ASSESSMENT OF FOOD DEMAND AND PRODUCTION POTENTIAL OF KUTTIPPURAM GRAMA PANCHAYATH USING GIS, REMOTE SENSING AND WATERSHED MODELING

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PROJECT REPORT

Submitted in partial fulfillment of the

requirement for the degree

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land & Water Resources & Conservation Engineering

Kelappaji College of Agricultural Engineering & Technology

Tavanur – 679573, Kerala, India

December 2011

DECLARATION

We hereby declare that this project entitled **"ASSESSMENT OF FOOD DEMAND AND PRODUCTION POTENTIAL OF KUTTIPPURAM GRAMA PANCHAYATH USING GIS, REMOTE SENSING AND WATERSHED MODELING"** is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us for any degree, diploma, associateship, fellowship or other similar title of any other university society.

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CERTIFICATE

Certified that this project report entitled **"ASSESSMENT OF FOOD DEMAND AND PRODUCTION POTENTIAL OF KUTTIPPURAM GRAMA PANCHAYATH USING GIS, REMOTE SENSING AND WATERSHED MODELING"** is a record of project work done independently by **Lekshmi S Prasad, Saranya J and Sreeju K B** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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ACKNOWLEDGEMENT

We would like to express our deep sense of gratitude, utmost indebtedness and heartfelt thanks to **Dr. Sathian, K. K.**, Associate Professor, Department of Land and Water Resources and Conservation Engineering, KCAET, Tavanur for his valuable guidance, profound suggestions, constant backing, prolific encouragement and advice throughout the project work.

We are thankful to **Dr. Sivaswami**, **M.**, Dean, KCAET, Tavanur for his support and co-operation during the course of work.

With deep respect we express our heartfelt gratitude to **Dr. Kurien**, **E. K.**, Head of the Department of Land and Water Resources and Conservation Engineering, KCAET, Tavanur for his immense guidance and support during this work.

We are also thankful to **Mr. Mathew George**, Agricultural Officer, Kuttippuram Grama Panchayath and other staff members for rendering the necessary support.

We extent our extreme gratitude to **Mr. Harris, K** and **Mrs. Pankajam, T** of library for their timely help for collecting the literature for the documentation of this work.

We express our deep sense of gratitude to our loving **parents** and all our dear **friends** for their stable support and inspiration throughout our study.

Above all we bow our head before **The Almighty**, whose blessings empowered us to complete this work successfully.

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Dedicated to
The Farming Sector of
Kerala

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SYMBOLS AND ABBREVIATIONS

%	Percentage
APR	April
AVSWAT	Arc View SWAT
cm	centimeter(s)
CN	Curve Number
CWC	Central Water Commission
D RECH	Deep Recharge
DEC	December
DEM	Digital Elevation Model
et. al	and others
FEB	February
Fig.	Figure
gcm^{-3}	gram per cubic centimeter(s)
GIS	Geographical Information System
GWQ	Ground water runoff
ha	hectare(s)
ham	hectare meter(s)
HRU	Hydrological Response Unit
ICMR	Indian Council of Medical Research
ILWIS	Integrated Land and Water Information System
IRS	Indian Remote Sensing
JAN	January
JUL	July
JUN	June
km	kilometer(s)
km^2	square kilometer(s)
LANDSAT	Land use Satellite
LATQ	Lateral flow

LISS	Linear Imaging Self Scanning
m	meter(s)
MAR	March
MAY	May
Mham	Million hectare metre(s)
Mkm^3	Million cubic kilometer(s)
mm	Millimeter(s)
NBSS	National Bureau of Soil Survey
No:	Number
NOV	November
NRSA	National Remote Sensing Agency
NSE	Nash–Sutcliffe Simulation model Efficiency
OCT	October
PAN	Panchromatic
RDA	Recommended Daily Allowance
SCS	Soil Conservation Service
SEP	September
Sl.No.	Serial Number
SOI	Survey of India
SOL K	Soil Electrical Conductivity
SOL_AWC	Soil Available Water Capacity
SPOT	Systeme Pour l’Observation de la Terre
SURQ	Surface Runoff
SWAT	Soil and Water Assessment Tool
SWS	Sub watershed
t	tonne
t/ha	tonne/hectare
t/yr	tonne/year
TM	Thematic Map
USDA	United State Department of Agriculture
USLE	Universal Soil Loss Equation

Introduction

Chapter 1

INTRODUCTION

Dwindling food production is a cause of great concern in all parts of the world. The severity of the problem is more in populated developing nations, where population increase is happening on one side and the agricultural production downslide on the other end causing the food demand- supply gap to widen at a faster pace. Many reasons can be attributed to the loss of food production in various parts of the world. Loss of profitability, shortage of farm labourers, scarcity of water, increased incidence of pests and diseases, fluctuating prices of agricultural commodities, perishability of the produces are some of the notable reasons for this. Climatic change has emerged as another major threat to the agricultural production.

In India, food security issues are more experienced in the State of Kerala compared to any other parts of the nation. The State is considered to be a consumer one in the case of food and industrial products. Some of the specific reasons for the state to remain disadvantage in the food sector, over and above the general reasons, are increased labour cost, small land holdings, flooding during rainy seasons, conversion of food cropped area into plantations and increased habitation demand which leads to encroachment into agricultural land and its irreversible conversion.

The important food crops grown in the State of Kerala are paddy, coconut, banana, vegetables, sesame etc. Paddy is considered as the staple food of the State. But, it is very disturbing to see that its production is nose diving to precarious low levels. Some recent statistics released by the International Rice Research Agency report that the acreage of rice production in the State of Kerala has gone down from 7.8 lakh ha to 2.3 lakh ha and corresponding to that production has decreased from 10.5 lakh tonnes to 5.3 lakh tonnes. In the case of other food crops also the acreage and the production have gone down considerably. Presently, the State is importing about 80% of its cereal demand from the neighbouring States. Though not to this extend, the import of other food items is also made at a very large volume in terms of physical quantity and money value.

Considering the above said precarious food scenario of the State of Kerala, it is highly imperative that remedial measures are formulated and implemented to save the State from food crunch, steeping price rise and starvation. Looking into the resource potential of the State, it has many strength which can be turned to opportunities. Ample amount of annual rainfall, moderate climate, utilisable land, moderate levels of basic infra structures are some of the most important strengths of the State.

To propose any workable plan for the development of agriculture for the State, a comprehensive demand analysis and resource assessment is essential. Such analysis will have to be carried out on watershed basis. Implementation of watershed programmes is generally carried out by Grama Panchayaths. Hence, implementation of the watershed development programme will have to consider the Grama Panchayath boundaries also. Further, the population statistics is available only for the geographical area of Grama Panchayaths and not on the sub-watershed basis.

Hence, it is proposed to carry out a study of food demand and resource analysis for the micro watersheds in and around a Grama Panchayath. The most challenging task in this is the delineation of the micro watershed, understanding the spatial distribution of land use and soil, assessing the hydrologic processes and determining the population of the watershed. All these works can be done efficiently and effectively by incorporating the techniques of GIS, Remote Sensing and Watershed Modeling.

Considering these aspects, a study has been carried out to assess the resources and food demand of sub watersheds representing one Grama Panchayath with the given below specific objectives.

1. To assess the periodic water resource availability of a Grama Panchayath
2. To estimate the food demand of a Grama Panchayath
3. To estimate the production potential of the Grama Panchayath

Review of Literature

Chapter 2

REVIEW OF LITERATURE

Schumann, A. H *et al.* (2000) conducted a study on application of geographic information system for conceptual rainfall - runoff modeling. In this, an approach was presented on how statistical descriptions of distributed catchments characteristics could be used to consider spatial heterogeneity within conceptual models. Three semi-distributed components were presented. These three components were combined to a hydrological model including feedback components between surface flow and infiltration and between subsurface return flow and surface flow in saturated areas. In the second part, it was shown how the application of this model to different catchments within a region benefit from boundary conditions for optimization, which were derived from GIS considering the variations of catchment's characteristics.

Chandrasekharan *et al*. (2001) studied the applications of satellite remote sensing and GIS on characterization and spatial modeling of runoff and soil erosion of Birantiya Kalan, an arid watershed in the district of Pali, Western Rajasthan. The digital analysis of the data carried out involved geometric correction with respect to map, digitization of watershed boundary, extraction of the study area and discrimination of land use/land cover types. Slope map for the study area was generated from DEM of the GRID module of ARC/INFO GIS. Curve Number (CN) method was used in GRID module of ARC/INFO GIS to generate runoff potential. Universal Soil Loss Equation (USLE) was used in ARC/INFO GIS to predict soil loss from the watershed. Results revealed that changes in land use/land cover in the watershed are marginal with a decline in the vegetation status. Thus there was a non-perceptible impact of conservation treatments for the development of the watershed. Though the findings relate to a particular watershed, these calls for a re-look into the action plans and implementation of various soil and water conservation measures in watershed development programmes. The study demonstrated the vast potentials of satellite remote sensing and GIS applications in impact assessment study, particularly for the areas, which are large and remotely located.

Sharma *et al.* (2001) conducted a study on micro-watershed development plans using Remote Sensing and GIS for a part of Shetrunji river basin, Bhavnagar district, Gujarat. Here an approach using remote Sensing and GIS has been applied to identify the natural resources problems and to generate local specific micro-watershed development plans for a part of Shetrunji river basin. Study of the multidate satellite data has revealed that the main land use or land cover in the area is rainfed agriculture, waste land with or without scrubs in the plains and undulating land and scrub forest on the hills. The depleting vegetation cover has resulted in excessive soil erosion exposing barren rocky waste.

A research work was pursued by Chattopadhyay and Sujit (2003) on the application of GIS and remote sensing for watershed development project in draught affected areas of Mungyr District, Bihar. Remote sensing data for faster assessment of natural resources such as soil, geology, drainage etc as well as assessment of economic activities through land use and infrastructure of the watershed area was made use. GIS was proved as a powerful tool for development of the watershed area with all natural and socio-economic facts for better planning, execution and monitoring of the project.

Alexander *et al.*(2004) carried out a case study at the Ferghana Province of Uzbekistan using remote sensing data for water depletion assessment at administrative and irrigation-system levels. Using recent developments in the field of remote sensing application in water management, this study shows that remote sensing tools can help in improving water management in three ways: (a) by providing information on the existing patterns of water use (b) by identifying the weaknesses in the approach to water management and (c) by assisting in identifying the potential areas where there are opportunities for water savings or improving water use efficiency. This study provides information on setting up and using remote sensing data for monitoring and analyzing water consumption in an irrigation water management perspective.

Hao FangHua *et al.* (2004) made a study on the runoff and sediment yield simulation in a large basin using GIS and a distributed hydrological model. A GIS-based distributed SWAT (Soil and Water Assessment Tool) model was used to simulate the runoff and sediment yield in the upper basin of the Luohe River, a tributary of the Yellow River in China. In the process of calibration, the automated digital filter technique was used to separate the surface runoff and base flow. The surface runoff, base flow, total runoff and the sediment yield were calibrated. The simulated results demonstrated that the GIS-based SWAT model could be successfully used to simulate long-term runoff and sediment yield.

Remote sensing applications for the management of water and land resources in rainfed area in Andhra Pradesh were carried out by Pavani *et al.* (2004). The study area was Racherla watershed of Prakasam district. The objectives of the study were

1. To study the existing cropping patterns and the available water resources in the Racherla mandal and evaluate the natural resources using Remote sensing data for the extraction of feasibility condition for its development.

2. To map all the thematic information by interpreting the satellite imageries and SOI top sheets for the production of maps through Arc/Info software.

3. To prepare the action plan maps i.e. land resources development and water resource development.

Drainage map was prepared using SOI toposheets and satellite imagery in order to determine the Drainage pattern and for calculating various drainage characteristics like density, stream frequency and basin slope for watershed. Hydro geomorphology map was prepared using SOI toposheets and satellite imagery which was further used for finding the groundwater prospects and to suggest water-harvesting structures like percolation tanks. By adopting suitable soil and water conservation measures like contour bunding, lands with poor productivity and serious soil erosion can be brought under fodder, silvipasture and social forestry development. These developmental activities help in reduced soil erosion, increased moisture conservation and improved productivity of the soil.

Roshan *et al.* (2004) conducted a quantitative water resources assessment in a poorly gauged mountainous catchment, i.e. the River Indrawati catchment in Nepal. This study has presented an example of integrating available tools and hydrological knowledge to analyse practical problems in a data-poor region. Tools like GIS and remote sensing have made it possible to extract valuable spatial information. Available water, available water demand, irrigation water demand and drinking water demand were assessed and estimated using empirical methods. Global DEM data was adopted to delineate the catchment boundary, river network and slope profile. They concluded that the water resource quantity needed is available at present, but the region needs a well-planned management strategy to assure long-term water availability.

Arun *et al.* (2007) carried out the assessment of runoff and erosion using GIS. The study has been carried out on Gayathri sub basin of Bharathapuzha river basin, with focus on runoff and erosion generating process of the watershed. The specific objective of the study included characterization of watershed from the stand point of runoff and erosion process and quantification of these physical processes. Surface runoff has been computed by SCS curve number method and the result indicate that 38% of annual runoff flows out as surface runoff. Erosion estimated from USLE shows that 31.03% of area comes under very high erosion (40-100 t/ha/yr), 34.48% under high erosion (10-40 t/ha/yr), 18.16% under medium erosion (5-10 t/ha/yr) and 9.9% under low erosion (0-2.5 t/ha/yr).

Dass *et al*. (2007) made a hydrological study and water resource assessment in Kokriguda watershed of Orissa for sustainable water management. They made an assessment of water resource potential, availability and demand in Kokriguda watershed, a representative of Eastern Ghats of Orissa, by considering all the sources of water, land uses for sustainable water management. The results showed the annual fresh water potential of 312.45 ha-m including runoff and surface flow 299.39 ha-m and 13.06 ha-m ground water. The annual water requirement in the watershed was estimated to be 155.46 ha-m, which included irrigation water requirement and public water demand. Therefore different interventions like installation of underground pipeline irrigation system, proper use of water, in-situ moisture conservation measures, crop diversification etc were executed and found to be effective for sustainable water management.

Praveen and Prasad (2008) conducted a study on integrated land and water resources conservation and management – development plan using remote sensing and GIS of Chevella sub-watershed in Andhra Pradesh. The main objective of the study was to generate information/databases on 1:25,000 scale pertaining to hydro geomorphology, drainage, surface water bodies, watershed, transport network etc. using multi-temporal satellite data. Conversion of these databases into digital form for future analysis and utilization and to prepare location specific land, water resources development plans, by integrating these databases with socio-economic data and contemporary technology in the GIS environment such that control of soil & moisture conservation and land degradation, optimal management of croplands and conservation and management of water resources could be achieved. IRS P6 LISS III, IRS 1D LISS-III and

IRS 1D PAN Imagery have been used for the preparation of land use/land cover, hydrogeomorphogy and soil maps. It was recommended that water harvesting should be given importance to avoid the wastage of rainwater from the watershed. This will also increase the groundwater recharge besides providing supplementary irrigation during Rabi season. The study points out that farmers should be encouraged in making farm ponds and soil conservation measures.

Divya *et al*. (2009) made a watershed simulation study using GIS integrated physically based model. They conducted the study on Kadalundi river basin of Kerala state to understand the hydrologic behaviour of the basin. Widely recommended SWAT model has been used for the study. It gave emphasis on simulation of watershed processes and calibration of the model. GIS techniques are made use of to incorporate spatial variability more thoroughly and efficiently. This study revealed that the model predict the low flow of the river with very good accuracy. Contribution of different sub watersheds towards the total stream flow has been quantified. Hence, recommendations to alleviate the water scarcity and developmental measures for micro watersheds can be given more specifically and effectively.

Sathian and Syamala (2009) studied about the calibration and validation of a distributed watershed hydraulic model. In this study, the SWAT model, developed by USDA has been used to analyse and quantify the water balance of a river basin namely Kunthipuzha in Kerala. DEM, land use, soil and digitized stream network were prepared from LISS-III imagery of IRS 1C. Climatic data has been collected from two meteorological observatories at Pattambi and Mannarkkad. Water balance components of the basin have been simulated and it is found that the base flow contribution is the maximum in the river flow followed by lateral flow and surface runoff. Predicted water balance components were also been compared with their measured or alternately computed counterparts and has shown good agreement. The study makes the recommendation that SWAT model can be effectively calibrated and validated for seven years period from 1996 to 2002 using the daily rainfall and observed river flow data. The results indicate that the predictive power of the model for both flow and sediment is very high as shown by the time series and NSE and COD.

A special emphasis was laid on the development of action plan for land and water resources management using GIS and Remote sensing by Yassir Arafat M.N (2010). The study area was Adilabad district of Andhra Pradesh. A special emphasis was laid on the development of action plan for land and water resources management mainly based on the land use/ land, cover, geomorphology and slope of the area. The main objectives were to study the available water resources and evaluate the natural resources using Remote sensing data for the extraction of feasibility condition for its development and to prepare the action plan maps i.e. land resources development and water resource development by integrating the information obtained from the analysis. Satellite data processing was done using ERDAS 9.1 Image Processing software. From the SOI Toposheet and GSI maps the layers such as drainage, geology, lineaments, soil and geomorphology were digitized. Then based on the criteria these layers were integrated and used according to requirements of the analysis. From the final output recharge wells, percolation tank and check dams were recommended for the study area, mainly to control sedimentation from the catchments. To increase the groundwater recharge vegetative cover and to control soil erosion, various action plans like construction of recharge structures and afforestation have been proposed. The result aim for optimum development of land and water resources and to meet the basic minimum needs of people thereby improving their socio-economic conditions. The information generated from such studies can be applied by decision makers and planners for sustainable development of any given watershed area.

Ahmed *et al*. (2010) developed an approach which incorporated (1) extraction of spatial and temporal data using recently developed models from a wide-range of global remote sensing data (2) integration of data to determine precipitation, soil moisture, reservoir volume and stages, and flows in large river channels, which are key components in hydrologic processes (3) development and application of hydrologic model that simulates hydrologic processes, water usage for energy production, and agricultural activities with a GIS capability to interpret and implement multiple satellite sensor data for model input and model calibration. This integrated; characterization method has been applied to the arid to semiarid areas, the Sinai Peninsula and the Eastern Desert of Egypt. This study demonstrated how wide-range available, globe remote sensing data sets could be potentially used to address apparent inadequacies in ground-based monitoring systems. The methodologies developed in the work provide an improved tool to simulate the hydrologic processes, crop growth, and water management for watershed basins at a regional scale. Applications of the developed methodologies in the test areas and elsewhere world-wide will contribute the understanding of the regional scale variability and storages of the terrestrial hydrosphere. The applications of these methods were especially valued for arid and hyper-arid parts of the world, where demand for freshwater supplies is on the rise due to increasing population and limited water supplies.

Moushumi *et al.* (2011) made a study on water stress assessment in Jharkhand state using soil data and GIS. They studied the interrelationship of water resources available with that of soil class and its properties including soil drainage and erosion characteristics which has been used to generate drainage stress map and water stress map inferring the basic reason for water scarcity in the district. It can be inferred that soil type is not suitable for water recharge. As most of the water goes off as runoff the recharge into ground water is less. Soil in Jharkhand is thus one of the components responsible for water stress in the state. Thus steps should be taken to capture the running water. This can be done by adopting measures like contour bunding, water harvesting ponds and other physical methods.

Materials & Methods

Chapter 3

MATERIALS AND METHODS

3.1 Study Area

The study area comprises Kuttippuram Grama Panchayath and the micro watersheds of that area. Kuttippuram lies within a geographical bound of $10^0$49’35”N, $75^0$59’37”E and $10^0$53’08”N, $76^0$04’36”E.

The Grama Panchayath is within the micro-watersheds of Bharathapuzha river basin and that of Tirurpuzha. It has an average elevation of 15 m and average annual rainfall of 2850.2 mm. The area has got six main micro-watersheds. Most of the study area has a hilly terrain with clay mixed gravel soil. Climate is humid tropic. Major soil series of the area are Vijayapuram, Chelikkuzhi and Anayadi. Important vegetations of the area comprises of coconut, arecanut, rubber, paddy and forest.

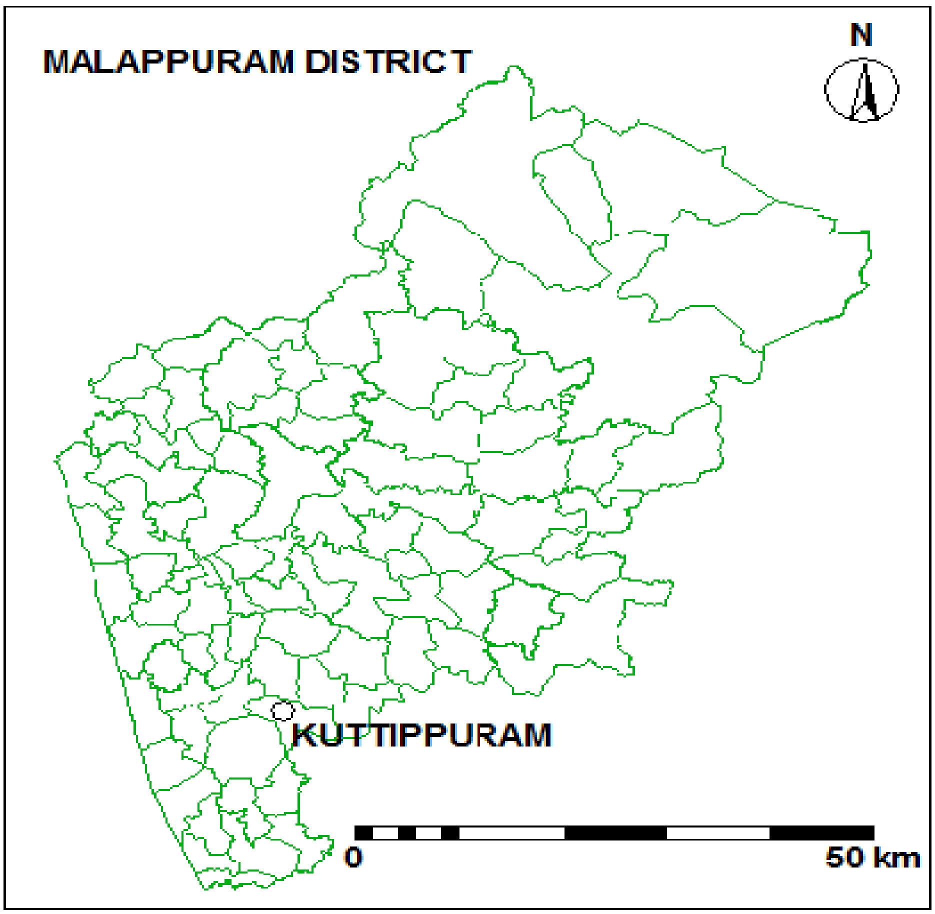

Fig. 1. Malappuram district map with Grama Panchayath boundaries

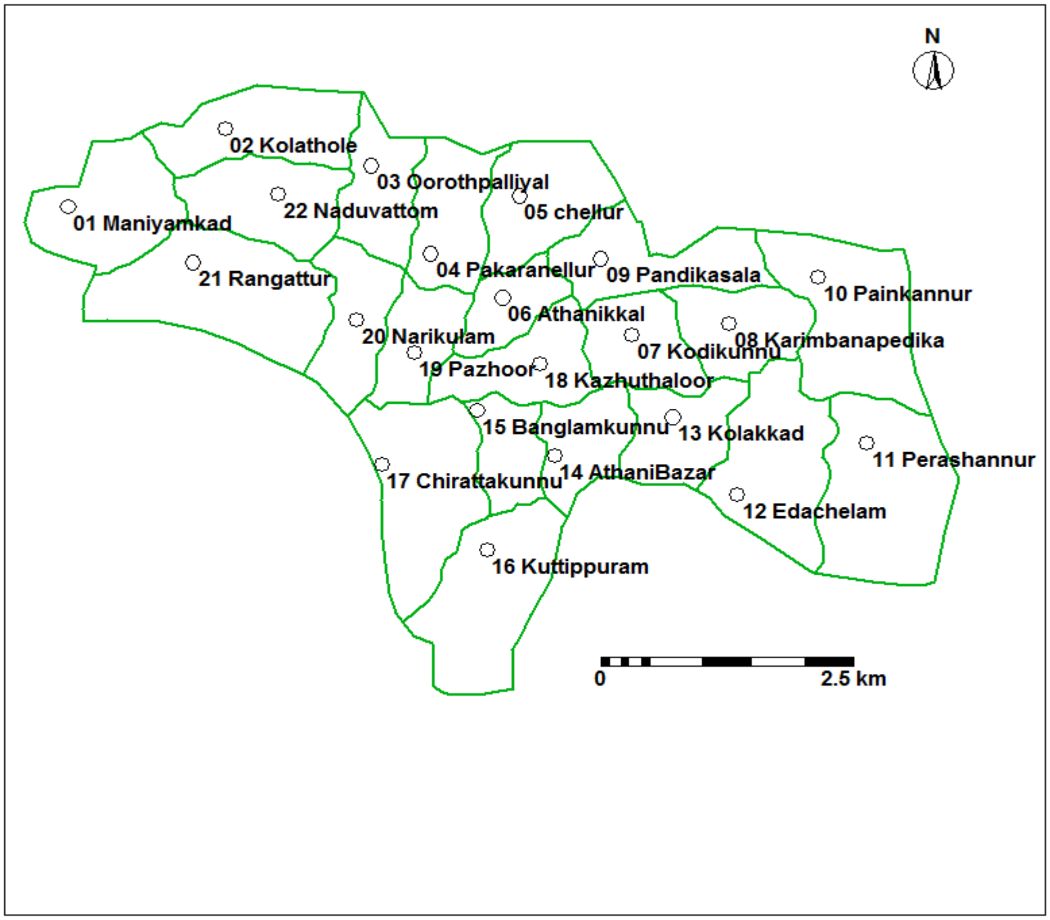

Fig. 2. Kuttippuram Grama Panchayath with wards

3.2 Data source

- Topographic map from Survey of India (SOI) prepared in 1:50000 scale.
- Multi spectral satellite imagery of LISS III of IRS P6 having four bands from NRSA, Hyderabad.
- Soil map from National Bureau of Soil Survey and Land Use Planning (NBSS and LUP) prepared in 1:500000 scale.
- Daily rainfall and temperature data from various meteorological observatories controlled by Water Resources Department, Kerala and Kerala Agricultural University.
- River flow data from Central Water Commission (CWC), Kochi.

3.3 Tools and Techniques used

3.3.1 ILWIS

ILWIS is an acronym of the Integrated Land and Water Information System. It is Geographical Information System (GIS) software with Image Processing capabilities. ILWIS has been developed by the International Institute for Aerospace Survey and Earth Sciences, Enschede, Netherlands.

As a GIS and Remote Sensing package, ILWIS allows inputting, managing, analysing and presenting geo-graphical data. From the data one can generate information on the spatial and temporal patterns and processes on the earth surface. Geographic Information Systems are now-a-days indispensable in applications related to spatial analysis.

3.3.2 SWAT

SWAT, the acronym for Soil and Water Assessment Tool, is a complex integrated river basin scale model which simulates the hydrologic processes of each HRU on daily or hourly time step (Arnold *et al*., 1990 & 1993, Jayakrishnan *et al.,* 2005 and Bouraoui *et al.,* 2005). The model has been developed by United State Department of Agriculture (USDA) and has undergone many capability expansions (Neitsch *et al*., 2005). The model can predict the impacts of land management practices on water, hydrologic components, sediment load and water quality. It can assist the land and water managers to assess the impact of land management practices in hydrology, erosion and non point source pollution. SWAT is a physically based model in which rather than incorporating regression equations to describe the relationship between input and output variables, which requires specific information about weather, soil properties, topography, vegetation and land management practices occurring in the watershed. SWAT divides the watershed into sub watersheds based on land slope direction and channel network.

3.3.3 Important Hydrologic Equations of SWAT

The important equations to predict the watershed of hydrology is given below. The hydrologic cycle is simulated by the water balance equation:

$$SW_t = SW_0 + \sum_{i=1}^{t}(R_i - Q_i - ET_i - P_i - QR_i)$$

where, SW_t and SW_0 are the final and initial soil water content respectively (mm).

R = daily rainfall (mm)

Q = daily surface runoff (mm)

ET = daily evapotranspiration (mm)

P = daily percolation (mm)

QR = daily lateral flow (mm)

Surface runoff is predicted by:

For R > 0.2S

$$Q = \frac{(R - 0.2S)^2}{R + 0.8S}$$

For R < 0.2S

$$Q = 0$$

$$Q = 254\left(\frac{100}{CN} - 1\right)$$

where, Q = daily surface runoff (mm)

R = daily rainfall (mm)

S = retention parameter (mm)

CN = curve number

Lateral flow is predicted by

$$q_{lat} = 0.024^{\frac{2S_x S_c \sin\alpha}{\theta_d L}}$$

where, q_{lat} = lateral flow (mm/ day)

S_x = drainable volume of soil water per unit area of saturated thickness (mm/day)

S_c = saturated hydraulic conductivity (mm/h)

L = flow length (m)

α = slope of the land

θ_d = drainable porosity

The base flow is estimated by

$$Q_{gw} = Q_{gwj-1} e^{(-\alpha_{gw} \Delta t)} + W_{recharge} \left(1 - e^{(-\alpha_{gw} \Delta t)}\right)$$

Where, Q_{gwj} = groundwater flow into the main channel on day j

α_{gw} = base flow recession constant

Δt = time step

3.4 GIS layers required for ILWIS and SWAT

3.4.1 Basic GIS layers

The basic map inputs required for the AVSWAT include digital elevation, soil maps, land use/cover, hydrography (stream lines). In addition, the interface requires the designation of land use, soil, weather, as well as the simulation period, to ensure a successful simulation. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling etc are directly modeled by SWAT using this input data.

Basic GIS layers such as DEM (Digital Elevation Model), Drainage network, Land use and soil have been taken from the geomatic division of Department of Land and Water Conservation Engineering.

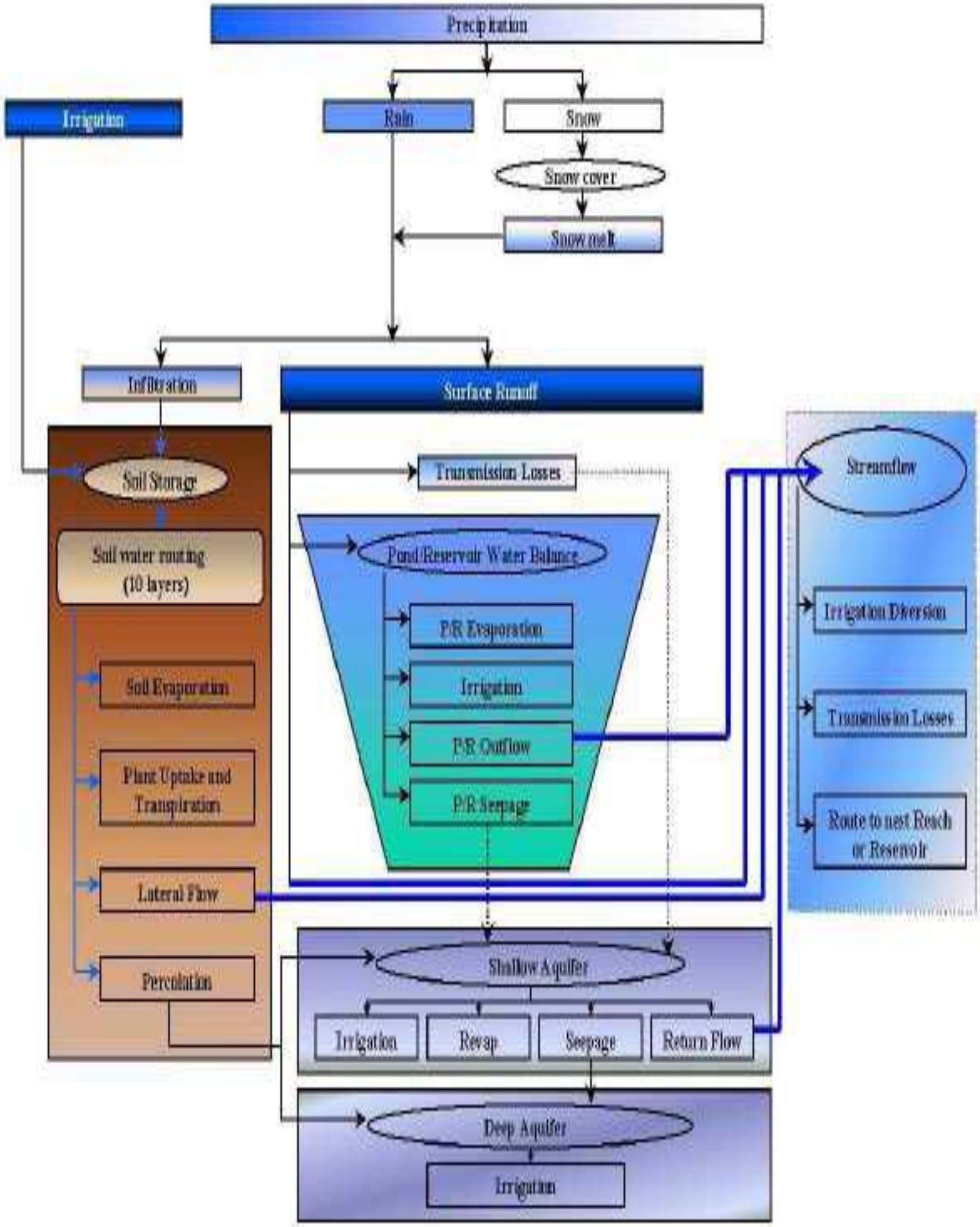

Fig. 3. The flow chart showing the pathway available for water movement in SWAT

3.4.2 District map with Grama Panchayath boundaries

Conventional map of Malappuram District with Grama Panchayath boundaries have been collected from the State Soil Survey Department, Trivandrum. It is digitized using the digitization capability of the ILWIS software. Thus segment map with Grama Panchayath divisions is prepared.

3.4.3 Delineation of sub-watersheds

All the sub-watersheds of Bharathapuzha river basin and a portion of Tirurpuzha in the neighbourhood of Kuttippuram Grama Panchayath have been delineated using SWAT. Watershed delineation has been carried out with the advanced GIS functions to aid in segmenting watersheds into several hydrologically connected sub-watersheds for use in watershed modeling.

3.4.4 Identification of sub-watersheds for Kuttippuram Grama Panchayath

The need of water for agricultural production in the Kuttippuram Grama Panchayath is met by the surplus water available in the sub-watersheds of Bharathapuzha and Tirurpuzha lying in and around the Grama Panchayath area. These sub-watersheds were identified by superimposing the Grama Panchayath boundary map on the sub-watershed map of Bharathapuzha and Tirurpuzha.

3.4.5 Physical characteristics of sub-watersheds

Physical characteristics of all sub-watersheds of Kuttippuram Grama Panchayath have been determined using SWAT and ILWIS. Major physical characteristics determined for the sub-watersheds were area, elevation, slope, channel length and channel slope.

3.4.6 Hydrologic characteristics

Using SWAT, hydrologic characteristics of all the sub-watersheds of study area have been estimated. Major hydrologic behaviour of sub-watersheds namely evapotranspiration, surface runoff, lateral flow, ground water flow and water yield have been determined on daily basis.

3.4.7 Demographic data

Population details of individual Wards of Kuttippuram Grama Panchayath were collected from the Panchayath records and are shown in the Table 1. Demographic map of Grama Panchayath showing the population of individual Wards of Kuttippuram Grama Panchayath has been prepared in ILWIS by creating segment map, point map and through the process of polygonisation. Population on each watershed is also estimated by crossing sub watershed map and the population density map of the Grama Panchayath.

Table 1. Population details of Kuttippuram Grama Panchayath

Sl.No.	Ward Name	Nom: of houses	Population
1	Maniyamkad	432	1098
2	Kolathole	168	1555
3	Oorothpalliyal	451	1329
4	Pakaranellur	430	1402
5	Chellur	515	1128
6	Athanikkal	455	1717
7	Kodikkunnu	557	1517
8	Karimbanapeedika	507	1183
9	Pandikashala	603	1407
10	Painkannur	564	1383
11	Perashannur	574	1157
12	Edachalam	371	1439
13	Kolakkad	490	1643
14	Athani Bazar	424	1427
15	Banglamkunnu	98	1253
16	Chirattakunnu	365	1065
17	Kuttippuram	470	1002
18	Puzhanambram	948	1207
19	Kazhuthalloor	412	1220

20	Pazhoor	539	1323
21	Narikkulam	402	1628
22	Rangatoor	332	1224
23	Naduvattom	346	1308
Total		10453	30615

Source: Voter's list 2011; Kuttippuram Grama Panchayath

3.4.8 Food demand

Food requirement of entire Grama Panchayath have been worked out as per the standards set by ICMR (Indian Council of Medical Research). Average balanced diet for adults consuming non-vegetarian food is shown in Table 2.

Table 2. Balanced diet for adults (The quantities given are in grams)

Food Stuffs	Female	Male
Cereals	440	520
Pulses	25	25
Vegetables	100	40
Roots and tubers	50	60
Fruits	30	30
Milk	150	200
Fats and oil	30	50
Flesh foods, fish	30	30
Eggs	30	30
Sugar	20	35

Source: RDA of foods, ICMR 1984

3.4.9 Production potential of individual sub-watersheds

Production potential of individual sub-watersheds is estimated considering the availability of land and water. In the summer season, majority of the fallow lands can be reformed for cultivation purpose if adequate amount of water is made available. For this a small fraction of surplus water available during the late part of rainy season can be made use to satisfy the food requirement of the population to a certain extent and there by the agricultural production can be improved.

3.4.10 Production potential of Kuttippuram Grama Panchayath

The overall production potential of Kuttippuram Grama Panchayath has been determined by crossing the Grama Panchayath map on the sub-watershed production potential map.

Results & Discussion

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Micro-watersheds of Bharathapuzha and Tirurpuzha

All the micro-watersheds of Bharathapuzha and a portion of Tirurpuzha have been generated at micro level using SWAT. A threshold level of 300 hectare is used in the delineation of micro-watersheds. 390 micro-watersheds have been delineated for Bharathapuzha river basin and 2 micro watersheds for Tirurpuzha in the vicinity of the study area. (Fig. 4)

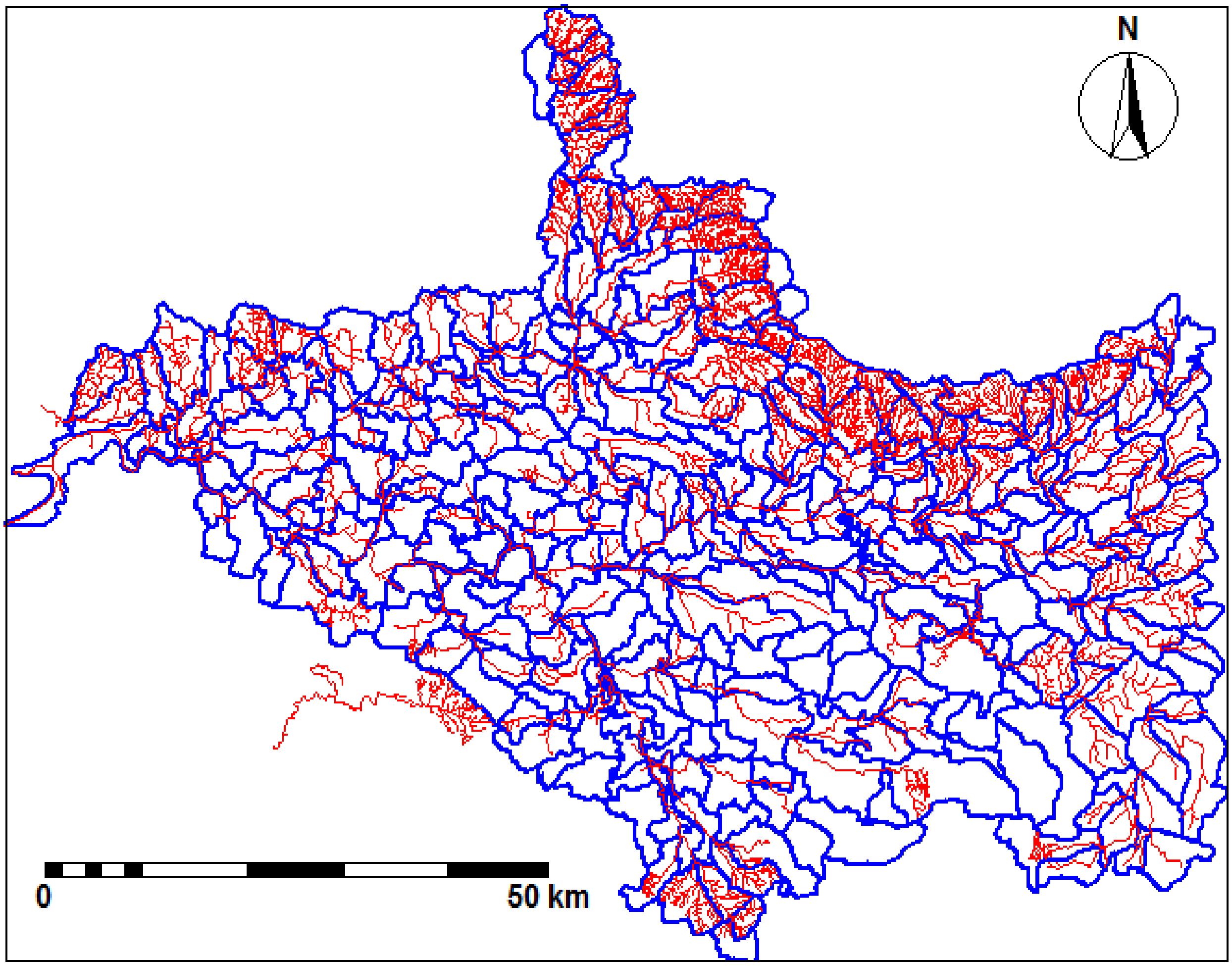

Fig. 4. Bharathapuzha and Tirurpuzha sub-watersheds with drainage network

4.2 Micro-watersheds of study area

A total of eight sub-watersheds in and around Kuttippuram Grama Panchayath have been identified. Among these, four micro-watersheds have more representation in the Panchayath area. These four micro-watersheds are SWS1, SWS2, SWS7 and SWS8. The delineated micro-watersheds of Kuttippuram Grama Panchayath with drainage network are shown in Fig. 5.

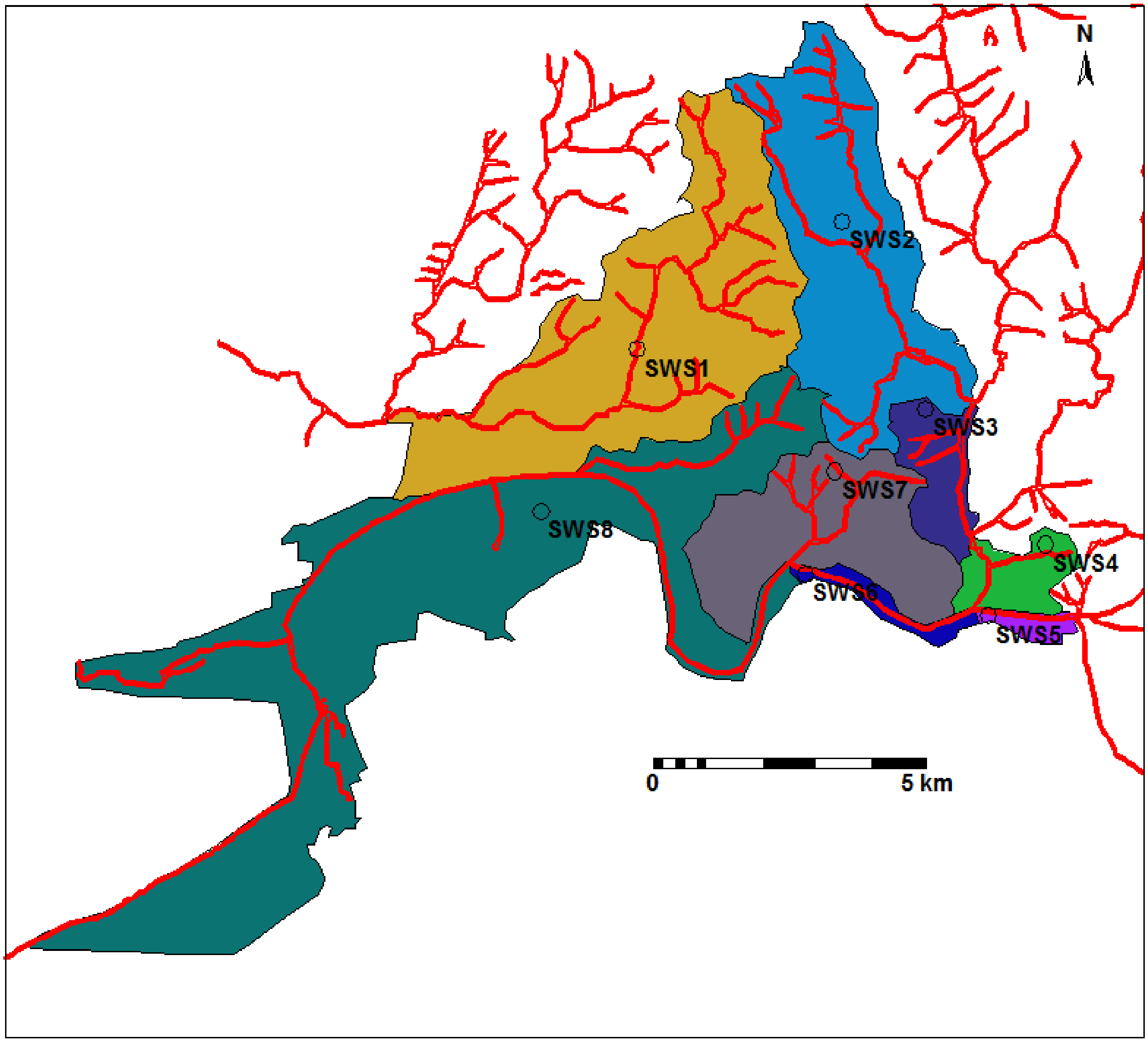

Fig. 5. Sub-watersheds in Kuttippuram Grama Panchayath with drainage network

4.3 Land use map of sub-watershed

The land use map (Fig.6.) developed by supervised classification of satellite imagery shows that there are 10 different land use classes. The major land use types identified in the watershed are garden land (46.94 %) and paddy (43.59%). The rest of the land use classes delineated in the watershed include dense forest, medium forest, moderate dense forest, river dry, rubber and water. The area covered by different land use classes is shown in Table 3.

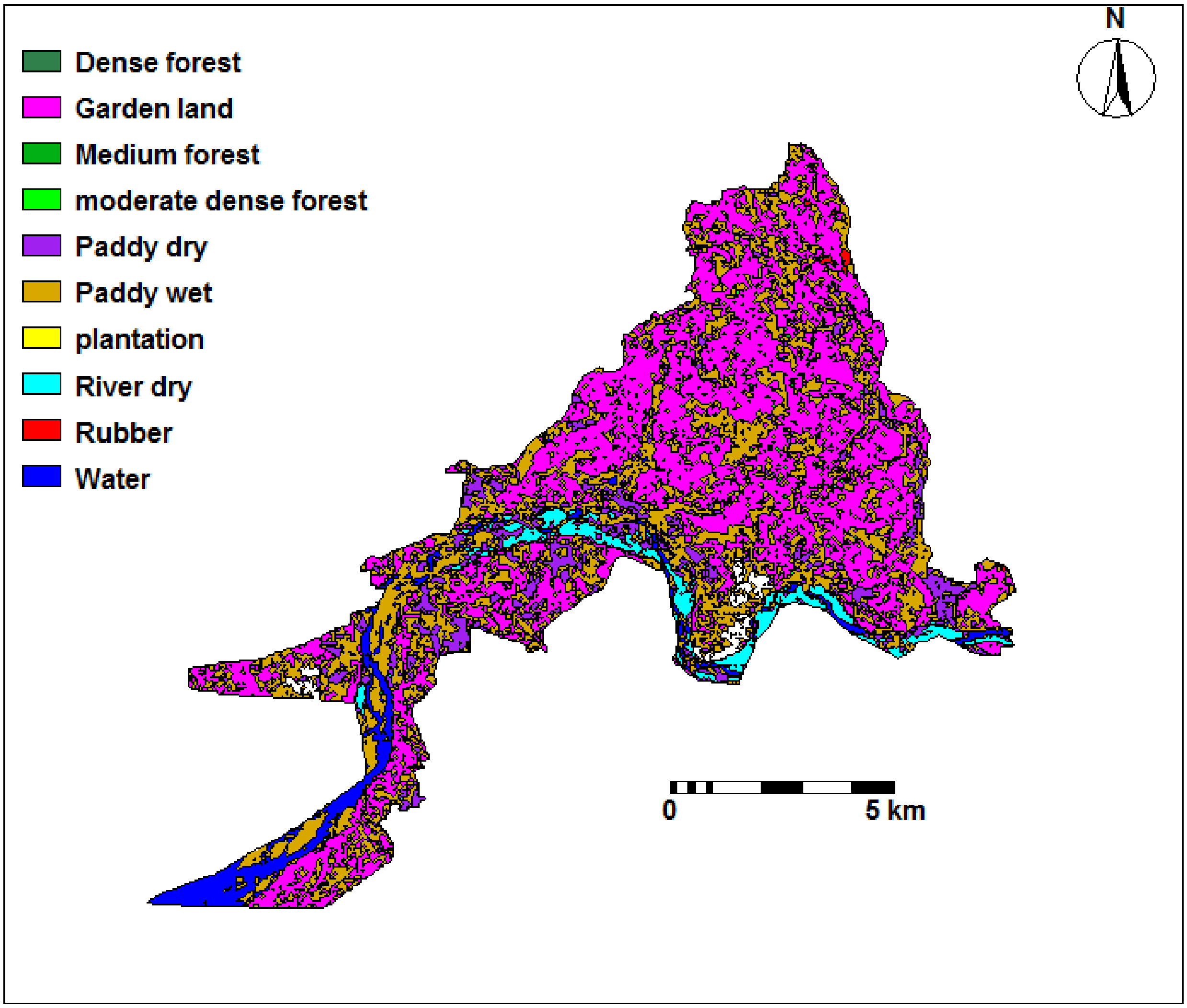

Fig. 6. Land use map of sub-watersheds in Kuttippuram Grama Panchayath

Table 3. Area covered by different land use classes (km^2)

Sub watersheds	Land use classes							
	Dense forest	**Garden land**	**Medium forest**	**Moderate dense forest**	**Paddy**	**River dry**	**Rubber**	**Water**
SWS1	0.225	14.141	0.110	0.057	8.576	0.185	0.005	0.110
SWS2	0.300	10.084	0.170	0.065	5.891	0.001	0.152	0.010
SWS3	0.008	1.615	0.025	0.025	1.370	-	0.002	-
SWS4	-	1.052	0.020	0.017	1.297	0.008	0.005	0.005
SWS5	-	0.130	-	-	0.194	0.275	-	0.160
SWS6	-	0.072	-	-	0.404	0.615	-	0.160
SWS7	-	5.187	0.085	0.042	4.617	0.095	-	0.037
SWS8	0.012	12.250	0.117	0.055	19.006	2.222	0.003	3.965
Total	0.545	44.531	0.527	0.261	41.355	3.401	0.167	4.447

4.4 Soil map of the micro-watershed

The digital soil map of the study area showing different soil series is shown in Fig. 7. About 80% of the sub-watersheds in the Kuttippuram Grama Panchayath are having Anayadi soil series. The other major soil series in the sub-watersheds are Chelikkuzhi and Vijayapuram.

Out of the eight delineated sub watersheds, taking into account only the four major ones based on area representation, the coverage of soil by different series is given in the Table 4.

Table 4. Area coverage of different soil series in major sub watersheds

Sub watersheds	Soil series	Area (km^2)
SWS1	Anayadi	13.661
	Chelikkuzhi	0.255
SWS2	Anayadi	10.162
SWS7	Anayadi	1.879
	Chelikkuzhi	6.894
	Vijayapuram	2.557
SWS8	Anayadi	13.791

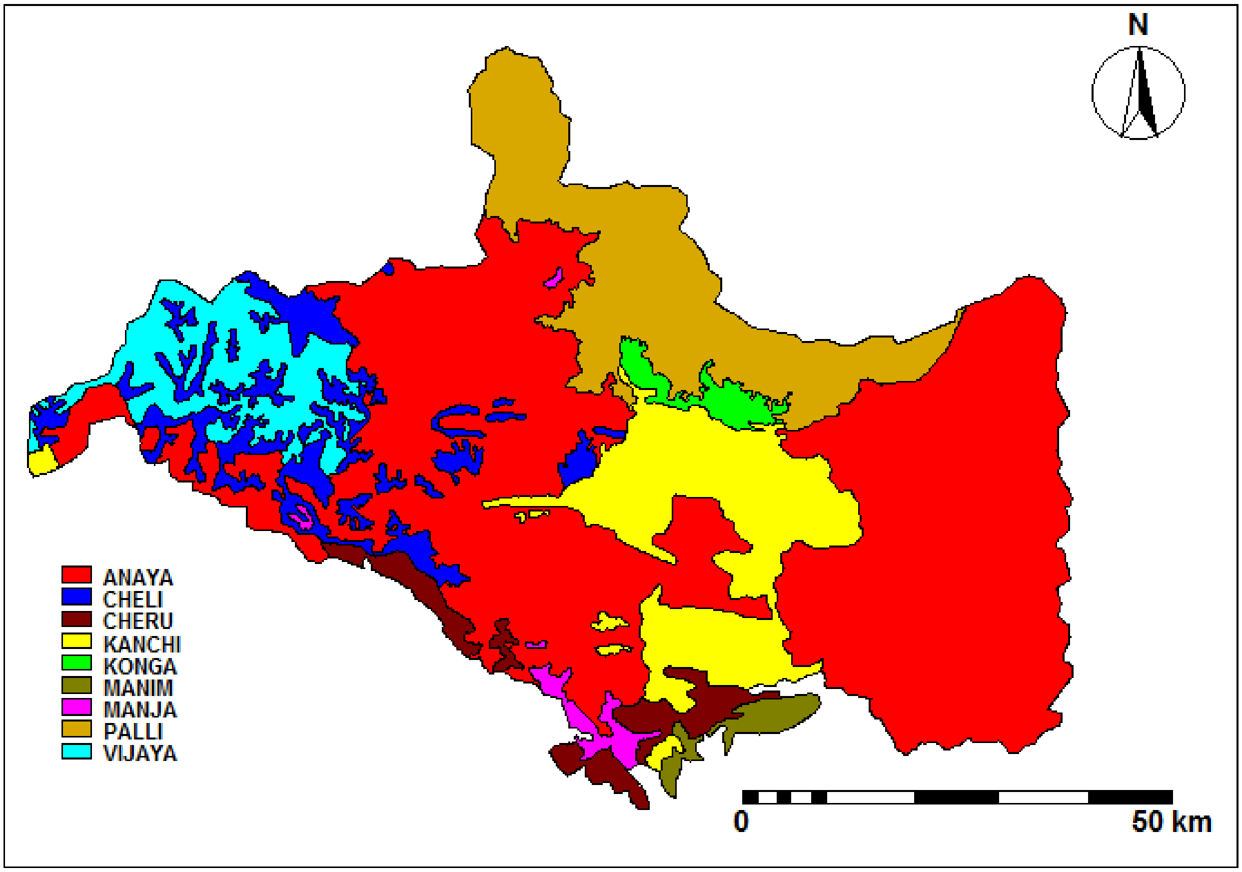

Fig. 7. Bharathapuzha watershed - Soil map

4.5 Physical properties of soil

Majority of the soils have very high clay and sand content with very low fraction of silt. Surface texture of the soils comes under clayey or clayey loam. Physical properties are shown in Table 5.

Table 5. Physical properties of different soil series

Sl.No.	Soil series	Clay (%)	Silt (%)	Sand (%)	Organic Carbon (%)	Bulk density (g/cm^3)	SOL_AWC (mm/mm)	SOL_K (mm/h)
1	Anayadi	27.80	8.50	63.70	0.89	1.18	0.08	6.00
2	Chelikkuzhi	33.70	8.00	58.30	2.18	1.20	0.08	2.50
3	Vijayapuram	24.70	9.50	65.80	1.01	1.17	0.07	7.80

4.6 Hydrologic characteristics

Hydrologic characteristics such as evapotranspiration, surface runoff, lateral flow and groundwater flow of major sub-watersheds in the Kuttippuram Grama Panchayath were estimated using SWAT and the details are shown in the Table 6.

Table 6. Monthly hydrologic characteristics of major sub-watersheds in Kuttippuram

Sub-watersheds	Month	ET (mm)	SURQ (mm)	GWQ (mm)	LATQ (mm)	Water Yield (mm)
SWS1	JAN	9.353	0.000	0.000	0.012	0.012
	FEB	8.074	0.000	0.000	0.020	0.020
	MAR	41.09	0.000	0.000	0.079	0.079
	APR	56.198	0.000	0.000	0.803	0.803
	MAY	84.550	0.000	0.000	0.679	0.679
	JUN	58.211	52.589	219.647	20.706	292.943
	JUL	52.633	73.747	284.960	18.049	376.755
	AUG	37.161	59.771	249.176	18.912	327.859
	SEPT	30.959	2.297	209.447	11.977	223.721
	OCT	61.658	11.785	161.421	10.795	184.001
	NOV	33.744	5.499	14.995	1.493	21.987
	DEC	9.062	1.609	48.936	3.665	54.210
SWS2	JAN	9.354	0.000	0.000	0.001	0.001
	FEB	8.080	0.000	0.000	0.075	0.075
	MAR	41.121	0.000	0.000	0.171	0.171
	APR	55.318	0.000	0.000	2.176	2.176
	MAY	84.354	0.000	0.000	1.632	1.632
	JUN	58.267	52.477	195.563	54.239	302.279
	JUL	52.689	73.831	260.484	39.114	373.429
	AUG	37.179	59.872	228.003	49.493	337.367
	SEPT	30.715	2.309	190.507	22.439	215.256
	OCT	61.666	11.926	147.386	24.141	183.454

	NOV	33.688	5.563	13.387	2.190	21.140
	DEC	8.992	1.505	44.023	8.345	53.873
SWS7	JAN	9.348	0.000	0.000	0.016	0.016
	FEB	7.930	0.000	0.000	0.027	0.027
	MAR	36.160	0.000	0.000	0.105	0.105
	APR	61.118	0.000	0.000	1.063	1.063
	MAY	85.783	0.000	0.000	0.900	0.900
	JUN	58.055	60.648	209.921	26.886	297.455
	JUL	52.432	79.181	273.671	23.395	376.247
	AUG	37.035	67.783	240.335	24.608	332.726
	SEPT	30.868	2.956	198.871	15.568	217.394
	OCT	61.443	13.822	156.462	14.112	184.396
	NOV	33.643	6.659	14.443	1.954	23.057
	DEC	9.044	1.900	46.589	4.746	53.235
SWS8	JAN	12.456	0.000	0.000	0.039	0.039
	FEB	7.274	0.000	0.000	0.009	0.009
	MAR	24.903	0.000	0.000	0.012	0.012
	APR	64.118	0.000	0.000	0.070	0.070
	MAY	92.198	0.000	0.000	0.079	0.079
	JUN	65.880	69.305	220.527	1.998	291.829
	JUL	58.594	85.897	280.790	2.415	369.103
	AUG	42.749	76.432	246.695	2.253	325.380
	SEPT	33.762	3.540	206.280	1.897	211.717
	OCT	69.800	15.310	158.535	1.527	175.371
	NOV	39.174	4.691	14.458	0.450	19.599
	DEC	11.706	4.269	45.202	0.486	49.958

1999

Fig. 8. Annual water balance as a percentage of rainfall of different micro-watersheds for the year 1999

2000

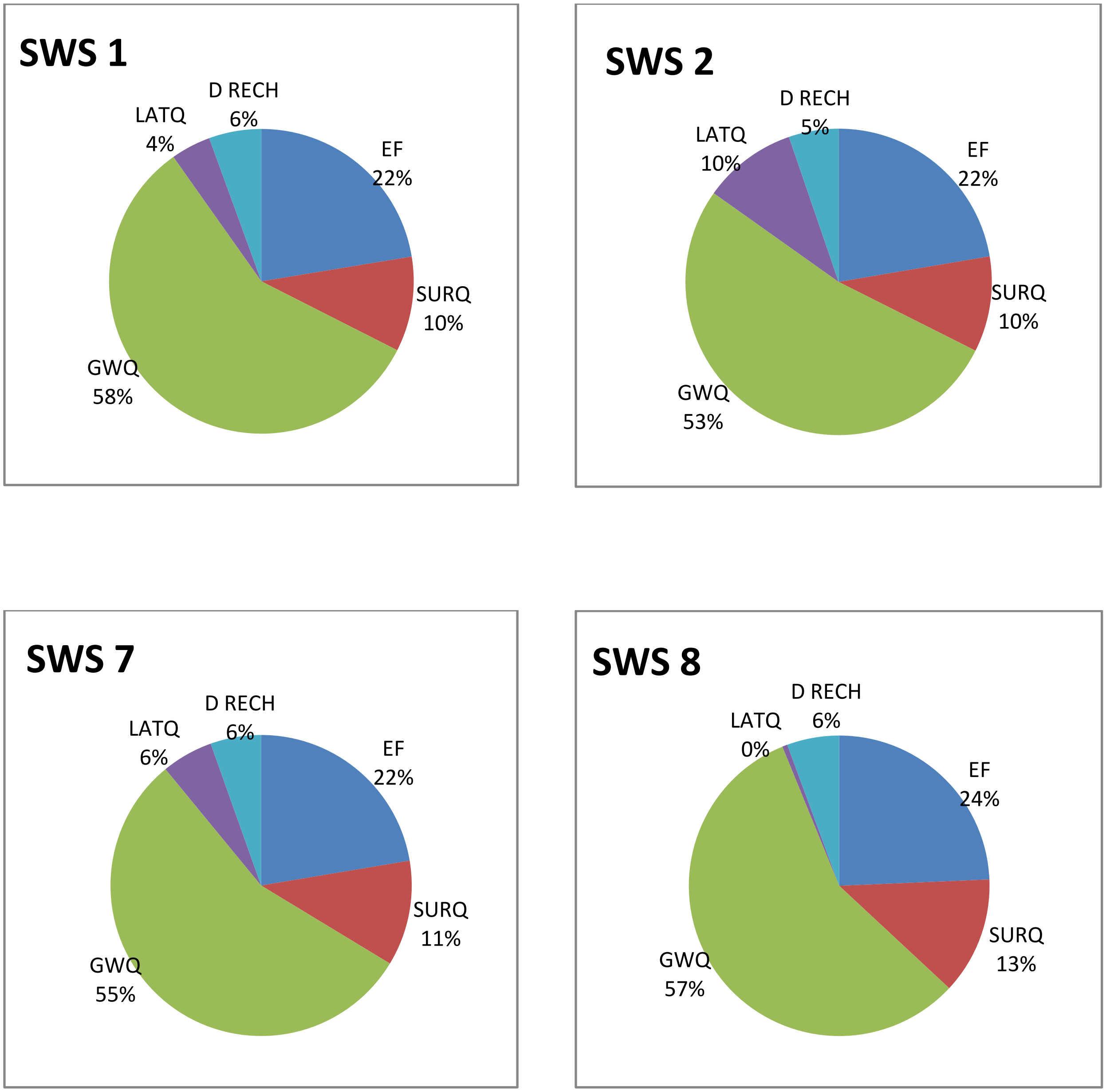

Fig. 9. Annual water balance as a percentage of rainfall of different micro-watersheds for the year 2000

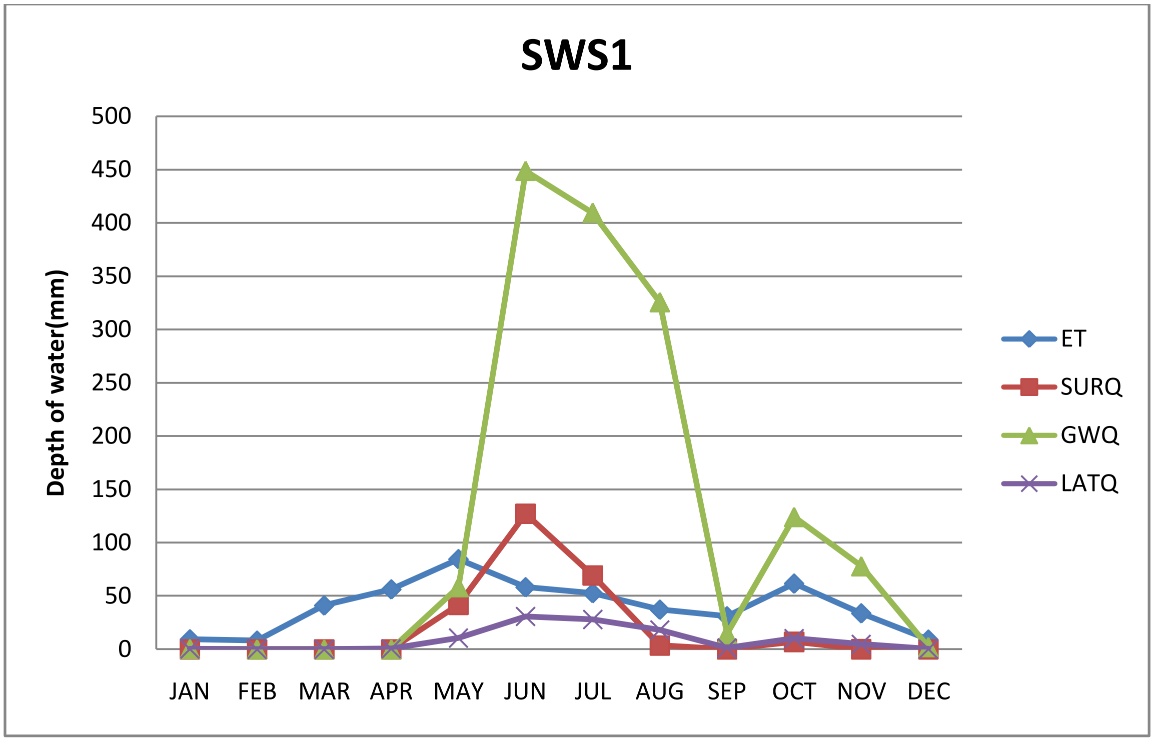

Fig. 10. Monthly water balance components of SWS1 for the year 1999

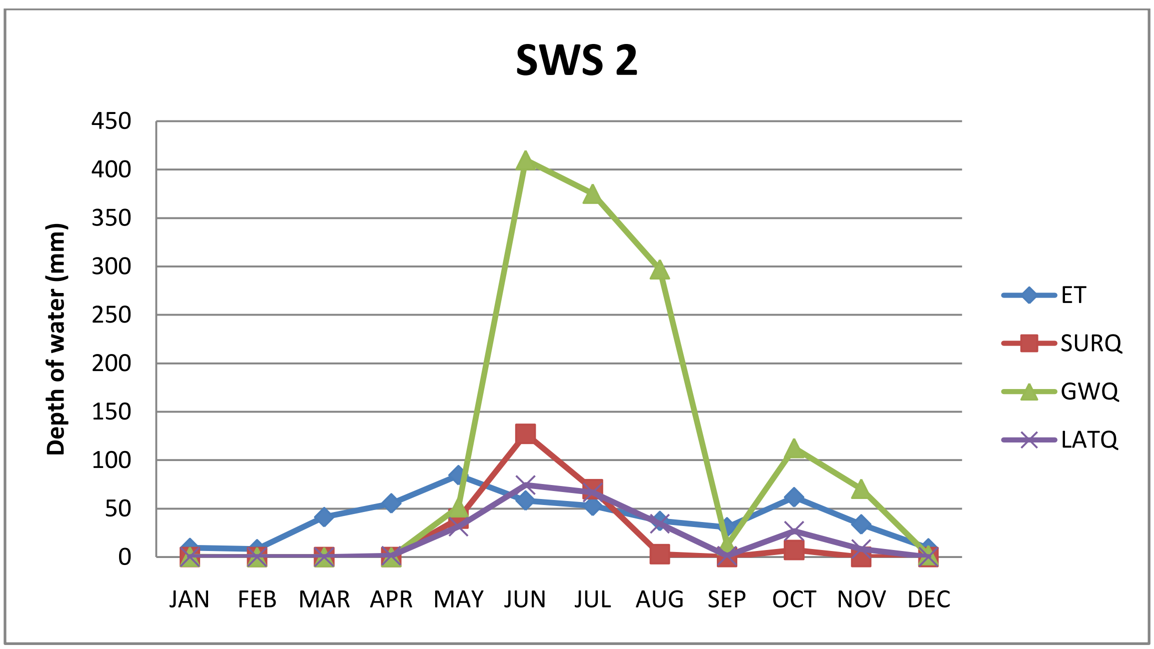

Fig. 11. Monthly water balance components of SWS2 for the year 1999

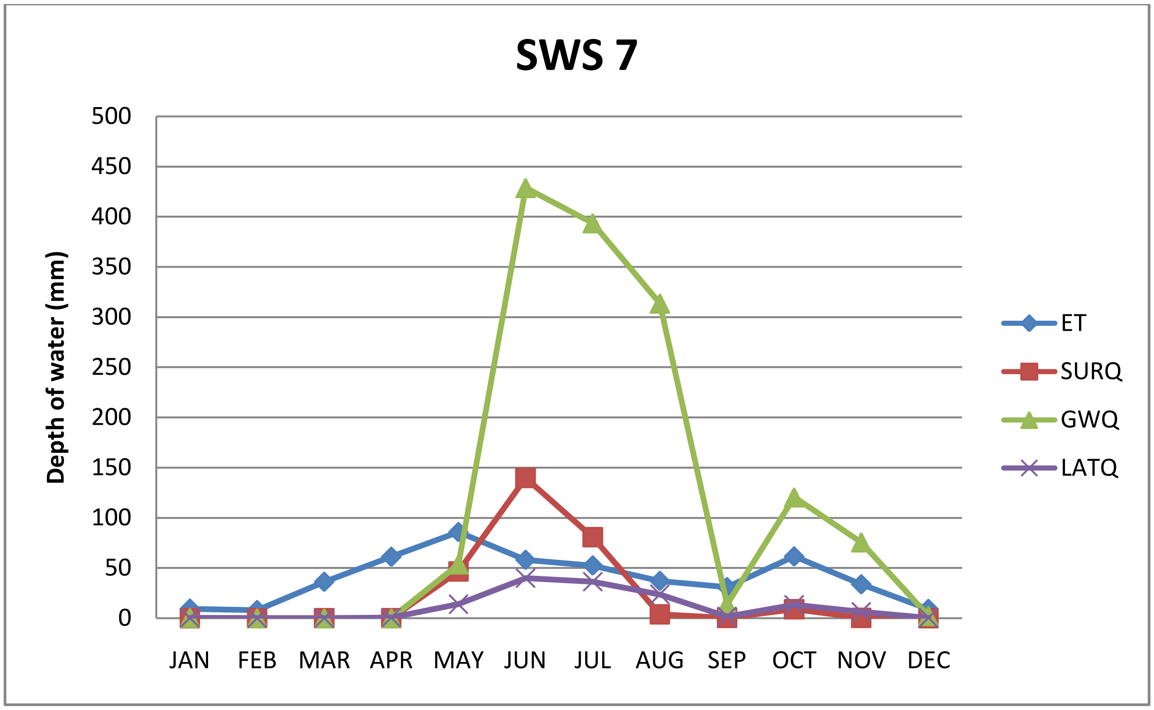

Fig. 12. Monthly water balance components of SWS7 for the year 1999

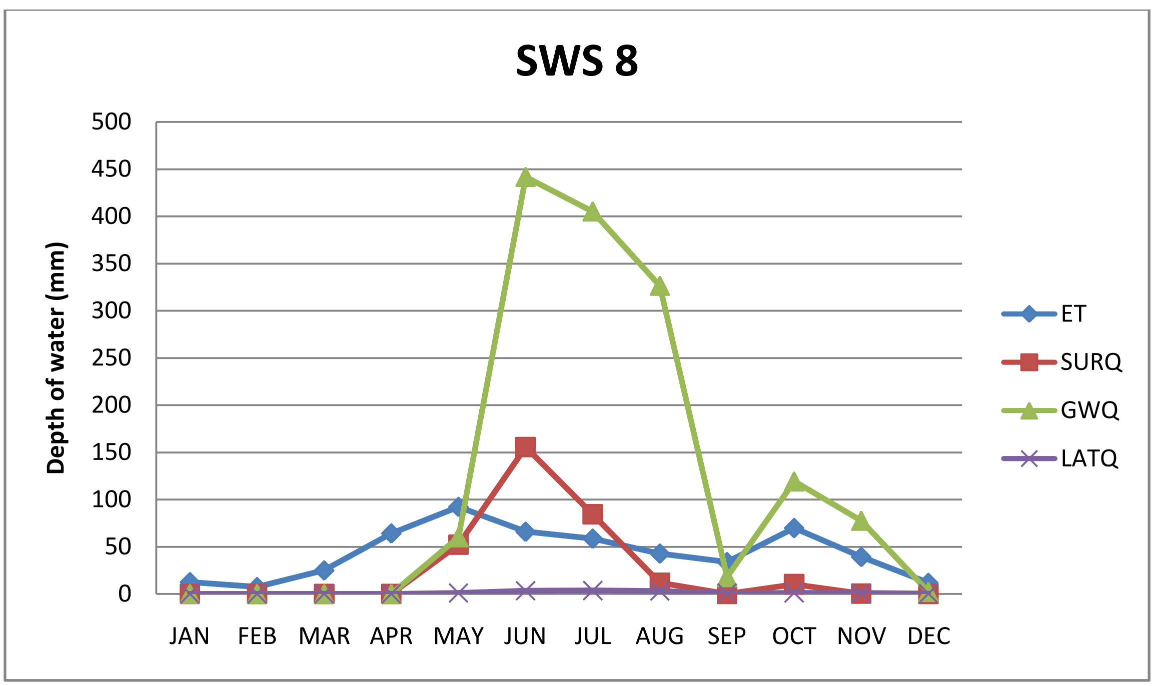

Fig. 13. Monthly water balance components of SWS8 for the year 1999

4.7 Population map

Using the population of the Wards, the population of the portion of the micro-watersheds within the panchayath boundary is delineated and the result is presented in Fig. 14.

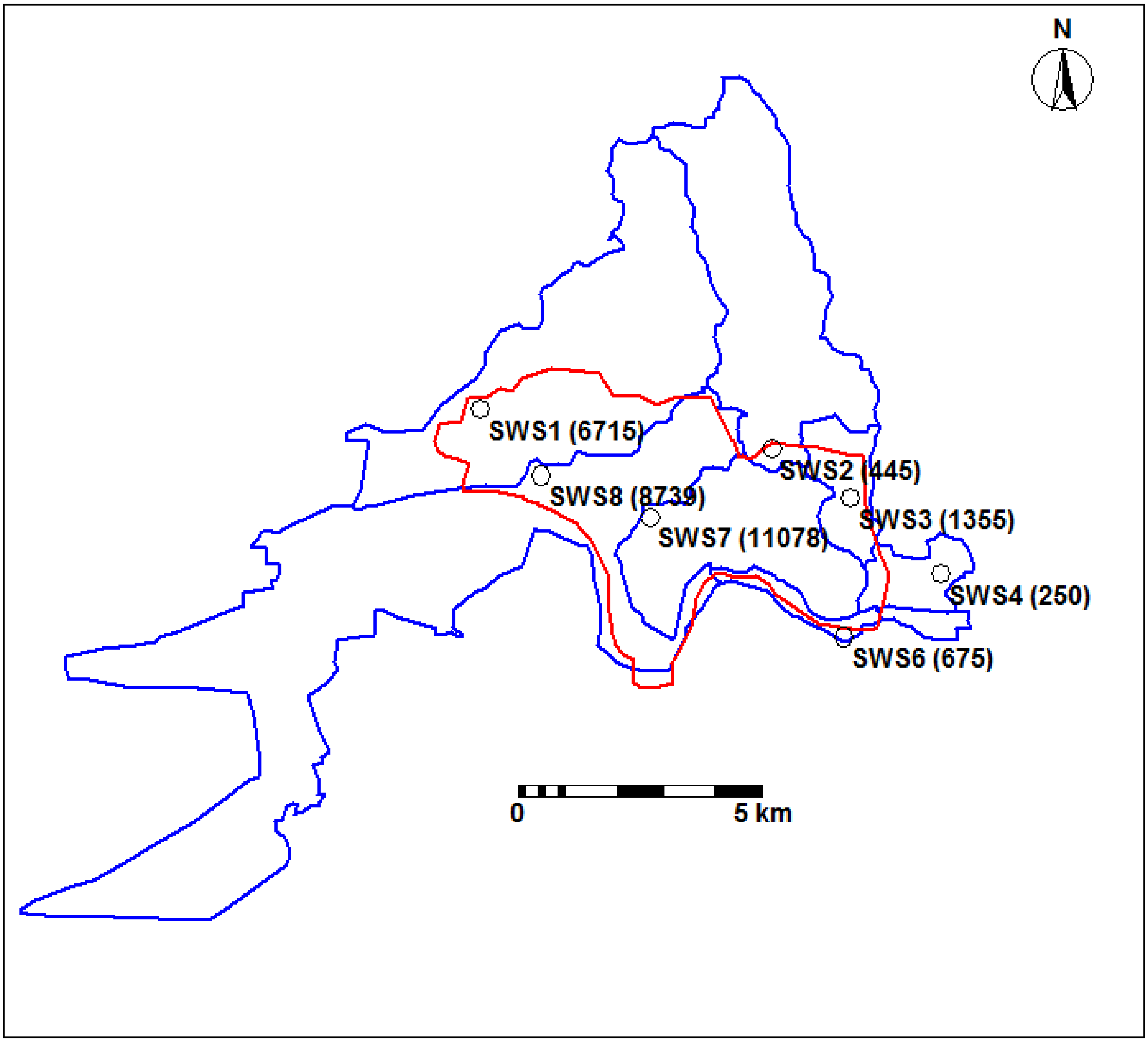

Fig. 14. Population of the Grama Panchayath within the sub-watersheds

Table 7. Division of population of the Grama Panchayath on individual sub-watershed

Sub watershed area representing Kuttippuram Grama Panchayath	Population
SWS1	6716
SWS2	445
SWS3	1355
SWS4	250
SWS5	7
SWS6	675
SWS7	11078
SWS8	8739

4.8 Production potential of SWS

By conserving a small fraction of surplus water during the rainy season, preferably during the end of the season, cultivation during the dry period can be made possible. The cumulative water yield of September and October months for the three years in the analysis namely, 1999, 2000 and 2001 were found to be 15 cm, 30 cm and 40 cm respectively. Taking the water yield (15 cm) of two months, September and October of the year 1999, which is the lowest, it is clear that a very large area can be put under cultivation during the summer months. The food required to meet the demand of total population of Kuttippuram Grama Panchayath is calculated based on the standards set by ICMR and also the area to be allocated for obtaining the required production is shown in Table 8.

Table 8. Food demand and area requirement

Crops cultivated	Food demand for self consumption (t/yr)	Area required for meeting self consumption demand (ha)	Extra area that can be cultivated for export (ha)
Paddy	8509.25	1701.85	1500
Pulses	3403.698	681	1000
Vegetables	2552.77	256	1000
Banana	5105.55	255	500
Coconut (oil)	681	475	1000
Tapioca	1701.84	34	100

4.9 Gap between demand and production

It can be made clear from Table 9 that the gap between demand and production of food can be bridged by utilizing a fraction of the water yield, which otherwise is running out from the watersheds.

Table 9. Production potential of different crops in the sub watersheds

Crops cultivated	Area that can be cultivated (ha)	Productivity (t/ha)	Production Potential (t)
Paddy	3202	5	16009
Pulses	1681	5	8405
Vegetables	1256	10	12650
Banana	755	20	15100
Coconut (oil)	1475	1.4	2065
Tapioca	134	50	6700

The extra area that can be put under cultivation during the summer months will provide substantial surplus amount of food. Thus, water conservation during monsoon will enable the Grama Panchayath to produce food in great excess to their consumption requirement. Within the constraints of availability of land and water, nearly double the demand for self consumption can be produced. A comparison on the demand and production potential is shown in Fig. 15.

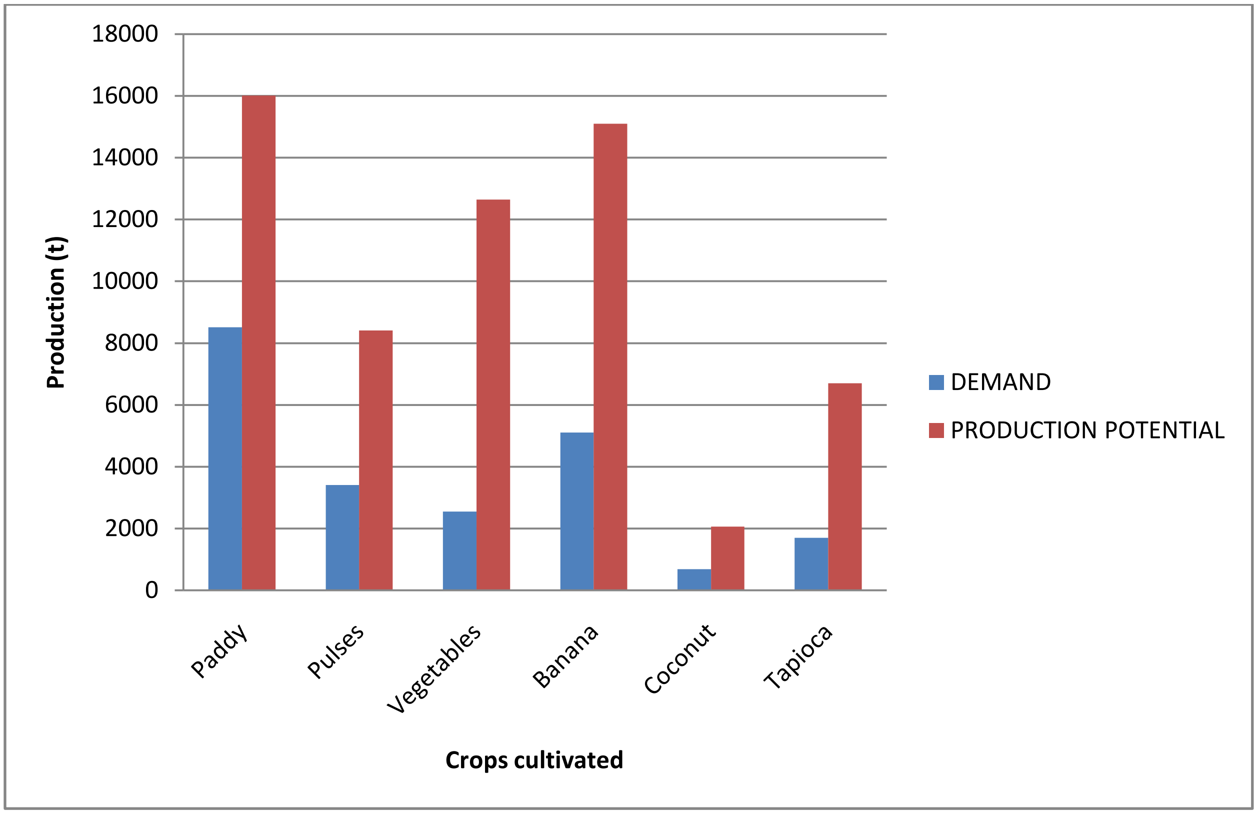

Fig. 15. Demand and production potential of different crops in the Grama Panchayath

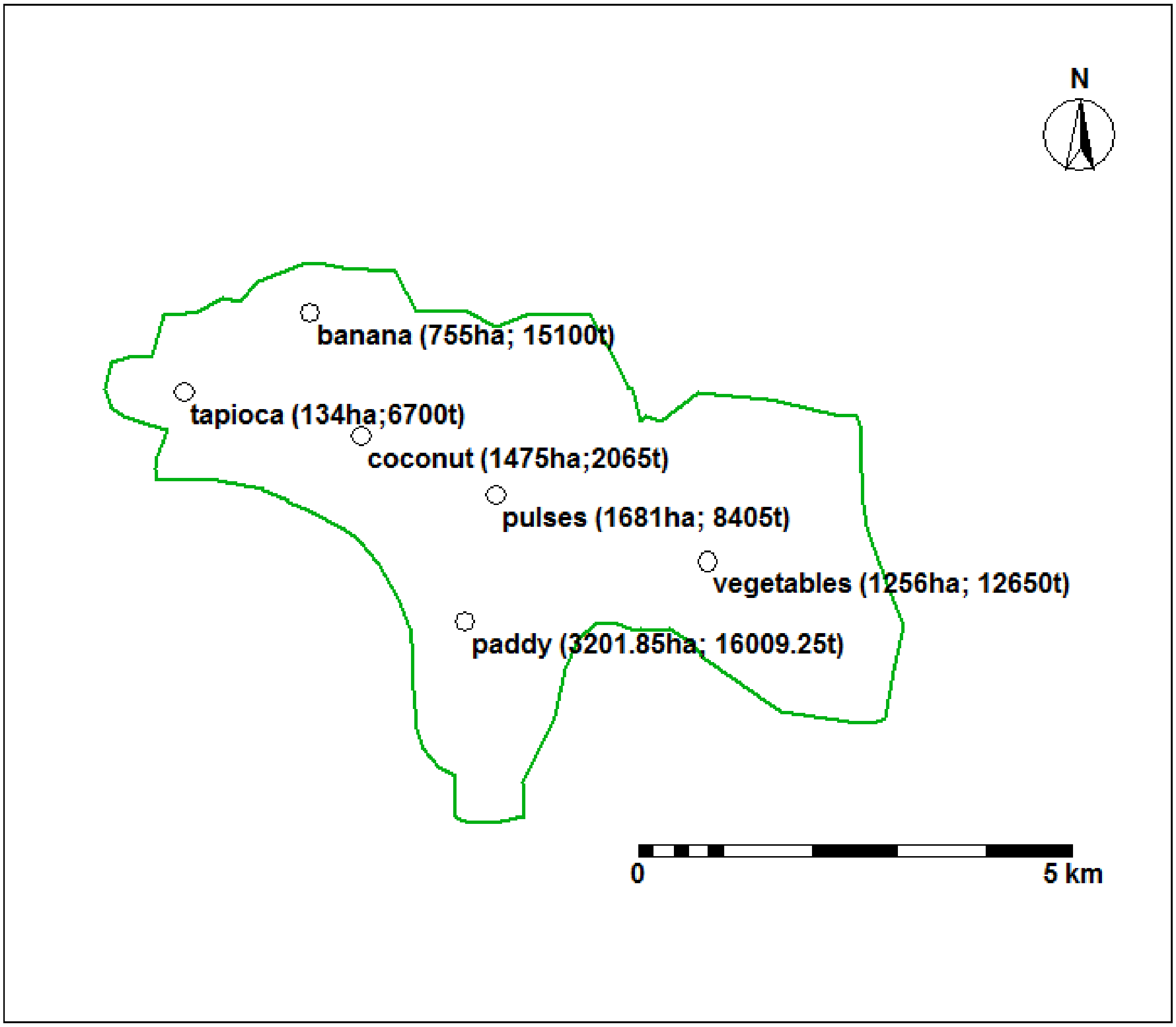

Fig. 16. Area and Production potential of Kuttippuram Grama Panchayath

The concept of conservation of excess water during monsoon and its efficient utilization will make the Kuttippuram Grama Panchayath well sufficient in food production. This will certainly enable the Panchayath to meet the food requirement for consumption and also for producing an extra amount. This aids to food security and also in uplifting the economic status of the Panchayath. Considerable upland is still left in the Panchayath which can further be put on for agricultural and allied activities.

Summary & Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

A scientific assessment on food demand and production potential of Kuttippuram Grama Panchayath in Malappuram district of Kerala State in India has been carried out using GIS, Remote Sensing and watershed modeling. Kuttippuram Grama Panchayath lies at a latitude longitude range from $10^0$49’35”N, $75^0$59’37”E to $10^0$53’08”N, $76^0$04’36”E with a total area of 31 km^2. The total population of the Grama Panchayath is about 45000. The main objective of the study includes the assessment of the periodic water resource availability of the Grama Panchayath, to estimate the food demand and production potential of the Grama Panchayath.

The Kuttippuram Grama Panchayath lies within eight sub-watersheds of Bharathapuzha and Tirurpuzha.The soil map of the area showed three soil series of which 80% of the total area of the Panchayath comprising Anayadi soil series. The other major soil series are Vijayapuram and Chelikkuzhi. A land use map of the study area has been prepared from LISS III imagery of IRS P6 by supervised classification .The classified imagery shows about ten different land use classes of which garden land and paddy area are the major land use categories.

All the micro-watersheds of Bharathapuzha and a part of Tirurpuzha have been delineated and the micro-watersheds lying in and around Kuttippuram Grama Panchayath have been identified. It is found that about 90% of the Grama Panchayath area lies in four sub-watersheds. Hydrologic processes taking place in these four sub-watersheds have been estimated by SWAT. It is found that major part of the outflow from the watersheds is by ground water flow (50-60%). Monthly analysis of the hydrologic processes reveals that ground water flow component is practically nil during summer months. This points out to the need of proper water conservation measures in the sub-watersheds.

An analysis on the food demand for self consumption in the Grama Panchayath has been carried out and it shows that the requirement of cereals, pulses, oilseeds, vegetables and fruits are 8509.3, 3403.7, 681, 2552.7 and 5105.6 t/annum respectively. At the same time, the current production of cereals and fruits in the Grama panchayath area are 3100 and 2220 t/annum respectively. Food production of the Grama Panchayath is nowhere near the food demand because of the present unscientific production strategy.

Hydrologic analysis of the basin indicated that about 15 cm of water which is running out from the basin towards the fag end of the monsoon period can be conserved and be utilized for summer cropping. The production potential of the Grama Panchayath during summer with the conserved water and that during monsoon has been worked out. It is found that the production potential is about 2 to 3 times than that of the consumption demand. Though the study has been done only for one Grama Panchayath, similar results are expected from majority of the Grama Panchayath in Kerala barring some exceptions. We hope that this study may be an eye opener to the food importing State of Kerala.

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ASSESSMENT OF FOOD DEMAND & PRODUCTION POTENTIAL OF KUTTIPPURAM GRAMA PANCHAYATH USING GIS, REMOTE SENSING & WATERSHED MODELING

By

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SARANYA, J.

SREEJU, K.B.

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfillment of the

requirement for the degree

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land & Water Resources & Conservation Engineering

Kelappaji College of Agricultural Engineering & Technology

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December 2011

ABSTRACT

Kuttippuram is one of the Grama Panchayaths of Malapppuram district of Kerala State with a population of about 46000. One of the major issues of the Panchayath is the non availability of irrigation water during summer months. Considering these circumstances, a study has been taken up to assess the food demand and production potential using GIS and remote sensing with the specific objectives of estimating water resource availability, food demand and agricultural production potential of Kuttippuram Grama Panchayath. The project area covers the sub-watersheds of Bharathapuzha and Tirurpuzha in and around Kuttippuram Grama Panchayath boundary. Sub-watershed delineation, spatial mapping of land use and soil were the most important preliminary tasks involved in the whole exercise. For the quick and efficient delineation of sub-watersheds and for spatial mapping of natural resources, GIS and Soil and Water Assessment Tool (SWAT) were made use of. SWAT was set up and calibrated for the basin with good simulation efficiency and the calibrated model was used to analyse the water balance components of the river basin. Hydrologic responses of the sub basins were very quick including that for ground water outflow. The study showed that by conserving a small fraction of the water yield during the late part of monsoon season, the food requirement for self consumption can be well satisfied together with a substantial extra production meant for export.