Extended Abstract

International Symposium of Sabaragamuwa University of Sri Lanka (ICSUSL) - 2017

Influence of Topographic Parameters on the Yield Variability of the Pelwatte Sugar Plantation in the Moneragala District, Sri Lanka

S.J.W.W.M.M.P. Weerasekera[1], U.W.A. Vitharana[2]

[1]Postgraduate Institute of Science, University of Peradeniya, [2] Department of Soil Science, Faculty of Agriculture, University of Peradeniya

1. Abstract

Pelwatte sugar plantation consists of three major cane cultivation areas; Nucleus Estate (NE), settlement scheme and out-growers scheme. It has been reported that the cane harvest has remarkably decreased during past years.

The study is aimed to explore the spatial variability of topographic parameters in the NE and to find their impact on the variability of sugarcane yield. Firstly, contour map of the study area was digitised and Digital Elevation Model (DEM) was generated using ordinary kriging with an independent validation. Weighted averages of the yield data were calculated for three consecutive*Maha* seasons; 2010/11 *Maha*, 2011/12 *Maha* and 2012/13 *Maha*followed by an exploratory data analysis. Topographic parameters; Elevation, Slope, Topographic Wetness Index (TWI) and Topographic Position Index (TPI) were derived from the DEM. Statistical analysis was performed using Rstatistical package.

The slope of the terrain ranged from 0-11 in degrees. Most of the terrain area was under 1-3 degree slope category. The curvatures of the cane cultivation area ranged from -11.4 to 11.5 representing three types of terrain features; flat or linear, upwardly concave and upwardly convex. The TPI values, -3.4 to -0.1, 0 and 0.1 to 4.0 showed valley areas, flat areas and the ridge areas of the terrain respectively. Correlation analysis showed low correlations among yield and topographic parameters. The Elevation showed low positive correlations, r = 0.28 and r = 0.21 with yields in 2010/11 and 2012/13 respectively. TPI showed the relatively significant negative correlation,-0.33 with 2011/12 *Maha* yield.Slope and TWI showed low correlations with yields during each *Maha* season.

It can be concluded that the spatial variability of the topographic parameters of the area is quite significant. The topographic parameters particularly the Elevation and theTPI are relatively significant factors which are affecting on the yield variability of sugarcane in the NE.

Keywords:Digital Elevation Model, Pelwatte Sugarcane Plantation, Sugarcane Yield, Topographic Parameters

2. Introduction and research problem/issue

Introduction

Sugarcane has been cultivated in Sri Lanka since 1840s. About two decades ago, in 1990s, sugarcane was cultivated in about 25,000 hectares. Currently Pelwatte, Sevanagala and Hingurana factories are contributing 13,200 ha, 4,200 ha, and 3,440 ha respectively. As the main sugar production factories, Pelwatte and Sevanagala are contributing 60,000 MT/ yr and 30,000 MT/ yr respectively for the domestic sugar production (Lanka Sugar, 2015).

The sugar cane growing area in Pelwatte Plantation mainly consists of three zones namely, Nucleus Estate (NE), Out-growers Scheme (OS) and settlement scheme.The NE (3,600 ha) has been established as a buffer area to fulfill the requirement of stock shortage from the other zones. From 1985 small scale sugarcane farmers started to shift towards growing alternative crops. As a consequence the OS was established to encourage people to grow sugarcane again by paying reasonable prices

for their production. It has been identified about 8,000 ha of land having the growing potential for small holders.

Efficient and reliable agricultural land use planning is an essential element as most of the developing countries are facing numerous of issues due to unsustainable agricultural land use.The changing topography affects soil types and their properties.The change of soil properties across space is often gradual(Zhu *et al.*, 1997).In the context of growing demand for high-resolution spatial information for environmental planning and modeling, fast and accurate methods are needed to provide high quality digital soil maps (Behrens *et al.*, 2005). Spatial variation in soil characteristics is so complex that no description of it can be complete, and prediction is inevitably uncertain (Aberegg *et al.*, 2009).

In pedology the spatial pattern and the taxonomic relationships of soils are important concerns while land form and landscape characteristics are also bringing relative importance in spatial soil variability (Behrens *et al.*, 2010).

Research Problem

Trends of sugarcane production have revealed that the yield has been reducing at a considerable amount in the NE and SS regions which accounts approximately above 7,500 ha by extent. This may be mainly due to the issues related to soil fertility parameters, topography, climatic factors or their combinations or other. This study aims to explore the spatial variability of topographic parameters and their effect on the yield variability of NEusing statistical and Geographic Information System (GIS) analysis techniques.

3. Research Methodology

Digitising and Construction of Digital Elevation Model (DEM)

Contour map and the boundary map (1:10,000 scale) of the study area were georeferenced and digitisedusing ArcGIS 10.0.Contour map was then converted in to raster format in ArcGIS 10.0. The rater map was re-converted to point vector map andthe point database file was converted to text format.The data base was imported to VESPER 1.6 (Minasny, McBratney and Whelan, 2002) application and ordinary block kriging was performed with 10 m x 10 m pixel size to generate the DEM.

Deriving Topographic Attribute Maps

Slope

Slope map was directly generated by using the DEM of the study area using ArcGIS 10.0. The map was classified in to five slope classes and slope was obtained in degrees.

Topographic Wetness Index (TWI)

The TWI map was generated using SimDTA application by means of Specific Catchment Area map and slope map. The resulted ASCII file was displayed in ArcGIS interface by converting into its raster format. The map was then classified into five index classes.

Topographic Position Index (TPI)

The TPI map of the area was directly derived in SimDTA interface using the DEM of the area. The resulted ASCII file was displayed in ArcGIS interface by converting into its raster format. The map was then classified to obtain meaningful map of TPI.

Processing of Yield Data

A desk study was carried out to explore yield data for three consecutive *Maha* Seasons,

2010/11, 2011/12 and 2012/13. Yield Per Hectare (YPH) values were then calculated for existing sugarcane fields. When a main field had been divided into subfields, YPH was calculated using weighted average technique.

Statistical Analysis

*Corresponding Author, *Tel:0094-71-8245459*, Fax: 0000-00-0000000

A data base containing yield and topographic parameters values was created and an exploratory data analysis was performed to explore the basic statistics and the normality of yield data. Correlation analysis was performed to examine the relationship between yield and topographic parameters.

4. Results and findings

DEM of the study area

The elevation of the study area ranged from 110.0-167.5 m. It showed highest elevation at northernmost parts while lowest at the southernmost region. DEM clearly visualised the undulated topography of the study terrain. The validation process resulted RMSE value and the correlation coefficient, 0.25 and 0.99 respectively. These values reflect that the ordinary kriging performed well in explaining the variability of the elevation data of the study terrain.

Spatial Maps of Topographic Parameters

Slope

The slope of the terrain ranged from 0-11 in degrees. Most of the terrain area was under

1-3 degree slope category. Moderate slope (4-5 degree) area observed at Eastern parts close to the boundary and middle areas of the southern part. The areas with highest slope values are not dominant feature and can be observed at few areas of Northern and southern parts of the study area close to boundary where, the slope ranged from 8 to 11 in degrees.

Topographic Wetness Index (TWI)

The highest values, 17-20 of TWI can be observed mostly close to the boundary of the study area both West and East sides. These areas probably lie where the ground water gradient lower and higher the soil moisture content. This can be confirmed as two rivers; "Kuda Oya" and "Manik Ganga" are flowing along these boundaries. Higher values for TWI can also be observed inside the study site and those are the areas which may close

to water bodies such as tanks and channels and hence it would result higher moisture content in soil. At higher elevation, the TWI decreased where ground water table possibly deeper hence lower moisture content in the soil.

Topographic Position Index (TPI)

The TPI values, -3.4 to -0.1, 0 and 0.1 to 4.0 representing valley areas, flat areas and the ridge areas of the terrain respectively. The elevation of the area ranged from 110.0 m to 167.5 m. The DEM together with TPI further confirmed that area was quite undulated in surface topography.

Results of Correlation Analysis

The correlation analysis of yield and topographic parameters showed an inconsistent pattern. Except TWI all other parameters showed at least one negative correlation with yield. Elevation showed positive correlations, r = 0.28 and r = 0.21 with yields in 2010/11 and 2012/13, respectively. Even though TWI showed positive correlation with yield, the correlation values were very low.TPI showed relatively high negative correlation, r = -0.33 with the yield in 2011/12. Slope did not show a good correlation with yield during three *Maha* seasons.

5. Conclusions, implications and significance

It can be concluded that the spatial variability of the topographic parameters of the area is quite significant. The undulated topography (elevation fluctuation) and the TPI are the predominant factors affecting the yield variations of the sugarcane in the Nucleus estate. There may be some other factors such as climate and also various management practices which may have effected the yield fluctuations of the area.

6. References (Selected)

Aberegg, I., Egli, M., SARToRI, G. and Purves, R. (2009). Modeling spatial distribution of soil types and characteristics in a high Alpine valley (Val di Sole, Trentino, Italy). *Studi Trent Sci Nat, 85*, 39-50.

Behrens, T., Förster, H., Scholten, T., Steinrücken, U., Spies, E. D. and Goldschmitt, M. (2005). Digital soil mapping using artificial neural networks. *Journal of Plant Nutrition and Soil Science*, *168*(1), 21-33.

Behrens, T., Schmidt, K., Zhu, A. X. and Scholten, T. (2010). The ConMap approach for terrain_based digital soil mapping. *European Journal of Soil Science*, *61*(1), 133143.

Zhu, A. Band, L., Vertessy, R., and Dutton, B. (1997). Derivation of soil properties using a soil land inference model (SoLIM). *Soil Science Society of America Journal*, *61*(2), 523-533.

