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# APPLICATION OF GEO-SPATIAL TECHNOLOGIES AND ICTs IN SMART AGRICULTURE (SMARTAGRI-2018)

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# Geospatial technologies for assessing seasonal variability in crop coefficient for efficient irrigation scheduling in cashew

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**Abstract:** In India, cashew is generally grown as a rainfed crop mainly along the coastal areas in low fertile soil. The productivity levels of cashew are low in India compared to other producer countries. Water limitation during critical periods of growth stages is one of the major constraints in realizing higher productivity in cashew. The common approach for irrigation scheduling is by estimating evapo – transportation demand by estimating reference evapo-transpiration and crop coefficients. Crop coefficients can be highly variable depending on the condition of canopy. Reliable estimation of crop coefficient and scheduling of irrigation is possible by combining the weather information and biophysical parameters derived from vegetation indices obtainable from remote sensing imageries in GIS. The present study was carried out for estimating the crop coefficient and crop evapotranspiration for a cashew plantation of 10 year. The study was performed in the cashew plantations of Karnataka Cashew Development Corporation near Savanoor, Puttur, Dakshina Kannada, Karnataka. The region experiences tropical monsoon climate with dry season from January to May. The multispectral images used for this study was Landsat 8 satellite for the months of December 2016, January to May 2017. Satellite imageries were processed in ERDAS Imagine 9.2. Digital Elevation Model by Cartosat was used in GIS and by performing hydrological modeling a watershed of interest in the study area was delineated. Subset image of each satellite imageries was prepared using watershed boundaries in Arc Map 10.2. The potential evapo-transpiration of the study area was worked out from the climatic data using FAO Penman-Monteith method. Vegetation index map prepared, was used to derive crop coefficient for each months. Finally the crop evapo transpiration was computed by combining potential evapotranspiration with crop coefficient. The crop coefficient values ranged from 0.27 to 0.42. The values increased linearly from January to May period. The study revealed the usefulness of geospatial technologies in assessing the crop coefficient in cashew which in turn will be useful in scheduling irrigation. The short comings in use of multi spectral sensor imageries such as Landsat in crop coefficient estimation could be overcome by using satellite imageries with frequent re-vist, better resolution and all-weather capability.

**Key words:** Cartosat Dem, Cashew, Crop coefficient, Irrigation scheduling, Landsat, Satellite imageries

## Introduction

Cashew is an important horticultural crop earning foreign exchange. Initially this crop was introduced to protect the coast from erosion. Realising the economic importance of kernels sooner its cultivation was spread along the east and west coast. The productivity of cashew in India is low compared to other producer countries. One of the constraints in realizing the potential yield of cashew is the practice of growing cashew in less fertile and eroded lands which are unfit for economic production of many other crops, without adequate nutritional and water management (Rejani and Yadukumar, 2006; Rejani and Yadukumar, 2010). Cashew by virtue of its deep root system can extract water from deeper soil layers during summer. However the yields are declined during summer due to nut fall under water deficit condition (Mishra *et al.*, 2008). Rupa (2017) reported pre-mature nut drop under water deficit condition. The active growth and reproductive phase of cashew occurs during summer season. Irrigation is important during critical period of growth of any crop and cashew is not an exception. The research studies indicate that irrigation during critical periods of growth in cashew can increase the yield and cashew responds well to irrigation and soil and water conservation practices (Rejani and Yadukumar, 2006). The water requirement of plant depends on climate, foliar coverage of the plant, growth phase of the plantation, soil type and the method of irrigation. The estimation of water requirement is essential to provide adequate water to supply the tree demand. FAO defined " the crop water requirement as the amount of water required to compensate the evapo-transpiration loss from the cropped fields and crop evapo-transpiration as the amount of water that is lost through evapo-transpiration". For efficient water management in crop production, the crop evapo-transpiration is to be determined accurately. Usually crop evapotranspiration is determined using reference evapo-transpiration and crop factor. The major challenge in this approach is obtaining reliable estimate of crop factor (Toureiro *et al.*, 2017). Traditional methods based on growing degree days and soil water balance is tedious and time consuming. The multi spectral images from remote sensing sensors can provide much useful information such as vegetation indices, which directly represent the real time status of vegetation, soil and topography. The receptivity of sensors provides continuous monitoring of the field conditions. Under this context the present investigation was carried out to assess the potential of geospatial technologies in assessing crop evapo-transpiration using crop coefficient data derived from remote sensing imageries.

## Material and methods

### *Study area*

The study area is located in the Dakshina Kannada district of Karnataka. The watershed selected for the study was located in the cashew plantations of Karnataka Cashew Development Corporation at Savnur in Puttur taluk (Fig. 1). The area of watershed was 605 ha. The area lies between 12°43'22.8"N to

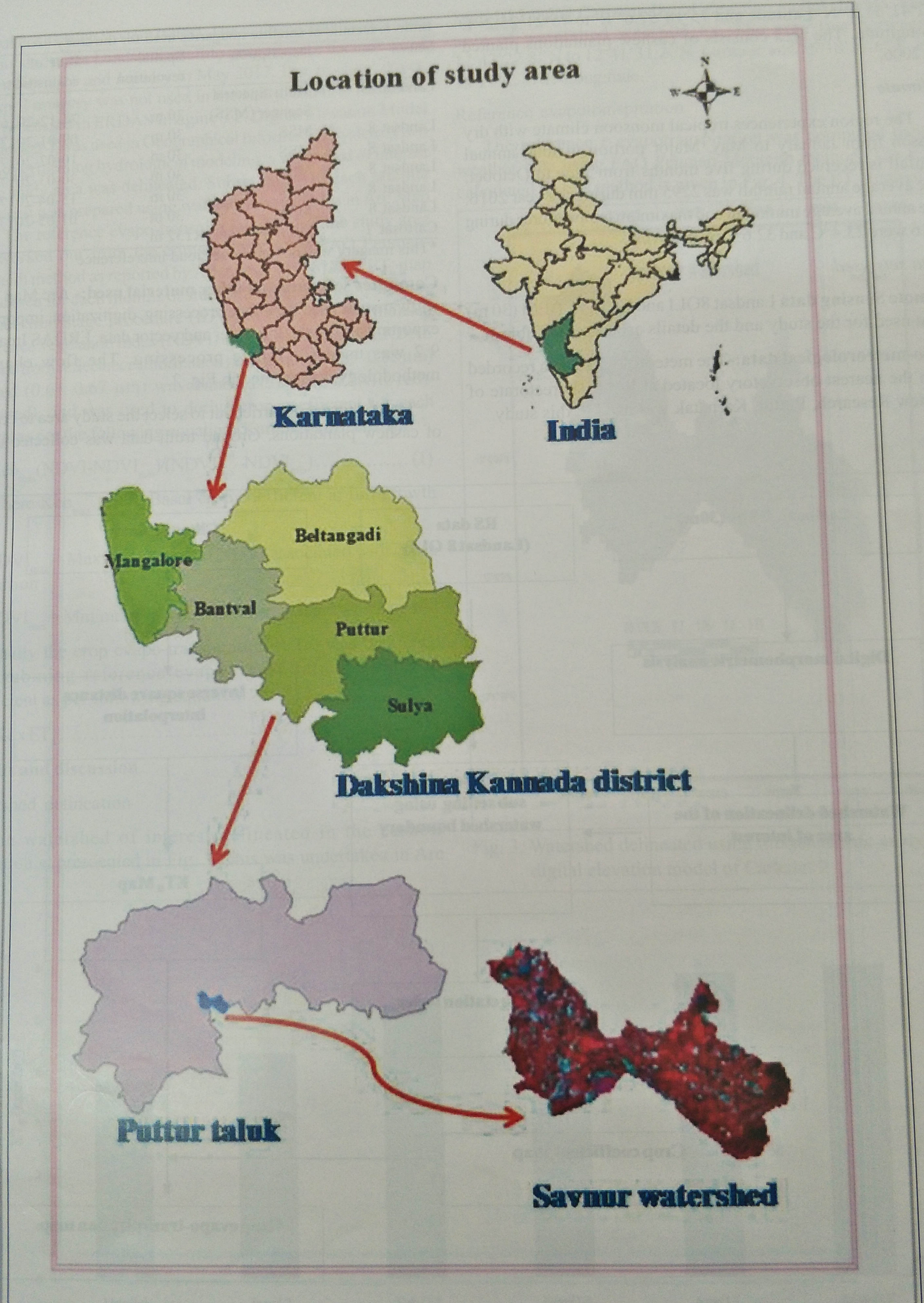


Fig. 1. Location map of the study area

12°41'31.2''N Latitude and 75°18'57.6''E to 75°21'25.2''E Longitude. The area consists of cashew plantations planted in 2006.

### *Climate*

The region experiences tropical monsoon climate with dry season from January to May. Major portion of total annual rainfall is received during five months from June to October. The average annual rainfall was 2295 mm during the year 2016. The annual average minimum and maximum temperatures during 2016 were 23.4 °C and 32.6°C respectively.

*Data sets used*

**Remote Sensing data** Landsat 8OLI and Cartosat DEM (30 m) were used for the study and the details are given in Table 1.

**Agro-meteorological data:-**The meteorological data recorded from the nearest observatory located at ICAR- Directorate of Cashew Research, Puttur, Karnatak was used in this study.

Table 1. Details of satellite imageries used for the study

| Sensor | Description | Spatial resolution | Date of acquisition |
|---|---|---|---|
| Landsat 8 | Multi Spectral Scanner (MSS) | 30 m | 24-12-2016 |
| Landsat 8 | MSS | 30 m | 09-01-2017 |
| Landsat 8 | MSS | 30 m | 10-02-2017 |
| Landsat 8 | MSS | 30 m | 30-03-2017 |
| Landsat 8 | MSS | 30 m | 15-04-2017* |
| Landsat 8 | MSS | 30 m | 01-05-2017 |
| Cartosat 1 | DEM version 3R1 | 32 m | - |

*This imagery was not used due cloud intereference

**Computer software and other material used:-** Arc Map 10.2 software was used for image processing, digitization, importing, exporting and analyzing raster and vector data. ERDAS Imagine 9.2 was used for image processing. The flow chart of methodology is presented in Fig. 2.

Field visits were carriedout to select the study area to consist of cashew plantations. Ground truth data was collected using

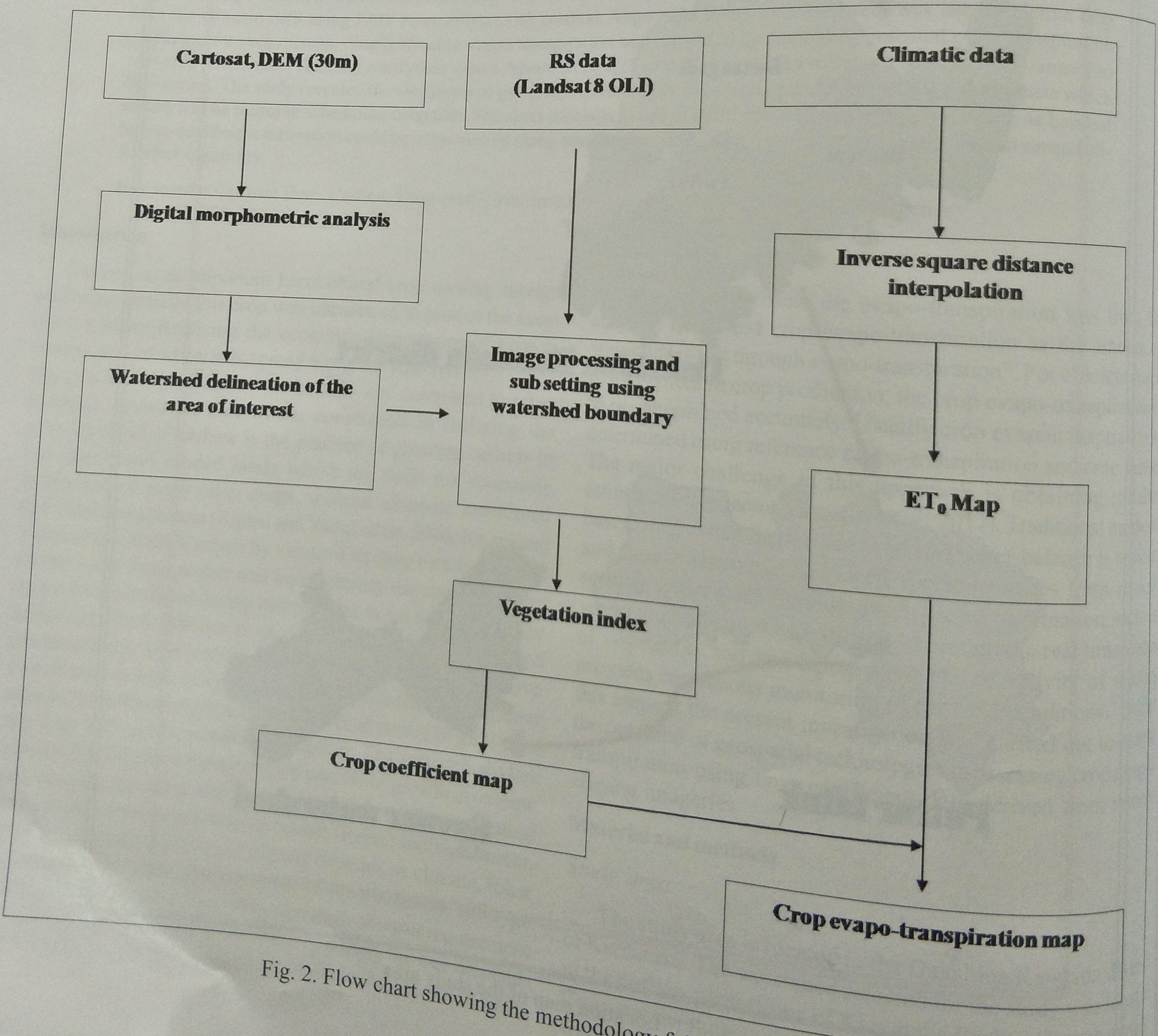


Fig. 2. Flow chart showing the methodology followed in the study

Global Positioning System (GPS). The multispectral images used for this study was Landsat 8 satellite imageries for the months of December 2016 and January to May 2017. Due to cloud cover, the April imagery was not used in the study. Satellite imageries were processed in ERDAS Imagine 9.2. Digital Elevation Model by Cartosat-1 was used in Geographical Information System (GIS) and by performing hydrological modeling, a watershed of interest in the study area was delineated. Subset image of each satellite imageries was prepared using watershed boundaries in Arc Map 10.2. The reference evapo-transpiration ($ET_0$) of the study area was worked out from the climatic data using FAO Penman-Monteith method as reported by Allen *et al.* (1998). The $ET_0$ map for the area for each months of study was prepared using inverse distance weightage procedure (IDW) in GIS. The Normalised Difference Vegetation Index (NDVI) map was prepared in ERDAS Imagine from reflectance information near infrared (0.85–0.88 μm) and red (0.64–0.67 μm) wavebands as: NDVI = (NIR-red)/(NIR+red), and was used to derive crop coefficient for each months as per the following equation (Kamble *et al.*, 2013).

$$Kc=Kcb_{max}(NDVI-NDVI_{min})/(NDVI_{max}-NDVI_{min}) \quad (1)$$

Where $Kcb_{max}$ = 0.8, Basal crop coefficient at full growth cover

$NDVI_{max}$ = Maximum value of NDVI associated with dense vegetation

$NDVI_{min}$ = Minimum value of NDVI associated with bare soil

Finally the crop evapo-transpiration (ETc) was computed by combining reference evapo-transpiration with crop coefficient as per following equation.

$$Etc=Kc \times ET_0 \quad (2)$$

## Results and discussion

### Watershed delineation

The watershed of interest delineated in the cashew plantation is presaented in Fig. 3. This was undertaken in Arc Map 10.3 using Cartosat digital elevation model (DEM). The area of watershed was 605 ha. The area lies between 12°43'22.8"N to 12°41'31.2"N Latitude and 75°18'57.6"E to 75°21'25.2"E Longitude.

### Reference evapotranspiration

The reference e evapotranspiration was computed using weather data using FAO Penman-Monteith method. The $ET_0$ calculated by this method is given in Fig. 4. The $ET_0$ gradually

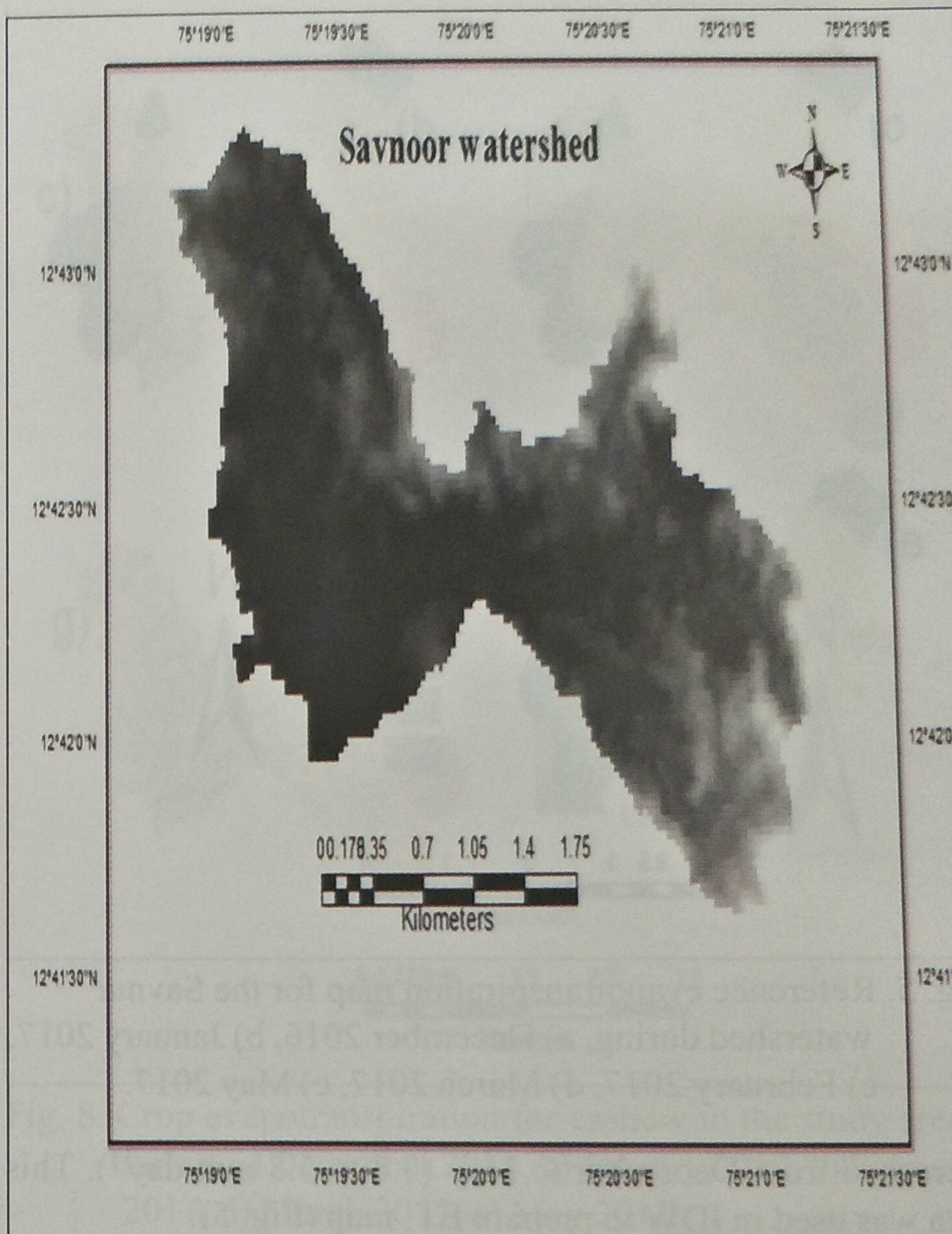


Fig. 3. Watershed delineated using morphometric analysis of digital elevation model of Cartosat 2

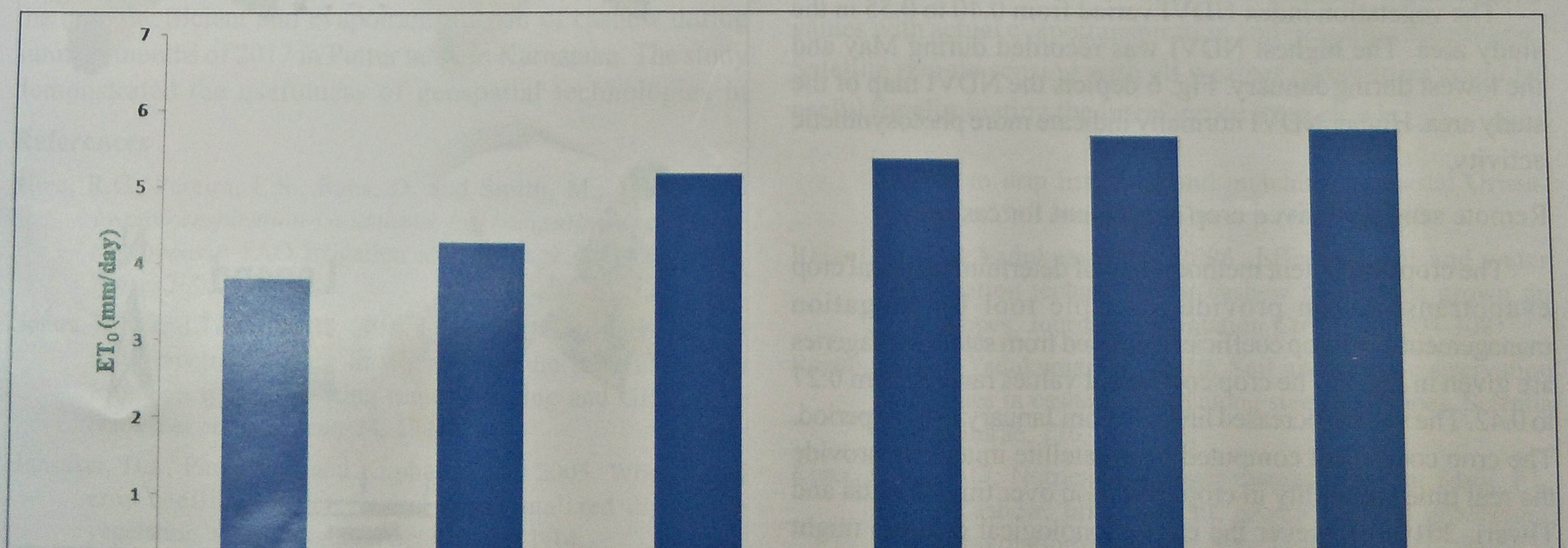


Fig. 4. Reference evapotranspiration ($ET_0$) calculated using FAO Penman-Monteith method

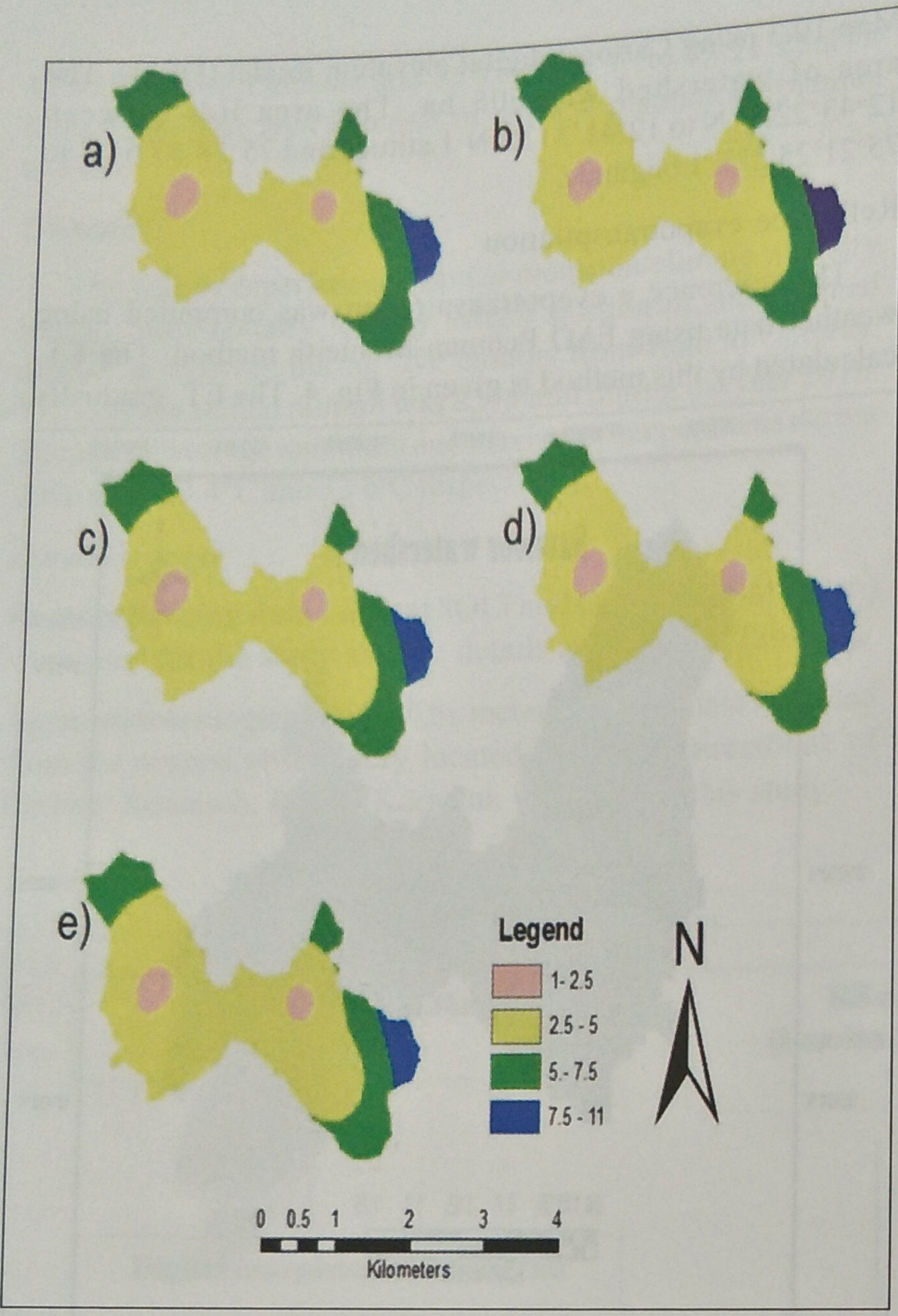


Fig. 5. Reference evapotranspiration map for the Savnur watershed during, a) December 2016, b) January 2017, c) February 2017, d) March 2017, e) May 2017.

increased from December to May (3.8 to 5.8 mm day$^{-1}$). This data was used in IDW to prepare $ET_0$ map (Fig. 5).

### Vegetation index

The vegetation index NDVI varied from 0.40 to 0.55 in the study area. The highest NDVI was recorded during May and the lowest during January. Fig. 6 depicts the NDVI map of the study area. Higher NDVI normally indicate more photosynthetic activity.

### Remote sensing derived crop coefficient for cashew

The crop coefficient methodology of determining actual crop evapotranspiration provide a simple tool for irrigation management. The crop coefficient, derived from satellite imageries are given in Fig. 7. The crop coefficient values ranged from 0.27 to 0.42. The values increased linearly from January to May period. The crop coefficient computed from satellite imageries provide the real time variability in crop condition over time (Gontia and Tiwari, 2010). However the crop phonological changes might affect the estimation, by influencing the spectral reflectance. The NDVI values found good correlation with Kc values ($R^2 = 0.914$). Kamble *et al.* (2013) obtained a strong correlation between NDVI and crop coefficient.

### Crop evapotranspiration for cashew

Crop evapotranspiration values for cashew in the study area ranged from 2.0 to 3.69 mm day$^{-1}$ for different months (Fig. 8). It followed the same trend as crop coefficient and was highest in the month of May. The major advantage of using satellite imageries in estimating ETc is its ability to quantify spatial and temporal differences in ETc within a single field. Quantification of such real-time variation in field will be helpful in accurate estimation of ETc. The daily average ETc estimated for wheat crop ranged from 4.7 to 5.2 mm day$^{-1}$ in Arizona (Hunsaker *et al.*, 2005). The data obtained through remote sensing is to be correlated with field estimation of crop coefficient.

The major short coming in the use of Landsat imageries is the cloud interference which makes some images unusable. Also the re-visit time of satellite is more, that it prevent occasional and frequent mapping of crop irrigation requirement. This can be overcome by using microwave remote sensing data with more spatial and temporal resolution.

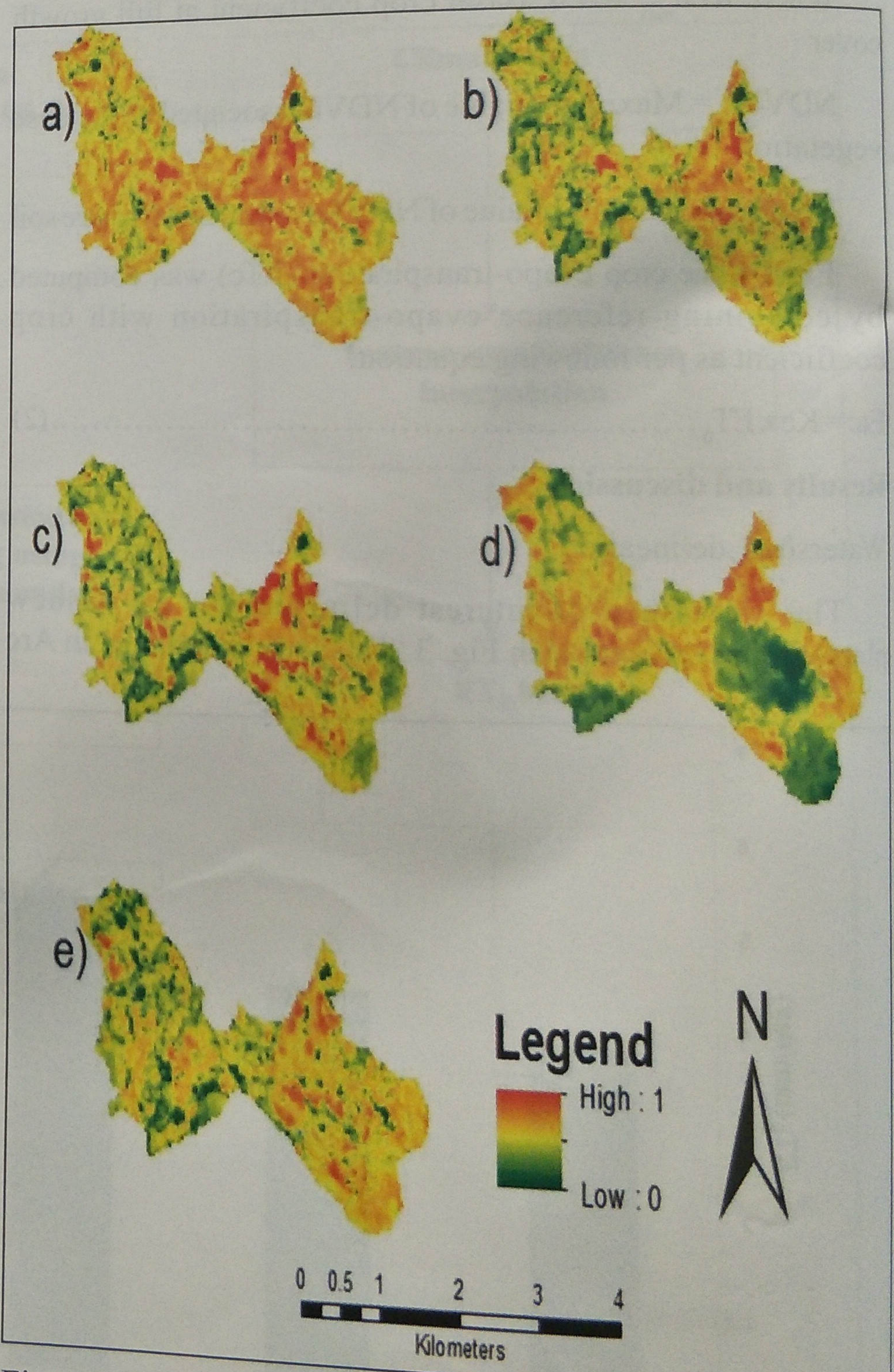


Fig. 6. NDVI of the study area during, a) December 2016, b) January 2017, c) February 2017, d) March 2017, e) May 2017.

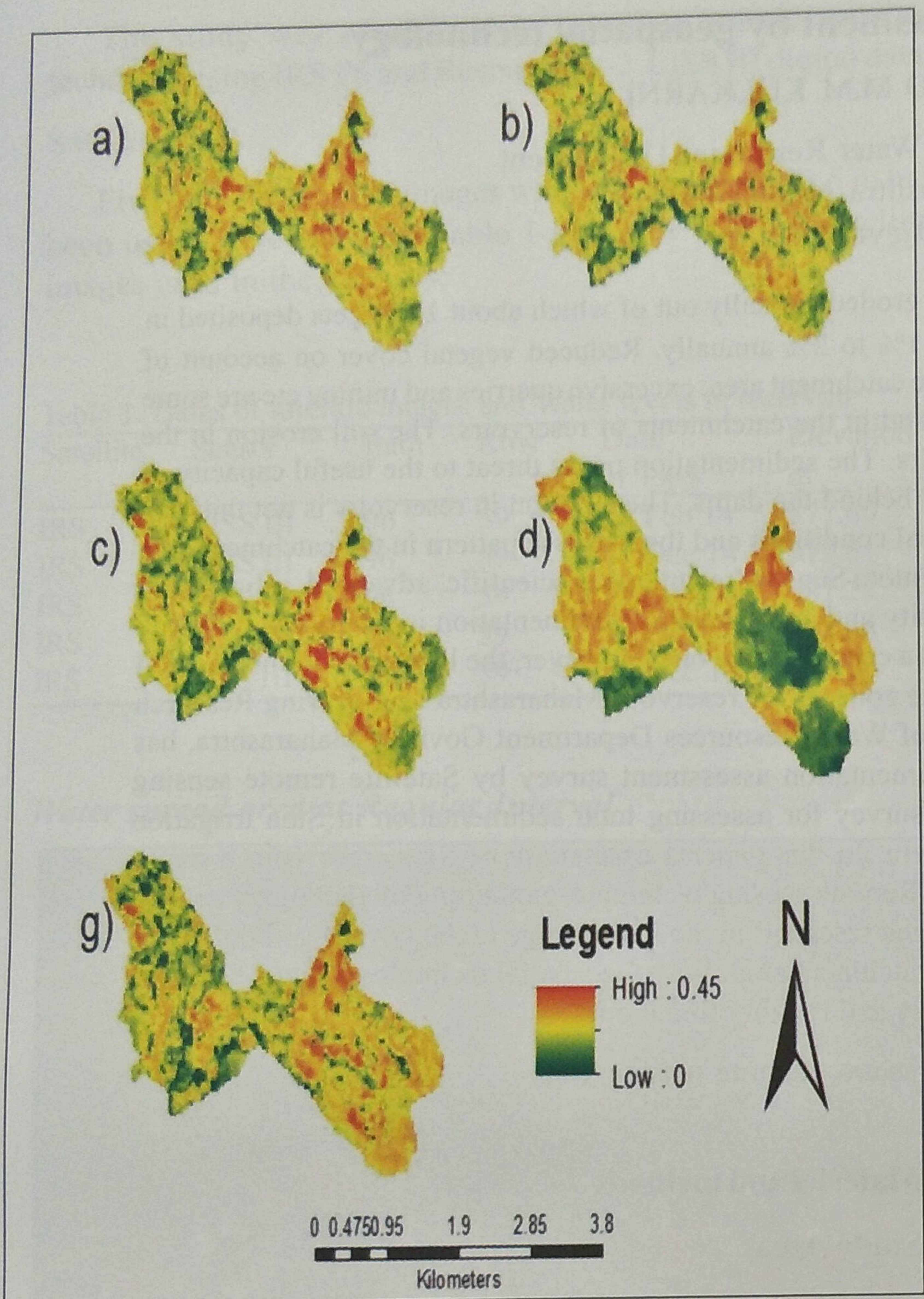


Fig. 7. Crop coefficient for cashew in the study area during, a) December 2016, b) January 2017, c) February 2017, d) March 2017, e) May 2017.

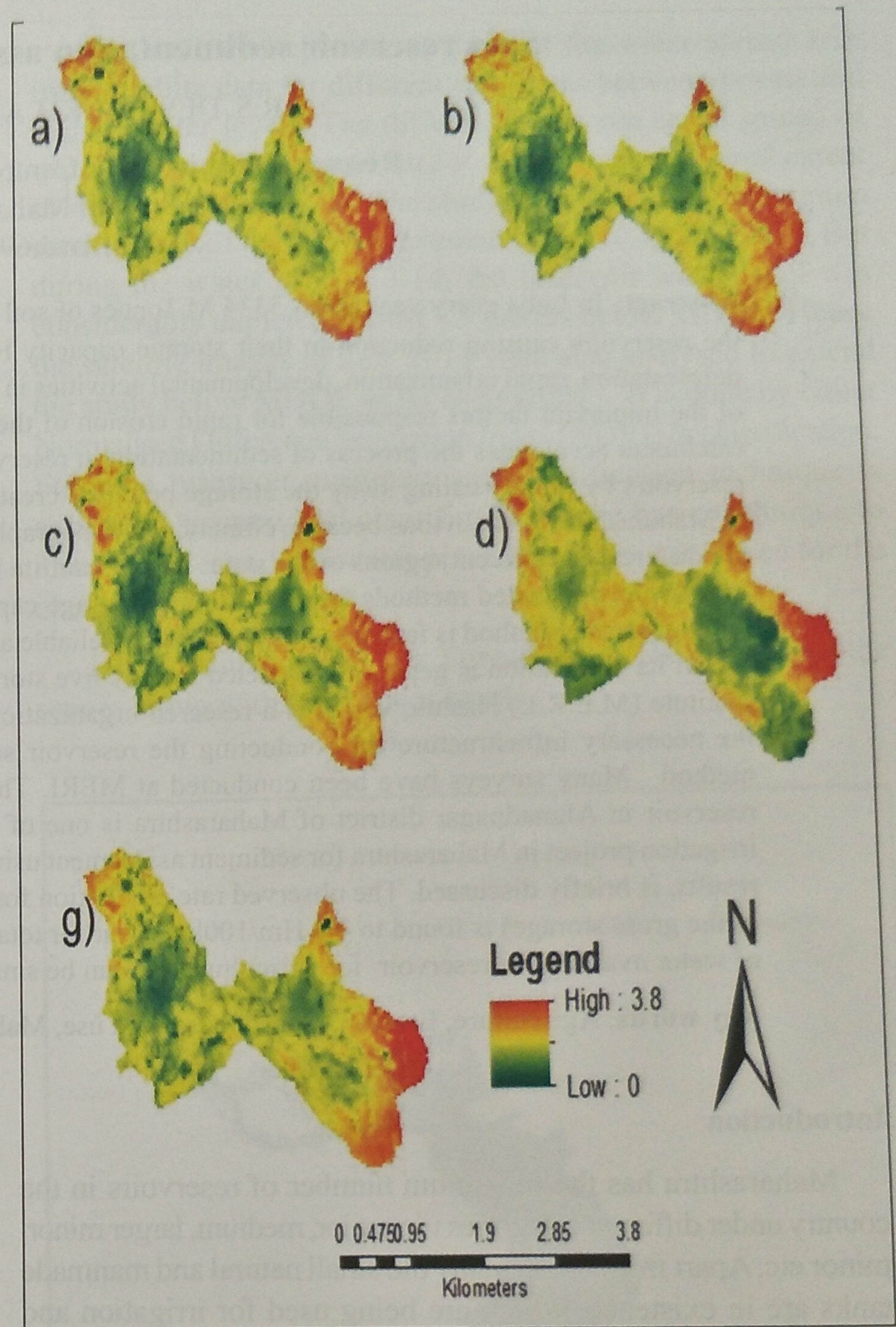


Fig. 8. Crop evapotranspiration for cashew in the study area during, a) December 2016, b) January 2017, c) February 2017, d) March 2017, e) May 2017.

## Conclusions

Remote sensing and GIS techniques were used to find out the crop coefficient and evapotranspiration of cashew during summer months of 2017 in Puttur taluk in Karnataka. The study demonstrated the usefulness of geospatial technologies in estimating the seasonal variability in crop coefficient in cashew. However further studies are required to correlate the estimated values with actual evapotranspiration and irrigation scheduling. Satellite remote sensing with all weather capabilities could be useful for eliminating the interference from clouds.

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