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A GIS based study on paddy land degradation in Eravur Pattu DS Division, Batticaloa, Sri Lanka

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Abstract

Land degradation becomes a noticeable issue in worldwide. The lack of reliable baseline information on land degradation is a limitation towards its monitoring and mitigation. Mapping the spatial distribution of paddy land degradation is significant where the paddy cultivation is primarily practiced. The paper focuses on a detailed study in analyzing the spatial variability of paddy land degradation in the Eravur Pattu Divisional Secretariat Division, Batticaloa District, Sri Lanka. A questionnaire study was carried out among the farmers to identify the sites fall under paddy land degradation in the study area. Soil analysis was carried out to explore the variation of the soil chemical parameters such as pH, Electrical conductivity and Total dissolved solids (TDS) in the degraded paddy lands in the study area. The findings show that the above parameters were exceeding the standard limits in the degraded lands. The higher variation was observed in the lands adjacent to river aquifer. The spatial variation maps of these soil quality parameters were derived and integrated through GIS. The final integrated maps show the range of the soil parameters quality zones of the study area and provide valuable information of the paddy land degradation in Eravur Pattu Divisional Secretariat areas of Batticaloa District, Sri Lanka.

Keywords: Geographical information system, land degradation, paddy, spatial variation.

Introduction

Land degradation is one of the most obvious factors influencing the agricultural world. Poor agricultural practices, overgrazing and deforestation over many decades have resulted the land degradation worldwide. Current socio-economic development of the nations leads the land degradation in an increasing trend in the world[1]. In the view of productivity, land degradation results the land quality and land use to be low. The study of Akram *et al.*[2] shows that the principle process of land degradation includes erosion by water and wind, chemical degradation such as acidification, salinization, fertility depletion and decrease in cation retention capacity, physical degradation such as crusting, compaction and hard setting and biological degradation including reduction in total and biomass carbon and decline in land bio-diversity.

Rice plays a major role as a staple food for more than half of the population in the world. Over 97% of the world's rice is grown in Asian region of the world. The world's rice production has been estimated as 482.7million tonnes in 2012[3]. Paddy cultivation in Sri Lanka is a prominent sector in agriculture which has being practiced since ancient times. It plays an important role in country's economy as well as in people's life as a main staple food. The statistical data in 2012 shows that the annual rice production in the country is 3,846 metric tonnes[4]. Achieving self-sufficiency in rice is a major policy of Sri Lankan government and it has being achieved by various developments in the paddy field. However, when considering the paddy land extent, a diminishing trend can be observed all over the country due to the land degradation by various factors. The table 01 shows the trend between the paddy production and harvested land area in Sri Lanka.

Table-1
Summary of paddy production and harvested area in Sri Lanka

	2010/11	2011/12	2012/13
Area harvested (Both seasons / in hectares)	1,117,000	1,262,000	1,192,000
Paddy rice production (Metric tons)	3,662,000	4,869,000	4,599,000

This is also apparent in Batticaloa District, which is one of the leading paddy producing districts in the country. It is noticeable that a certain extent of paddy land are being either fallowed or abandoned during Yala and Maha seasons of paddy production where the lands fall both into rain fed and irrigable cultivation either by major or minor tanks irrigation.

Therefore, this study was carried out as an attempt to develop a GIS based information to identify the spatial pattern of chemical degradation of paddy land in the study area. The specific objectives of this study are to: i. Identify the places fall under paddy land degradation in the study area, ii. Identify the factors

influencing the paddy land degradation, iii. To assess the chemical parameters of the soil in paddy degraded lands and to develop a spatial mapping of the study area.

Methodology

Description of the Study Area: The study was conducted at Eravur Pattu DS division of the Batticaloa District which is geographically located in the coastal tract of Eastern Province of Sri Lanka. The study area is located between 7°25′ to 8°15′ N latitude and 81°15′ to 81°45′ E longitude covering an area of about 634.16 Km^2. The location of the study area is shown in figure 1.

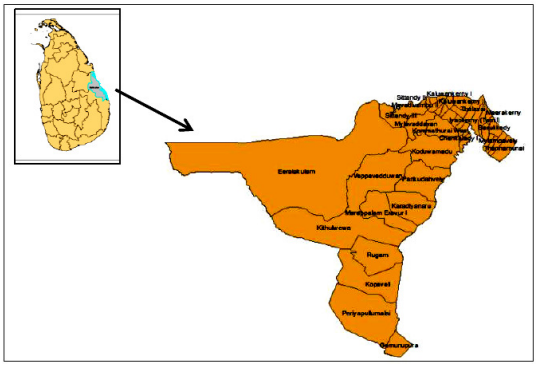


Figure - 01
Location Map of Study Area

The study area is chiefly composed of non- calcic brown soils, gley humic soils and alluvial soils along the region [5]. Irrigation channels of the Rugam tank flows along the study area where, the paddy cultivation is being carried out extensively in both Yala and Maha seasons. The average annual rainfall of this zone varies from 564mm – 3081mm. The North-East monsoon contributing to 65% of annual rainfall is the major component of recharge the aquifer during the months of September to January. The average temperature falls between 25.7°C to 33.9°C. This study area is one of the leading contributors to the paddy production (23% in 2011) in the Batticalola District, which consists of 39 GN divisions with the population of 74020, belonging to all 3 communities namely Tamil, Muslims and Sinhalese, whose main livelihoods are paddy, high land crops and animal husbandary[6]. The agricultural land contributes around 43% of the total land extent of Eravur Pattu DS division and this clearly shows that the majority of the population engages in farming activities.

Data collection: The study used primary and secondary data to find out the factors responsible for the paddy land degradation in the Eravur Pattu DS Division, Batticaloa.

Questionnaire survey: A pre- tested, semi – structured questionnaire survey was carried out to assess the present socio-economic problems and factors related to paddy land degradation. A total of 150 questionnaires were administered randomly among the farmers belong to 3 Agriculture In-service (AI) divisions namely Vantharumoolai, Eravur and Karadyinaru.

Soil Sample Analysis: Soil Samples were collected for the analytical studies from 7 selected places of paddy degraded land in the study area. Randomly selected 50 samples were analyzed for Electrical Conductivity (EC), pH and total dissolved solids (TDS) and compared with the permissible limits. The layout map with sample station location in Eravur Pattu DS division is shown in figure 2. Field visits and observation were carried out during the sample selection and questionnaire survey to ensure the situation around the study area.

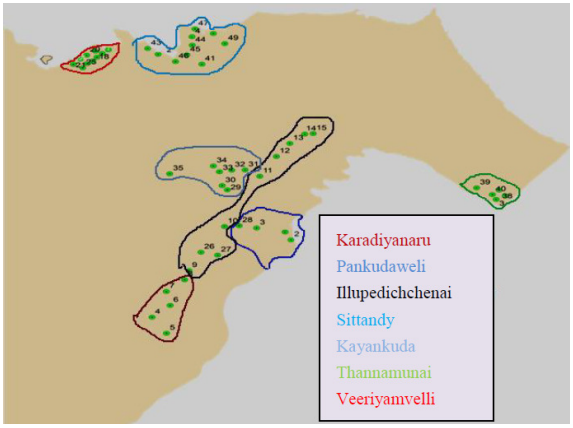


Figure-2
Layout Map with Sample Location in Study area

Data analysis: The collected data and analytical results of the quality parameters were analyzed using SPSS software to produce graphs and relevant charts. Attribute information of the soil parameters were entered into a GIS database (ArcGIS 9.2) and analyzed through Geo-statistical analysis tool in GIS technique, display on maps to show the spatial distribution of the soil parameters.

Results and Discussion

The survey findings revealed that 75% of the respondents agreed that there is noticeable paddy land degradation in the study area. Flood (88%) and salinization (40%) were pointed out as important factors giving more impact in the paddy land degradation in the study area. The geographical boundaries and the elevation of the Eravur Pattu DS division make the area more possibility to be affected by the climatic disasters such as tsunami in 2004 and major flood in 2010/11. These disasters cause direct and indirect effects on the community through the land degradation causing yield reduction, soil erosion and sedimentation. Lagoon water intrusion and intensive fertilizer application are the main causes for the salinization of the paddy land degradation. The study reported that the lands belong to Karadiyanaru and Vantharumoolai AI divisions have been abandoned due to the above reasons which fall adjacent to the lagoon.

Based on the primary data, 7 areas were selected to the analytical study of soil and spatial mapping for pH, EC and TDS in the degraded paddy lands. The pH value of the soil samples varied from 5.1 to 8.1 which are shown in figure 3. The minimum pH value was obtained at Thannamunai, near the side of river and the maximum value is obtained from the inner land area of the Illupedichchenai. However, most of the paddy lands got low pH range (<7) where the water logging condition and heavy agronomic practices are being carried out. Studies show that the pH should be 6-7.5 for the optimum production of the paddy [7]. In contrast, spatial mapping of the paddy derived from the present study shows (Figure 03) that the most of the lands deviate from the optimum range which is an evident for the land degradation in the study area.

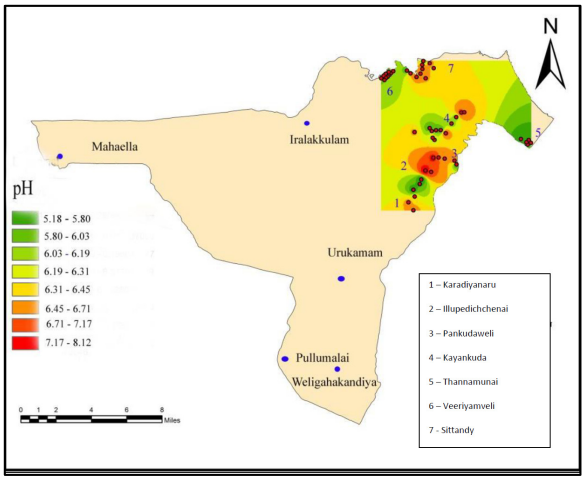
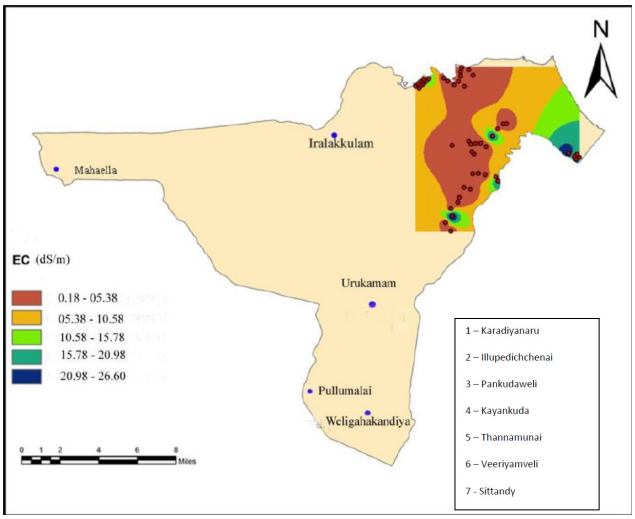


Figure-3
Spatial Variation map of soil pH

The higher EC shows the higher salinity of the paddy land. Maximum EC of 26.2ds/m was obtained in Karadiuanaru paddy land. The figure-4 shows, 66% of the paddy lands are highly affected by the salinity.



Figure–4
Spatial Variation map of Soil EC

The map on the spatial pattern (figure 4) shows that the higher EC is observed in the land near the river aquifer might be due to the salt water intrusion for the paddy lands and a reducing pattern of EC can be observed from the coastal area to inner land area in the map. This type of condition has been proven by the findings of Pandian and Sashikumar[8] during the ground water quality study.

The weight of the residue consisting of dissolved ions left behind after all the water from a water sample is evaporated is a measure of the TDS and gives the general nature of quality and extent of contamination[9].

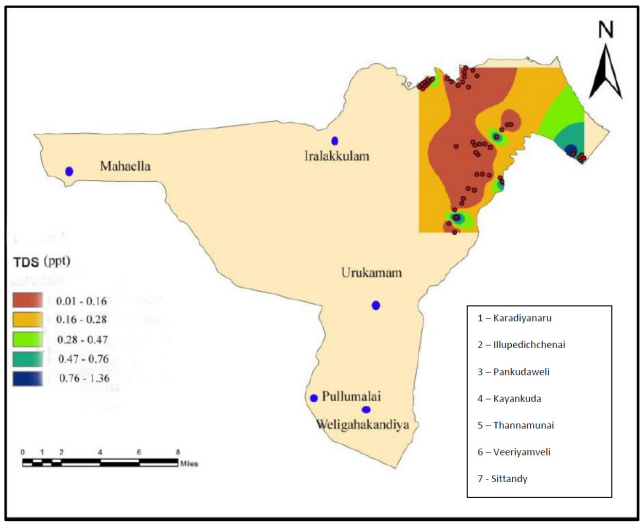


Figure-5
Spatial Variation Map of soil TDS

Analytical studies on TDS concentration on soil sample show that, the TDS range of the degraded lands fall into the range of 0.01-1.36 ppt. From the map representation (figure-5) the spatial pattern of the TDS distribution shows a decreasing trend from the lands adjacent to lagoon and river to inner land of the study area.

Conclusion

GIS based spatial analysis technique has been proven to be a powerful tool to represent the distribution of paddy land degradation in the study area. The parameters such as pH, EC and TDS of the soil samples were exceeding the standard limits in the degraded lands. TDS and EC distribution shows a decreasing trend from the lands adjacent to lagoon to inner land of the study area. Therefore, proper reclamation practices to be adopted in this area to ensure the productivity of the land.

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