Available online at www.sciencedirect.com

ScienceDirect

Procedia Food Science 6 (2016) 127 – 132

Procedia Food Science

International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015)

Identifying an appropriate and sustainable irrigation method using some remotely sensed parameters for the crop cultivation in Vavuniya district

Arjunan, K.* and Nanthakumaran, A.

Department of Bio-Science, Faculty of Applied Science, Vavuniya Campus of the University of Jaffna, Sr Lanka

Abstract

Over consumption of water resources due to unplanned and inappropriate irrigation methods would be a threat to the ecosystem health and to the sustainable agriculture in Vavuniya District. The objective of this study was to identify the most appropriate irrigation method using remotely sensed or derived hydro geological and meteorological information. The impact of different types of irrigation methods on water use efficiency, water consumption, socio economic aspects of irrigation and soil condition were considered to fulfil the objective of this study. Evaporative fraction, soil moisture content, hydrological parameters and the meteorological parameters were derived using satellite imageries namely the products of Moderate Resolution Imaging Spectro-radiameter (MODIS), MOD 09 A1 (Solar Zenith Angle), MOD 11 A1 (Land Surface Temperature), MOD 13 A1 (Normalized Different Vegetation Index) and MOD 43 B3 (Surface Albedo) and the Shuttle Radar Topography Mission (SRTM) DEM (90m resolution) associated with field reference data during January 2014 to June 2014. Estimation of evaporative fraction and soil moisture content were collectively done with the aid of Surface Energy Balance Algorithm (SEBAL) methodin Ilwis 3.7 environment. Appropriate geometric corrections and image processing operations were applied. Parameterization of hydrological and meteorological parameters was done using automated operations associated with auxiliary information of respective imageries. Information on socio economic aspects of irrigation methods were gathered from semi structured interviews and secondary data sources. This study revealed that integral of hydrological, topographical, meteorological and socio economic factors signifying the importance of micro irrigation methods as viable and effective irrigation method in agriculture. Encouraging the farmers to use micro irrigation methods by providing the credit facilities and the subsidy to install micro irrigation systems is vital for the water resource conservation and thereby the sustainable agriculture.

Peer-review under responsibility of International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015).

Keywords: Hydrological; Irrigation; Meteorological; Socio economic aspects; Water use efficiency

* Corresponding author. Tel.: +94774658608 E-mail address: arjunan17@hotmail.com

Peer-review under responsibility of International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015).
doi:10.1016/j.profoo.2016.02.030

1. Introduction

The Vavuniya District is in the Northern Low Lands of Sri Lanka covering an area of about 1966.90 Sq km (Fig. 1). This district falls within the agro climatic zone of Low Country Dry zone. The average rainfall in this district is 1310 mm. The water resources mainly depend on rainfall as there are no perennial rivers. There is one major, 23 medium and 674 minor irrigation tanks found in this district store water during rainfall and supply water for irrigation during crop cultivation. Major livelihood activity in the study area is cultivation of paddy, vegetables and some other cash crops. Cultivation activities associate with seasonal rain fall and with major and minor tanks[1].

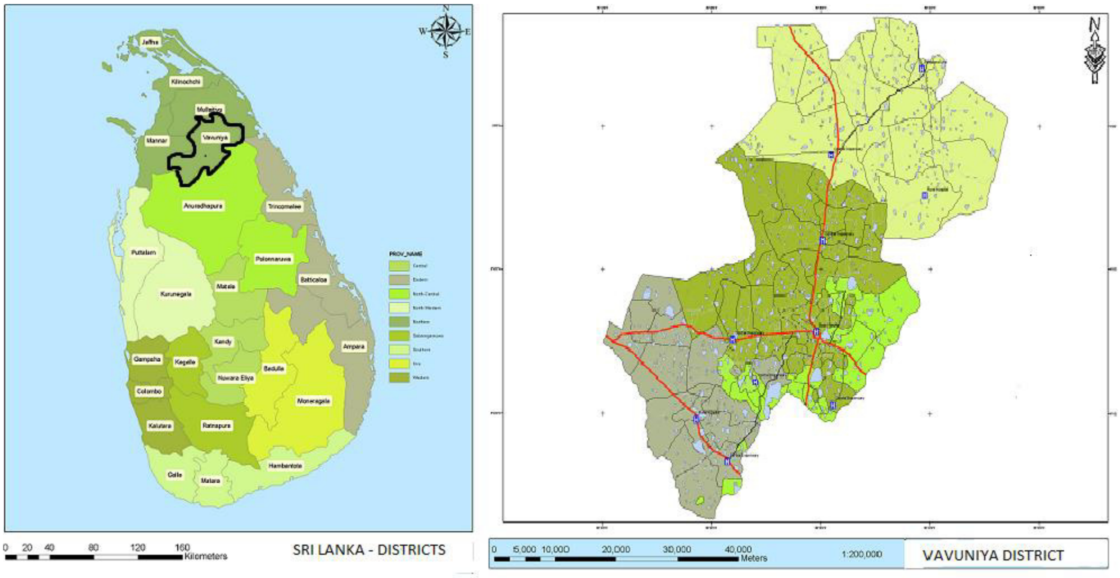

Fig.1. District Map of Vavuniya (Source: Survey Department, Government of Sri Lanka, 2005)

The general landscape of study area with 3% to 4% of slopes contains minor and medium water sheds and catchment basins. Reddish brown earth, Low humicgley and Alluvial soil which occupy the concave valleys and bottom lands are the main soil groups. The cultivation of subsidiary food crops obtains water mostly from seasonal rainfall and supplementary irrigation from shallow dug wells of unconfined aquifer. At present, total population in Vavuniya District is 241,659, out of which there are 53,237 of urban population located in the Vavuniya Division. If an average of 120 liters/person is required for daily use, then the total water demand is 1,687,646 gallons/day.

However, at present the maximum extraction (from groundwater) is around 700 cum/day or 184920 gallons/day which is only 11% of the requirement. It is abstracted by eight wells in which four shallow with large diameter and four relatively steeper with small diameter[2]. Hence, there is a strong management implication for the surface and underground water resources. This study aimed to suggest sustainable irrigation method for the effective management of water resources by minimizing the quantity of water required for irrigation purposes.

2. Methodology

The following steps were carried out in order to identify the most appropriate irrigation method (Fig. 2):

- Estimation of evapotranspiration potential based on evaporative fraction[3] using Surface Energy Balance Algorithm (SEBAL) method
- Estimation of soil Moisture content Using Surface Energy Balance Algorithm (SEBAL) method [4].
- Remotely sensed topographical profile/ terrain structure[5].
- Socio- economic aspects of different irrigation practices

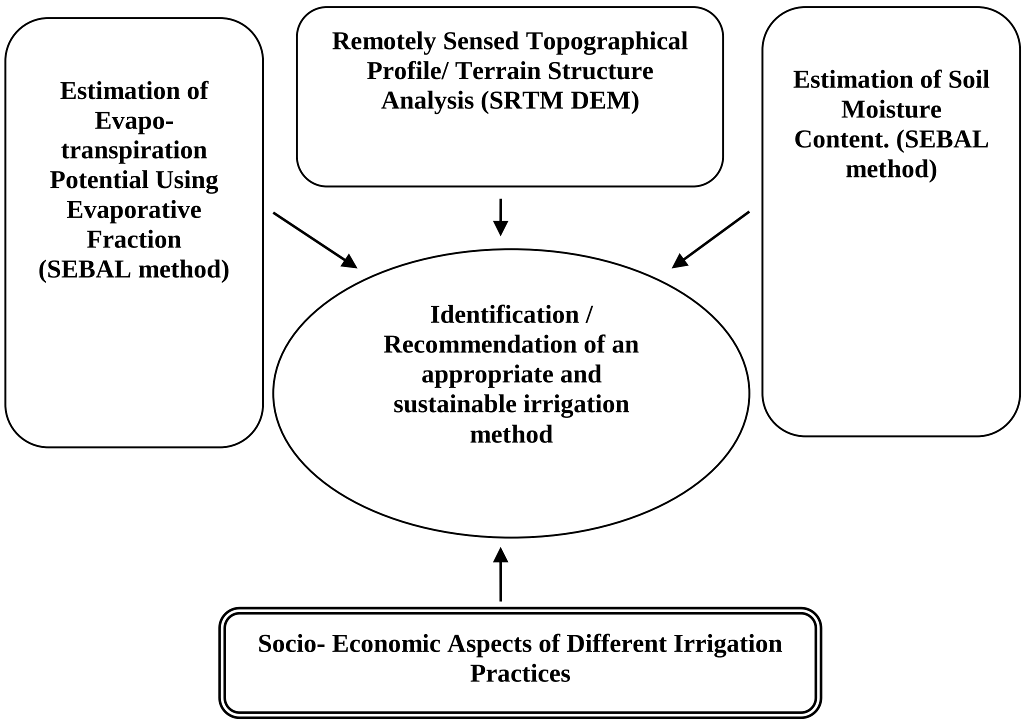

Fig.2: Flow diagram of steps followed

2.1 Estimation of evapotranspiration potential and Soil Moisture content using Surface Energy Balance Algorithm (SEBAL) method.

From USGS website, MOD 11 A1 (Land Surface Temperature band 31,band width 10780-11280 µm), MOD 13 A1 NDVI (Normalized Different Vegetation Index,band 1,band width 620-670 µm**,** The data type is *16 bit signed integer*, which has a theoretical range of values from 32,768 to +32,768. The documented data range is from -2000 to +10000 with a fill value of -3000and MOD 43 B3 (Surface Albedo band 4,band width540-565µm) and MOD 09 A1 (Solar Zenith Angle, The data type is *16 bit signed integer*, which has a theoretical range of values from -32,768 to +32,768). The documented data range is from -100 to +16000 with a fill value of -28,672, geo-referenced and pre-processed images were downloaded. ILWIS 3.3 and ENVI image processing software were used for image processing (Re-sampling, slicing, color composite, stretching) of MODIS products. For geo-referencing of maps warping using Ground Control Points (GCP) used to convert into LATLON system in ENVI software. Instantaneous net radiation was developed for each month from solar zenith angle, corrected albedo, land surface temperature, incoming long wave radiation and outgoing long wave radiation image of respective month. Instantaneous soil heat flux was estimated from instantaneous net radiation, albedo, NDVI and LST images. Instantaneous sensible heat flux was calculated by iteration procedure until reach stable aerodynamic resistance and stable sensible heat flux. Instantaneous latent heat flux was calculated from Instantaneous net radiation, Instantaneous soil heat flux and Instantaneous sensible heat flux. Evaporative fraction was estimated from Instantaneous latent heat flux, Instantaneous net radiation and Instantaneous sensible heat flux. It was identified from both LST (Land Surface Temperature) and albedo images after downloading pre-processed images from MODIS website. The meteorological data such as relative humidity and air temperature were affixed with the images as secondary data for processing for heat flux estimation.

2.2 Remotely sensed Topographical profile/ terrain structure

As Vavuniya district is a flat slightly undulating terrain, generalized topographical profile/ slope was studied using the Shuttle Radar Topography Mission (SRTM) DEM (90m resolution) and the hydrological parameterization at Ilwis 3.3 software platform. Flow direction, flow accumulation, drainage, watershed boundaries, topographic, and hydraulic parameters using automated process in spatial environment were computed using SRTM DEM (90 resolution) to find the suitability for different types of irrigation methods.

2.3 Socio- economic aspects of irrigation practices

Interviews using semi structured questionnaires from 30 randomly selected farmers, secondary data sources and the past studies carried out bySuceendra and Nanthakumaran[6] were used to find out the following aspects of cultivation extent, yield, quantity of water pumped per unit area of different crops, irrigation interval, labour cost, total cost for irrigation, willingness to practicing the existing micro irrigation methods.

3. Results and discussion

Estimation of evapotranspiration potential using evaporative fraction clearly showed that the regions with high water availability in irrigated lands reported to have a higher evaporative fraction. In contrast, the regions with low water availability reported to have a lower evaporative fraction. This variation in evaporative fraction varied with land use pattern as well.

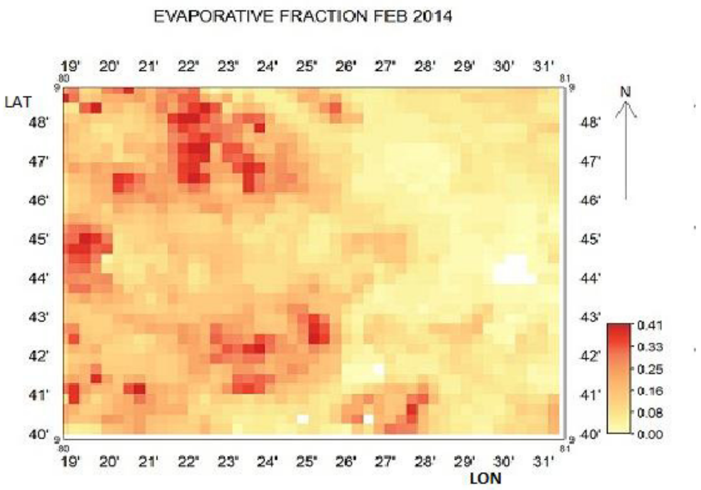

Fig. 3.Estimated Evaporative Fraction February 2014

As far as temporal variation of evaporative fraction was concerned**,** it lay in the range of (0.11 – 0.86) in January 2014 (Fig. 4) because of higher availability of water and the intensive plant vegetations. Then, there was a drop in evaporative fraction in February (0.24-0.52) as well as in March (0.12-0.59) after the harvesting of paddy. Then, a sudden increase was observed in evaporative fraction in April (0.26-0.68), May (0.45-0.63) and June (0.53-0.78). It showed that the increased evapotranspiration potential plays a major role in the unwanted loss of water from irrigated lands. Hence, the adoption of micro irrigation methods for the suitable crops may be a solution to reduce the evapotranspirational loss of water from agricultural lands compares to conventional irrigation methods.

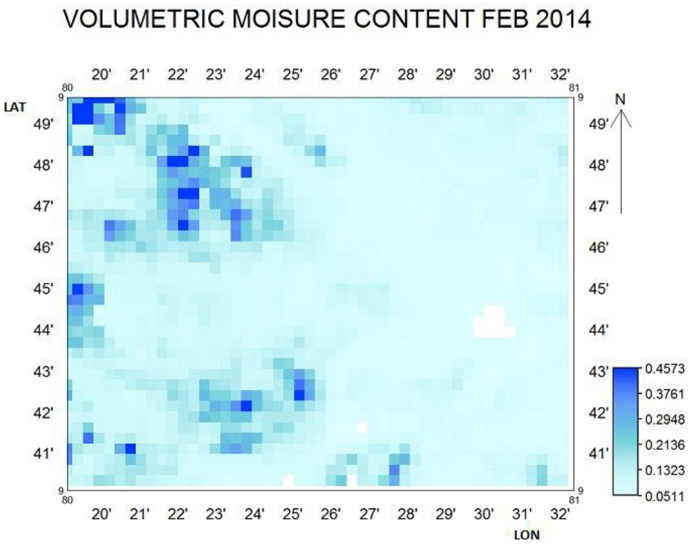

Fig. 4.Estimated Volumetric Soil Moisture Content February 2014

As far as the temporal variation of soil moisture content was concerned a moderate water retaining capacity of soils were observed. Further, the residual average volumetric soil moisture content of 18%, 11%, 8%, 7%, 9%, and 10% was observed from January to June2014 (Fig. 4),respectively. This reveals that there is a strong tendency of utilizing the remaining soil moisture with small scale revised supplementary irrigation for the cultivation of vegetable and cash crops.

Terrain Structure characterized by unvarying/ steady slope along with catchment basin without abundant distribution of depression/ fill sinks or steep slopes can support all kinds of irrigation practices such as sprinkler, drip, and furrow and basin irrigation.

Socio-economic analysis reveals that the farmers were prepared to shift for the micro irrigation methods associated with existing irrigation practices mainly for the cash crops like chilli and onion. Only a small percentage of the farmers who received micro irrigation systems under the subsidy were practicing the same with limited extent. Farmers expressed their willingness to use sprinkler irrigation method if the financial assistance would be provided through subsidy or any other means.

4. Conclusion and Recommendations

This study concluded that integral of hydrological, topographical, meteorological and some selected socio economic factors signifying the importance of micro irrigation methods as viable and effective irrigation method in agriculture in the study area. Micro irrigation methods would result in increase in agricultural production by increasing the extent cultivated through water conservation. Encouraging the farmers to use micro irrigation methods by providing credit facilities and the subsidy for the installation of micro irrigation systems is vital for the conservation of water resource and thereby the sustainable agriculture.

References

1. Anon. 2013. District statistical hand book. Vavuniya.
2. Ranasinghe, H. 2013. Are Water Resources Sufficient To Support The Proposed Development in the Nothern Province .Journal of Environmental professionals Sri Lanka, Vol 2 pp 42-56.
3. Arjunan, K., Nanthakumaran, A. and Suthakar, S. 2014. Application of SEBAL Model for the Mapping of Evapotranspiration Potential in Vavuniya District. Proceedings International Conference Of Agricultural Sciences 2014, Sabragamuwa University of Sri Lanka pp 68.
4. Parodi, G. and Bastiaanssen, WGM. 2002. AHVRR Hydrological Analysis System Algorithms and theory version 1.3. International Institute for Geo-information Science and Earth Observation, P.O.Box 6, 7500 AA, Enschede, The Netherlands.
5. DurgaRao, KHV.,Bhanumurthy, V. and Roy, PS. 2009. Application of satelite - based Rainfall Products and SRTM DEM in Hydrological Modelling of Bharmaputra Basin. Journal of Society of Remote sensing ,vol 37, pp. 587-600.
6. Suceendra, T. and Nanthakumaran, A. 2013. Economic viability of sprinkler irrigation system on onion in Vavuniya Case Study in Nedunkerny. International symposium of Agriculture & Environment ISAE 2013, University of Ruhuna, pp 317 – 320.