waterhole	0.36	0.03	Trace	0.01	0.10 ± 0.08

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 h

Variation in organic carbon content of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Organic carbons(%)				
	I*	**II***	**III***	**IV***	**Average ± SD**
Muthanga range					
Nellur vayal checkdam	0.16	0.5	0.25	0.04	0.24 ± 0.20
Nellur vayal- water stream	0.33	0.33	0.33	0.17	0.29 ± 0.08
Maragadha Water Body	0.91	0.66	0.33	0.17	0.52 ± 0.33
Maragadha water body	0.33	0.41	0.25	0.28	0.32 ± 0.07
Maragadha - water sample 2	0.5	0.41	0.5	0.45	0.47 ± 0.04
Maragadha thodu water stream	0.41	0.33	0.33	0.17	0.31± 0.10
Karadimunda - check dam	0.25	0.41	0.33	0.17	0.29 ± 0.10
Karadimunda check dam	0.25	0.33	0.25	0.17	0.25 ± 0.07
Karadimunda- stagnant waterbody	0.41	0.33	0.16	0.17	0.27 ± 0.12
Bagagadha check dam	0.25	0.33	---	0.17	0.25 ± 0.08
Muthappankolli water body	0.30	0.41	0.33	0.08	0.28 ± 0.14
Kurichiyath range					
Waterhole	0.41	0.33	0.33	0.17	0.31 ± 0.01
Anapandhi check dam	1.08	0.16	0.16	0.16	0.39 ± 0.12
5th mile water hole	0.25	---	0.16	0.17	0.19 ± 0.05
Doddakullasy – waterhole	0.33	0.50	0.33	0.08	0.25 ± 0.14
Bathery range					
Malachikundu canal	0.16	1.33	---	0.17	0.55 ± 0.26
Tholpetty range					
watehole Onnampalam	1.91	0.25	0.33	0.17	0.66 ± 0.28
Kakkeripond waterhole	0.41	0.33	0.5	0.08	0.33 ± 0.18
Dasankatte/Kaimara Jn: waterhole	0.25	0.25	0.33	0.08	0.23 ± 0.10
Dasankatte - undichira waterhole	0.33	0.33	0.25	0.08	0.25 ± 0.12
Dasankatte waterhole	0.25	0.41	0.58	0.25	0.37 ± 0.16

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 2 i

Variation in phosphate of the water samples collected from Wayanad Wildlife Sanctuary

Locations	Phosphates (mg/L)				
	I*	II*	III*	IV*	Average±SD
Muthanga range					
Nellur vayal checkdam	1.03	2.39	1.38	1.4	1.50 ± 0.59
Nellur vayal- water stream	0.90	2.86	1.62	1.56	1.64 ± 0.8
Maragadha Water Body	0.61	7.50	0.60	2.28	2.86 ± 1.83
Maragadha water body	1.17	1.61	2.64	1.55	2.86 ± 0.63
Maragadha - water sample 2	1.20	1.96	1.60	1.25	1.50 ± 0.23
Maragadha thodu water stream	---	2.36	1.39	1.06	1.25 ± 0.27
Karadimunda - check dam	1.10	1.46	1.39	0.04	1.26 ± 0.66
Karadimunda check dam	2.71	0.52	1.35	2.47	1.38 ± 1.02
Karadimunda- stagnant waterbody	0.76	0.90	1.51	1.94	1.52 ± 0.55
Bagagadha check dam	1.08	2.05	---	2.09	1.47 ± 0.57
Muthappankolli water body	1.94	1.40	1.78	1.25	1.66 ± 0.32
Kurichiyath range					
Waterhole	1.20	3.29	0.84	1.52	1.71 ± 1.09
Anapandhi check dam	1.28	1.92	0.92	1.03	1.5 ± 0.45
5th mile water hole	1.42	---	1.25	1.44	1.32 ± 0.11
Doddakullasy – waterhole	0.57	2.66	1.72	0.99	1.44 ± 0.92
Bathery range					
Malachikundu canal	1.92	0.77	---	2.5	1.73 ± 0.88
Tholpetty range					
watehole Onnampalam	2.89	0.77	1.59	2.31	1.89 ± 0.92
Kakkeripond waterhole	1.03	---	1.1	1.37	1.58 ± 0.18
Dasankatte/Kaimara Jn: waterhole	1.26	1.71	1.21	1.37	1.29 ± 0.23
Dasankatte - undichira waterhole	1.56	2.58	1.12	1.56	1.55 ± 0.62
Dasankatte waterhole	1.87	1.33	2.93	1.78	1.84 ± 0.68

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 3 a

Variation in pH of the water samples collected from Aralam WLS water bodies

Locations	pH				
	I*	II*	III*	IV*	Average±SD
Chullicondam	7.83	6.84	7.20	7.90	7.44 ± 0.51
Valanchal thodu	6.94	----	7.20	7.52	7.22 ± 0.29
Panthalplave check dam	---	7.07	6.90	7.45	7.14 ± 0.28
Meen matti	---	---	7.13	---	7.13 ± 0.00
Parip thodu	6.50	---	6.30	7.33	6.71± 0.55

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 b

Variation in chlorides content of the water samples collected from Aralam WLS water bodies

Locations	Chlorides (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Chullicondam	1.77	2.12	2.40	1.70	2.0 ± 0.33
Valanchal thodu	4.25	---	2.12	1.41	2.6 ± 1.48
Panthalplave check dam	---	1.77	2.80	1.13	1.9 ± 0.84
Meen matti	---	---	3.10	---	3.1 ± 0.00
Parap thodu	1.13	---	1.70	1.13	1.3 ± 0.33

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 c

Variation in hardness of the water samples collected from Aralam WLS water bodies

Locations	Hardness (mg/ L)				
	I*	II*	III*	IV*	Average ± SD
Chullicondam	12	8	18	14	13.0 ± 4.16
Valanchal thodu	10	---	16	12	12.7 ± 3.06
Panthalplave check dam	---	14	20	22	18.7 ± 4.16
Meen matti	---	---	10	---	10.0 ± 0.00
Parap thodu	12	---	10	12	11.3 ± 1.15

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 d

Variation in calcium content of the water samples collected from Aralam WLS water bodies

Locations	Calcium (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Chullicondam	4.0	2.04	2.4	2.4	2.71± 0.88
Valanchal thodu	----	---	3.6	3.2	3.40 ± 0.28
Panthalplave check dam	---	4.0	4.0	4.0	4.00 ± 0.00
Meen matti	---	---	2.4	---	2.40 ± 0.00
Parap thodu	3.0	---	2.4	2.4	2.60 ± 0.35

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 e

Variation in alkalinity of the water samples collected from Aralam WLS water bodies

Locations	Alkalinity (mg/L)				
	I*	II*	III*	IV*	Average±SD
Chullicondam	0.28	0.28	0.07	0.14	0.18 ± 0.11
Valanchal thodu	0.20	---	0.10	0.18	0.14 ± 0.06
Panthalplave check dam	---	0.46	0.10	0.10	0.18 ± 0.21
Meen matti	---	---	0.07	---	0.07 ±.0.00
Parap thodu	0.10	---	0.10	0.14	0.12 ± 0.02

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 f

Variation in dissolved solids of the water samples collected from Aralam WLS water bodies

Locations	Dissolved solids (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Chullikandam check dam	0.01	0.03	0.03	0.1	0.020 ± 0.01
Valayanchal thodu	0.01	---	0.03	0.01	0.016 ± 0.00
Ponthan Plavu check dam	---	0.01	0.03	---	0.020 ± 0.01
Meen matti	---	---	0.03	---	0.030 ± 0.00
Parap thodu	0.02	---	0.03	0.01	0.016 ± 0.01

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 g

Variation in Suspended solids content of the water samples collected from Aralam WLS water bodies

Locations	Suspended solids (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Chullikandam check dam	0.34	0.01	0.01	Trace	0.09 ± 0.02
Valayanchal thodu	0.32	---	Trace	Trace	0.32 ± 0.00
Ponthan Plavu check dam	---	0.01	0.01	Trace	0.01± 0.00
Meen matti	---	---	0.01	---	0.01± 0.00
Parap thodu	---	----	0.002	0.003	0.002 ± 0.00

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 h

Variation in organic content of the water samples collected from Aralam WLS water bodies

Locations	Organic carbon (%)				
	I*	II*	III*	IV*	Average ± SD
Chullikandam check dam	0.33	0.58	0.33	0.17	0.35 ± 0.17
Valayanchal thodu	0.33	---	---	0.42	0.37 ± 0.06
Ponthan Plavu check dam	---	0.58	0.41	0.17	0.39 ± 0.21
Meen matti	---	---	0.41	---	0.41± 0.00
Parap thodu	0.323	---	0.33	0.17	0.27 ± 0.09

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 3 i

Variation in phosphates content of the water samples collected from Aralam WLS water bodies

Locations	Phosphates (mg/L)				
	I*	II*	III*	IV*	Average ± SD
Chullikandam check dam	0.94	2.70	1.28	1.40	1.58 ± 0.77
Valayanchal thodu	1.05	---	1.36	1.32	1.24 ± 0.17
Ponthan Plavu check dam	---	1.64	0.95	1.63	1.37 ± 0.4
Meen matti	---	---	1.63	---	1.63 ± 0.00
Parap thodu	1.30	---	1.40	1.71	1.52 ± 0.21

*Sampling Dates; I-June 2000; II-December 2000; III-June 2001; IV-January 2002

APPENDIX 4 a

Variation in pH of the soil samples collected from Eravikulam National Park

Locations	pH				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	4.80	4.30	5.30	4.95	4.83 ± 0.42
Rajamalai roadside near wireless station	4.40	4.89	5.15	5.00	4.86 ± 0.32
Soil sample near wire less station	4.50	4.36	5.60	5.92	5.09 ± 0.78
Soil sample below the ferns	4.80	4.17	5.00	4.85	4.70 ± 0.37
Eravikulam hut area					
Eravikulammala surface soil	5.40	4.53	5.40	5.45	5.19 ± 0.44
Eravikulammala-Upper portion (fire occurred last Jan 2000)	4.80	4.45	4.65	4.68	4.62 ± 0.25
Eravikulammala-Lower portion (fire occurred last Jan 2000)	5.20	4.73	5.15	5.60	5.17 ± 0.44
Eravikulam mala-Unburnt	4.40	4.85	4.95	5.35	4.87 ± 0.70
Hut area-experimental plot outside	4.50	4.35	5.60	8.15	5.66 ± 2.15
Hut area- experimental plot inside	4.40	4.40	5.10	5.25	4.78 ± 0.45
Eravikulammala surface soil	4.70	4.90	5.00	4.80	4.85 ± 0.21
Vattachadambu experimental plot (10 X 10 m) - outside	4.40	4.54	5.20	5.40	4.78 ± 0.54
Vattachadambu experimental plot (10 X 10 m) - inside	4.80	4.53	5.40	5.30	5.00 ± 0.41
MPCA plot	4.70	4.32	5.00	5.20	4.80 ± 0.38

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 4 b

Variation in Magnesium content of the soil samples collected from Eravikulam National Park

Locations	Mg (%)				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.29	0.55	1.17	1.51	0.88 ± 0.56
Rajamalai roadside near wireless station	0.29	0.45	0.98	1.22	0.74 ± 0.44
Soil sample near wire less station	0.32	0.16	1.19	2.18	0.96 ± 0.93
Soil sample below the ferns	0.17	0.36	1.05	1.24	0.71± 0.52
Eravikulam hut area					
Eravikulammala surface soil	0.44	0.34	1.05	1.04	0.72 ± 0.38
Eravikulammala-Upper portion (fire occurred last Jan 2000)	0.09	0.05	0.06	0.08	0.07 ± 0.03
Eravikulammala-Lower portion (fire occurred last Jan 2000)	0.10	0.10	0.55	1.52	0.57 ± 0.32
Eravikulam mala-Unburnt	0.05	0.8	0.9	1.11	0.78 ± 0.35
Hut area-experimental plot outside	0.01	0.20	0.12	0.10	0.11 ± 0.05
Hut area- experimental plot inside	0.35	0.47	1.24	1.38	0.83 ± 0.53
Eravikulammala surface soil	5.31	3.20	1.06	3.80	3.19 ± 3.01
Vattachadambu experimental plot (10 X 10 m) – outside	0.34	0.11	1.07	1.35	0.72 ± 0.59
Vattachadambu experimental plot (10 X 10 m) – inside	0.13	0.32	1.00	1.39	0.71 ± 0.59
MPCA plot	0.02	0.20	1.12	1.25	0.65 ± 0.63

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 4 c

Variation in Calcium content of the soil samples collected from Eravikulam National Park

Locations	Calcium (%)				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.46	1.28	3.12	3.91	2.19 ± 1.6
Rajamalai roadside near wireless station	0.99	2.27	2.51	3.79	2.39 ± 1.15
Soil sample near wire less station	1.42	0.75	5.2	13.00	5.09 ± 3.62
Soil sample below the ferns	0.51	0.26	1.77	3.06	1.4 ± 1.29
Eravikulam hut area					
Eravikulammala surface soil	3.03	0.70	1.96	3.03	2.18 ± 1.1
Eravikulammala-Upper portion (fire occurred last Jan 2000)	0.90	0.80	0.80	0.70	0.8 ± 0.18
Eravikulammala-Lower portion (fire occurred last Jan 2000)	0.02	0.43	0.98	2.42	0.96 ± 0.28
Eravikulam mala-Unburnt	1.5	3.4	3.8	3.54	3.54 ± 0.00
Hut area-experimental plot outside	0.67	1.64	1.7	1.61	1.64 ± 0.00
Hut area- experimental plot inside	0.67	1.19	3.05	3.65	2.14 ± 1.43
Eravikulammala surface soil	0.19	1.10	2.38	1.35	1.29 ± 0.55
Vattachadambu experimental plot (10 X 10 m) - outside	0.59	0.13	2.18	3.24	1.54 ± 1.44
Vattachadambu experimental plot (10 X 10 m) - inside	0.34	0.84	1.94	3.90	1.76 ± 1.58
MPCA plot	Trace	0.79	2.10	2.59	1.83 ± 0.93

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 4 d

Variation in Sodium content of the soil samples collected from Eravikulam National Park

Locations	Sodium (%)				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	5.67	0.11	6.01	7.10	4.72 ± 2.45
Rajamalai roadside near wireless station	0.10	0.80	5.88	0.99	1.76 ± 0.78
Soil sample near wire less station	0.38	0.70	5.59	0.39	1.61 ± 1.53
Soil sample below the ferns	0.40	0.20	6.09	6.18	3.08 ± 1.99
Eravikulam hut area					
Eravikulammala surface soil	0.90	0.90	6.00	5.89	3.12 ± 1.76
Eravikulammala-Upper portion (fire occurred last Jan 2000)	0.14	0.80	0.10	0.10	0.11 ± 0.04
Eravikulammala-Lower portion (fire occurred last Jan 2000)	11.00	0.60	2.12	6.26	5.14 ± 1.40
Eravikulam mala-Unburnt	0.60	0.20	0.30	6.62	3.34 ± 0.44
Hut area-experimental plot outside	0.50	0.80	0.80	0.06	0.7 ± 0.02
Hut area- experimental plot inside	0.12	0.01	6.16	1.30	1.9 ± 0.09
Eravikulammala surface soil	0.10	3.40	6.48	3.10	3.29 ± 2.49
Vattachadambu experimental plot (10 X 10 m) - outside	0.60	0.60	6.12	6.91	3.29 ± 0.44
Vattachadambu experimental plot (10 X 10 m) - inside	0.41	0.90	6.20	1.65	2.09 ± 1.12
MPCA plot	0.80	0.60	6.22	6.90	3.32 ± 0.9

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 4 e

Variation in total nitrogen content of the soil samples collected from Eravikulam National Park

Locations	TN (%)				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	15.8	13.10	0.70	0.77	7.6 ± 4.23
Rajamalai roadside near wireless station	7.88	15.20	---	0.70	7.9 ± 4.7
Soil sample near wire less station	14.60	10.20	0.60	0.66	6.5 ± 3.94
Soil sample below the ferns	7.51	---	0.90	0.7	3.0 ± 1.04
Eravikulam hut area					
Eravikulammala surface soil	11.9	9.08	0.40	0.68	5.5 ± 3.35
Eravikulammala-Upper portion (fire occurred last Jan 2000)	13.00	11.70	12.20	12.30	12 ± 0.93
Eravikulammala-Lower portion (fire occurred last Jan 2000)	0.48	0.02	0.17	0.04	0.2 ± 012
Eravikulam mala-Unburnt	0.04	0.32	0.38	0.66	0.4 ± 0.22
Hut area-experimental plot outside	10.1	9.48	6.70	0.68	6.8 ± 1.77
Hut area- experimental plot inside	7.88	4.51	0.90	0.73	3.5 ± 1.91
Eravikulammala surface soil	7.08	4.10	0.60	3.50	3.9 ± 0.76
Vattachadambu experimental plot (10 X 10 m) - outside	6.2	7.99	0.60	0.67	3.9 ± 0.89
Vattachadambu experimental plot (10 X 10 m) - inside	6.71	14.40	6.80	0.59	7.2 ± 4.7
MPCA plot	8.66	4.80	0.70	0.43	3.7 ± 2.02

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 4 f

Variation in total phosphorus content of the soil samples collected from Eravikulam National Park

Locations	TP (%)				
	I*	II*	III*	IV*	Average ± SD
Sankumalai	0.19	0.25	0.09	0.18	0.18 ± 0.07
Rajamalai roadside near wireless station	0.15	0.36	0.16	0.19	0.22 ± 0.1
Soil sample near wire less station	0.21	0.16	0.16	0.15	0.17 ± 0.03
Soil sample below the ferns	0.32	0.17	0.21	0.17	0.22 ± 0.07
Eravikulam hut area					
Eravikulammala surface soil	0.35	0.11	0.15	0.17	0.19 ± 0.01
Eravikulammala-Upper portion (fire occurred last Jan 2000)	0.10	0.18	0.12	0.16	0.14 ± 0.06
Eravikulammala-Lower portion (fire occurred last Jan 2000)	0.29	0.36	0.36	0.14	0.26 ± 0.01
Eravikulam mala-Unburnt	0.17	0.17	0.19	0.18	0.18 ± 0.00
Hut area-experimental plot outside	0.01	0.11	0.04	0.01	0.04 ± 0.02
Hut area- experimental plot inside	0.11	0.01	0.23	0.14	0.12 ± 0.09
Eravikulammala surface soil	0.04	0.10	0.19	0.15	0.12 ± 0.11
Vattachadambu experimental plot (10 X 10 m) - outside	0.10	0.17	0.16	0.19	0.16 ± 0.04
Vattachadambu experimental plot (10 X 10 m) - inside	Trace	0.11	0.16	0.14	0.14 ± 0.03
MPCA plot	0.14	0.11	0.20	0.16	0.15 ± 0.04

*Sampling Dates; I-October 2000; II- January 2001; III-June 2001; IV-February 2002

APPENDIX 5 a

Variation in pH of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	PH				
Muthanga Range	I*	II*	III*	IV*	Average ± SD
Nellur vayal under bamboo clump soil salt lick	8.4	7.8	7.5	6.1	7.33± 0.97
Nellur thodu	6.9	6.7	6.8	6.6	6.76± 0.13
Nellur thodu under bamboo clump	6.5	6.3	6.35	6.2	6.35± 0.13
Maragadha thodu soil salt lower portion	6.2	8.2	6.5	6.3	6.80± 0.94
Maragadha thodu soil salt lick 1	6.2	7.3	6.2	6.2	6.47± 0.55
Maragadha thodu soil salt lick 2	8.6	8.5	8.7	---	8.60± 0.10
Maragadha thodu soil salt lick 3	6.4	6.3	6.6	6.2	6.40± 0.17
Maragadha thodu soil salt lick 4	8.3	8.3	7.5	8.3	8.11± 0.41
Maragadha 5	7.7	7.2	6.9	7.1	7.22± 0.34
Maragadha trijunction (upper portion)	---	5.6	6.4	5.5	5.83± 0.49
Bathery Range					
Nallathanni soil salt lick	6.5	7.2	6.7	5.9	6.20± 0.54
Malchikudi vayal, soil under the mango tree	8.2	7.3	7.9	8.7	8.06± 0.59
Manjal Vayal	6.5	6.7	7.6	5.7	6.65± 0.78
Varalam	8.4	8.6	8.8	---	8.80± 0.20
Kumallihalla (visible evidence of Elephants activity)	8.9	8.5	8.9	8.6	8.75± 0.21
Kurichiyath Range					
Kummichi vayal (previously artificial salt licks were provided)	---	5.6	6.2	6.0	5.80± 0.31
Udimaran vayal	8.0	7.9	7.8	8.2	7.90± 0.16
Doddakulasi Vayal	8.0	7.9	6.5	5.3	5.30± 0.12
Mavinthal vayal near flowing water	6.9	7.0	7.2	7.4	7.00± 0.19
Tholpetty Range					
Onnampalam 1	6.8	6.7	5.9	6.0	6.35± 0.47
Onnampalam 2	---	7.5	7.3	8.5	7.76± 0.64
Onnampalam 3	6.1	6.7	6.5	7.9	6.83± 0.77
Onnampalam 4	7.1	6.8	6.4	6.7	6.75± 0.71
Kakkeri Vayal	6.5	5.9	7.6	6.9	6.75±.0.99
Ayyappanpara (near animal pass)	8.7	7.9	7.7	7.15	7.86± 0.64
Ayyappan para rocky area	6.8	7.0	6.8	7.0	6.90± 0.12
Dassankatte	5.2	5.9	5.5	5.8	5.60± 0.31

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 5 b

Variation in Magnesium content of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	Mg (%)				
	I*	II*	III*	IV*	Average ± SD
Muthanga Range					
Nellur vayal under bamboo clump soil salt lick	6.24	2.13	1.93	0.98	2.11± 1.33
Nellur thodu	1.38	1.50	1.55	1.57	1.50± 0.09
Nellur thodu under bamboo clump	1.00	1.10	1.20	1.38	1.19± 0.16
Maragadha thodu soil salt lower portion	7.18	12.30	1.98	2.16	5.91± 4.9
Maragadha thodu soil salt lick 1	3.03	1.39	2.54	2.11	2.27± 0.7
Maragadha thodu soil salt lick 2	1.33	3.69	3.27	---	2.76± 1.26
Maragadha thodu soil salt lick 3	11.06	4.50	2.01	1.45	4.84± 4.41
Maragadha thodu soil salt lick 4	2.65	2.91	1.85	2.33	2.44± 0.46
Maragadha 5	2.41	0.76	2.63	1.74	1.89± 0.84
Maragadha trijunction (upper portion)	---	2.67	2.28	------	2.48± 0.28
Bathery Range					
Nallathanni soil salt lick	2.48	2.61	2.16	1.21	1.85± 0.63
Malchikudi vayal, soil under the mango tree	6.53	2.74	2.12	2.33	3.87± 2.08
Manjal Vayal	1.85	2.12	2.25	1.92	2.09± 0.18
Varalam	5.64	5.64	5.64	--	5.64± 0.00
Kumallihalla (visible evidence of Elephants activity)	6.20	5.80	7.40	5.40	6.40± 0.86
Kurichiyath Range					
Kummichi vayal (previously artificial salt licks were provided)	--	0.75	0.83	0.97	0.86± 0.11
Udimaran vayal	--	9.49	9.20	7.80	9.49± 0.71
Doddakulasi Vayal	--	---	6.30	1.10	1.10± 0.23
Mavinthal vayal near flowing water	--	4.71	5.30	5.10	4.71± 0.30
Tholpetty Range					
Onnampalam 1	2.80	4.41	1.72	1.62	2.58± 1.30
Onnampalam 2	3.50	10.30	3.06	-----	5.27± 3.61
Onnampalam 3	3.80	3.40	1.55	5.48	3.52± 1.61
Onnampalam 4	3.00	2.30	2.46	2.40	2.46± 0.65
Kakkeri Vayal	3.00	2.22	3.81	3.01	3.02± 1.72
Ayyappanpara (near animal pass)	6.90	12.70	3.77	14.10	10.2± 4.86
Ayyappan para rocky area	2.80	2.91	2.79	2.78	2.85± 0.06
Dassankatte	--	1.43	1.14	1.71	1.43± 0.29

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 5 c

Variation in Calcium content of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	Calcium %				
Muthanga Range	I*	II*	III*	IV*	Average ± SD
Nellur vayal under bamboo clump soil salt lick	10.50	4.50	4.22	----	2.11± 1.52
Nellur thodu	4.50	5.10	9.47	1.18	5.05 ± 3.41
Nellur thodu under bamboo clump	2.80	1.95	3.50	2.83	2.82 ± 0.66
Maragadha thodu soil salt lower portion	4.31	16.40	9.66	4.82	8.80 ± 5.62
Maragadha thodu soil salt lick 1	10.00	0.45	10.50	8.08	7.26 ± 4.66
Maragadha thodu soil salt lick 2	2.81	6.98	7.34	---	5.71± 2.52
Maragadha thodu soil salt lick 3	12.40	9.80	15.60	0.92	9.65 ± 6.31
Maragadha thodu soil salt lick 4	7.66	4.74	2.28	2.22	4.23 ± 2.51
Maragadha 5	1.52	1.19	3.35	3.45	2.38 ± 1.19
Maragadha trijunction (upper portion)	---	7.21	9.47	------	8.34 ± 1.6
Bathery Range					
Nallathanni soil salt lick	3.50	2.80	2.90	1.10	2.30 ± 1.03
Malchikudi vayal, soil under the mango tree	16.00	8.00	9.00	10.30	11.40 ± 3.59
Manjal Vayal	8.90	6.50	4.50	10.10	7.29 ± 2.49
Varalam	8.30	6.90	7.20	--	7.20 ± 0.74
Kumallihalla (visible evidence of Elephants activity)	26.00	26.20	29.70	22.60	26.20 ± 2.9
Kurichiyath Range					
Kummichi vayal (previously artificial salt licks were provided)	2.43	2.60	2.50	2.34	2.47±.0.11
Udimaran vayal	8.90	7.71	9.30	8.30	7.71 ± 0.41
Doddakulasi Vayal	7.60	7.1	7.45	8.22	7.70±.0.34
Mavinthal vayal near flowing water	4.13	4.13	4.85	4.01	4.13 ± 0.38
Tholpetty Range					
Onnampalam 1	7.12	7.19	4.55	9.91	7.22± 2.19
Onnampalam 2	11.20	8.98	12.60	12.20	11.30± 1.63
Onnampalam 3	3.39	8.60	10.20	13.40	8.99± 4.17
Onnampalam 4	12.30	9.80	9.95	10.20	5.29±.0.45
Kakkeri Vayal	5.90	5.42	6.18	5.20	5.80± 0.38
Ayyappanpara (near animal pass)	8.85	18.10	14.00	13.70	13.70± 3.79
Ayyappan para rocky area	8.30	9.90	6.93	8.50	8.42± 1.22
Dassankatte	6.10	5.80	4.41	7.52	5.97± 1.28

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 5 d

Variation in Sodium content of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	Sodium %				
	I*	II*	III*	IV*	Average ± SD
Muthanga Range					
Nellur vayal under bamboo clump soil salt lick	4.90	9.11	16.70	16.40	2.11± 1.77
Nellur thodu	5.90	14.20	17.80	20.10	14.60± 6.23
Nellur thodu under bamboo clump	4.50	11.10	13.50	19.50	12.00 ± 6.20
Maragadha thodu soil salt lower portion	24.40	15.40	12.10	19.20	17.80 ± 5.20
Maragadha thodu soil salt lick 1	12.00	5.70	10.60	17.30	11.40 ± 4.70
Maragadha thodu soil salt lick 2	6.30	5.90	25.90	12.50	12.70± 9.30
Maragadha thodu soil salt lick 3	6.00	9.00	18.80	15.40	13.40 ± 5.80
Maragadha thodu soil salt lick 4	13.00	16.00	14.40	18.60	15.50 ± 2.40
Maragadha 5	6.00	2.00	17.10	19.80	11.20 ± 8.50
Maragadha trijunction (upper portion)		1.90	17.00	----	9.44 ± 10.70
Bathery Range					
Nallathanni soil salt lick	28.00	22.00	23.00	17.90	23.00 ± 4.15
Malchikudi vayal, soil under the mango tree	6.56	4.60	8.90	16.50	9.22 ± 5.20
Manjal Vayal	14.00	16.00	12.00	19.30	15.70 ± 3.10
Varalam	4.60	4.40	4.54		4.54 ± 0.10
Kumallihalla (visible evidence of Elephants activity)	10.00	14.10	6.75	18.20	12.50 ± 4.90
Kurichiyath Range					
Kummichi vayal (previously artificial salt licks were provided)	9.80	12.00	9.80	18.20	9.16 ± 3.90
Udimaran vayal	6.30	7.96	6.20	7.80	7.96 ± 0.90
Doddakulasi Vayal	13.20	7.96	12.80	18.50	18.50 ± 4.30
Mavinthal vayal near flowing water	10.20	9.20	8.80	11.20	10.30 ± 1.40
Tholpetty Range					
Onnampalam 1	11.80	3.13	14.40	18.70	12.10 ± 6.80
Onnampalam 2	15.00	6.50	23.40	21.10	17.00 ± 7.50
Onnampalam 3	7.00	13.80	16.20	23.50	15.60 ± 6.80
Onnampalam 4	5.60	11.80	20.20	13.50	12.90 ± 5.20
Kakkeri Vayal	8.50	10.60	15.10	9.80	9.15 ± 4.50
Ayyappanpara (near animal pass)	113.00	45.10	18.40	15.60	48.00 ± 45.30
Ayyappan para rocky area	4.30	1.19	8.17	4.80	4.68 ± 2.86
Dassankatte	18.10	18.90	18.20	18.80	18.50± 0.41

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 5 e

Variation in total nitrogen content of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	TN %				
	I*	II*	III*	IV*	Average ± SD
Muthanga Range					
Nellur vayal under bamboo clump soil salt lick	0.49	0.23	0.40	0.13	2.10± 0.16
Nellur thodu	0.36	0.80	0.20	0.03	0.40 ± 0.27
Nellur thodu under bamboo clump	0.25	0.27	0.25	0.26	0.30 ± 0.01
Maragadha thodu soil salt lower portion	0.09	0.06	1.70	0.11	0.50 ± 0.20
Maragadha thodu soil salt lick 1	1.56	0.05	2.00	0.20	0.90 ± 0.37
Maragadha thodu soil salt lick 2	0.14	0.2	0.80	---	0.40 ± 0.25
Maragadha thodu soil salt lick 3	0.14	0.17	2.50	---	1.30 ±0.00
Maragadha thodu soil salt lick 4	0.21	0.11	---	0.11	0.10± 0.06
Maragadha 5	0.07	0.02	0.60	0.08	0.20 ± 0.08
Maragadha trijunction (upper portion)	--	3.39	0.60	0.07	1.40 ± 1.02
Bathery Range					
Nallathanni soil salt lick	0.25	0.19	0.21	0.12	0.20 ± 0.05
Malchikudi vayal, soil under the mango tree	0.66	0.31	0.42	0.53	0.50 ± 0.15
Manjal Vayal	0.90	0.90	1.30	0.10	0.70 ± 0.49
Varalam	0.70	0.60	0.60	0.60	0.60 ± 0.05
Kumallihalla (visible evidence of Elephants activity)	0.80	0.60	1.30	0.80	0.70 ± 0.54
Kurichiyat Range					
Kummichi vayal (previously artificial salt licks were provided)	0.18	0.20	0.18	0.13	0.20 ± 0.03
Udimaran vayal	0.04	0.03	0.07	0.05	0.04 ± 0.01
Doddakulasi Vayal	0.03	0.02	0.03	0.04	0.00 ± 0.01
Mavinthal vayal near flowing water	0.08	0.06	0.09	0.04	0.10 ± 0.02
Tholpetty Range					
Onnampalam 1	0.68	0.13	2.10	0.26	0.72 ± 0.25
Onnampalam 2	0.12	0.10	0.20	0.18	0.12 ± 0.04
Onnampalam 3	0.39	0.66	1.80	0.07	0.80 ± 0.76
Onnampalam 4	0.08	0.24	0.50	0.28	0.30 ± 0.09
Kakkeri Vayal	0.45	0.39	0.40	0.39	0.40 ± 0.28
Ayyappanpara (near animal pass)	0.09	0.18	2.80	0.33	0.80 ± 0.28
Ayyappan para rocky area	0.12	0.02	1.70	1.20	0.90 ± 0.82
Dassankatte	0.30	0.30	0.50	0.11	0.30 ± 0.16

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002

APPENDIX 5 f

Variation in total phosphorus content of the soil samples collected from Wayanad Wildlife Sanctuary

Locations	TP %				
	I*	II*	III*	IV*	Average ± SD
Muthanga Range					
Nellur vayal under bamboo clump soil salt lick	0.02	0.02	0.15	0.06	2.11± 0.06
Nellur thodu	0.03	0.04	0.06	0.05	0.03± 0.01
Nellur thodu under bamboo clump	0.05	0.03	0.04	0.05	0.03± 0.01
Maragadha thodu soil salt lower portion	0.03	0.03	0.06	0.08	0.05± 0.02
Maragadha thodu soil salt lick 1	0.07	0.04	0.03	0.06	0.05± 0.03
Maragadha thodu soil salt lick 2	0.07	0.04	0.18	---	0.07± 0.07
Maragadha thodu soil salt lick 3	0.07	0.07	0.25	---	0.13± 0.1
Maragadha thodu soil salt lick 4	0.01	0.23	0.18	0.06	0.12± 0.1
Maragadha 5	0.01	0.01	0.31	0.05	0.12± 0.06
Maragadha trijunction (upper portion)	Trace	0.02	0.05	0.04	0.1± 0.03
Bathery Range					
Nallathanni soil salt lick	0.02	0.02	0.06	0.06	0.04± 0.02
Malchikudi vayal, soil under the mango tree	0.03	0.02	0.04	0.03	0.03± 0.01
Manjal Vayal	0.03	0.01	0.03	0.01	0.02± 0.01
Varalam	0.10	0.07	0.08	---	0.08± 0.02
Kumallihalla (visible evidence of Elephants activity)	0.20	0.24	0.22	---	0.22± 0.02
Kurichiyath Range					
Kummichi vayal (previously artificial salt licks were provided)	0.05	0.05	0.06	0.07	0.06± 0.01
Udimaran vayal	0.05	0.04	0.04	0.07	0.02± 0.01
Doddakulasi Vayal	0.05	0.05	0.05	0.05	0.05± 0.00
Mavinthal vayal near flowing water	0.01	0.01	---	---	0.01± 0.00
Tholpetty Range					
Onnampalam 1	0.08	0.04	0.12	0.14	0.1± 0.04
Onnampalam 2	0.09	0.03	0.15	0.06	0.08± 0.05
Onnampalam 3	0.06	0.09	0.22	0.04	0.11± 0.08
Onnampalam 4	0.02	0.09	0.2	0.12	0.11± 0.05
Kakkeri Vayal	0.03	0.06	0.31	0.18	0.19± 0.03
Ayyappanpara (near animal pass)	0.11	0.06	0.4	0.09	0.17± 0.16
Ayyappan para rocky area	0.37	0.67	0.09	0.39	0.38± 0.31
Dassankatte	0.32	0.26	0.29	0.29	0.29± 0.15

*Sampling dates; I-June 2000; II-December 2000; III-April-May 2001; IV-January 2002