

# Disperse Pattern of Geomorphological Units of the Partial-Nature-based Wetland in Kirala Kele of Southern Sri Lanka

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**Abstract--** Wetland resources form an integral part of the environment and their management must be pursued in the context of interaction between conservation and the national development strategies. Sri Lanka has a tremendous partial nature based wetland resources that have a great potential for further development in Southern Asia. Wetland as a category of natural environmental system has multi variant sub-systems with physical and chemical properties which can be developed in a sustainable manner. Kirala Kele wetland area is one of the most appropriate areas which has a concentration on the regional development of the Southern region in Sri Lanka. After implementation of the Flood Control Scheme, this land did not have suitable soil and water for agriculture. This paper explores the disperse pattern and process of geomorphologic units of the partial-nature-based wetland at Kirala Kele for the long-term development. The study applied a survey research with field work and findings from pre-studies for the data collection in order to accomplish the main objective of the research. The cultivated land area was abandoned due to the changes of physical and chemical properties of soil and water. Now, it is becoming a marsh area and converted as a partial-nature-based wetland.

**Key words--** Wetlands, Soil, Geomorphology, Development, Sustainability

## I. INTRODUCTION

The evolution of most of the wetlands and the lagoons in Sri Lanka is the outcome of eustatic sea level fluctuations and the geology and geomorphology of the local environment (Silva et al., 2013). The Kirala Kele wetland too submerged habitat during the Mid- Holocene sea level rises. Mid- Holocene sea level was at least 2.5m higher than the present sea level at the west, south and east coasts of Sri Lanka (Katupotha & Fujiwara, 1988; Katupotha & Wijayananda, 1989). Due to the marine transgression of this period (Mid- Holocene period – first episode of high sea-level rise; 6240-5130 years BP) the earlier-formed drainage basins were submerged and dead corals and shell beds thrived in places. The soil profiles of the Kirala Kele wetland comprise of the previous buried shell beds and organic matters just after alluvial soils on the top.

Even though it is difficult to define cause and effect relationship between morphology and evolutionary processes of the wetlands, most probably the origin and the evolution of the coastal land forms would depend on the short term and temporary processes affecting the coastal belt. The entire coastal belt in Sri Lanka has been submerged by the Miocene, Pleistocene and the Holocene marine transgressions during the tertiary quaternary geological periods in the earth's history. Hence, most of the ancient marine land forms are evolved by the eustatic sea level changes and submergence of the coastal zone during the quaternary period (Weerakkody, 1988). A unique geomorphologic feature of the lower Nilwala basin has

an oval shape of the flood plain including the Kirala Kele back swamp. Due to the lower elevation and low velocity of the river, braided channels can be seen. The fluvio- marine process is part of the main denudation processes in the study area. The fluvial system has been generated by two basic geomorphologic units as the flood plain with back swamp and the river channel (Wolf, Cooper, & Hobbs, 2007) in the area. Flood plain comprises of the alluvial fans that extend across the Kirala Kele wetland area.

## II. METHODOLOGY

Based on the characteristics pertaining to the design of the research, this study applied a survey research with field work and findings from pre-studies for the data collection in order to accomplish the main objective of the research. The spatial data was used to identify and compare terrain and soil properties in Kirala Kele wetland area between 1983 and 2011, using remote sensing data were used.

Except the pre studies from Literature survey (Weerakkody, 1997, 1998; Katupotha, 1988, 1994; Panabokke, 1996; Fernando & Weerakkody, 1998) field observation of the soil layers across the in situ beds using Iron Auger, observation of human made profile and cross section methods were used to collected soil data of the area. The satellite images were provided by the Survey Department of Sri Lanka. The images were radio metrically and geometrically corrected and co-registered Transverse Mercator Projection with UTM zone 47 North and WGS 84. The spatial resolution was 4\*4 meters. They were acquired between January and February in 1983, 2003 and 2011. A pair of black and white aerial photographs with the scale of 1:20,000 taken in 1983 was provided by the Department of Geography, University of Ruhuna, Matara, Sri Lanka.

### A. Acquisition of Soil property data

Soil can be characterized using a standard soil probe. Soil data was collected in accordance with the following soil elements; thickness of the organic horizon, soil texture, organic matter content and Munsell soil color. Soil properties of the study area were helpful to determine the wetland evolution of Kirala Kele wetland along the Nilwala River basin. The properties of the soil were examined by a previous research (Weerakkody, 1992 and 1997; Katupotha, 1988 and 1994; Fernando and Suranganee, 2009; Panabokke, 1996) and field observation of cross section method using Iron Auger taken from the selected location in the field. Visual observations were made at each site which resulted in twenty four locations which could be considered for sediment sampling for the test of soil color and materials. Seven sampling sites were visually observed based on the random selection for the identification of the layers and the properties of the soil. Table 1.1 shows the descriptions of the soil profiles of site locations.

Table 1: GPS locations of the soil profiles in the study area

Sample No	Location	Descriptions	GPS Position (National coordinates)
SOSA 1	Magallagoda	Near to abundant river channel	5.5850 N, 80.3340 E
SOSA 2	Godagama	Canal bank area, thick top soil layer	5.5820 N, 80.3125 E
SOSA 3	Paranadugala	Abandoned well, high micro elevation from the wetland	5.5845 N, 80.3048 E
SOSA 4	Lena duwa	Canal bank area, alluvial soil on the top layer	5.5845 N, 80.3150 E
SOSA 5	Kali duwa	Road cut area, some layers can be seen	5.5855 N, 80.3148 E
SOSA 6	Thudawa	Home, garden and settlement area	5.5840 N, 80.3235 E
SOSA 7	Bandaththara	Near the main road, roadside profile is there	5.5910 N, 80.3320 E

Note: SOSA= Soil sample, N= North, E=East, Source: Field observation, 2013

More sampling plots were selected near the wetland boundary where some places had natural in situ soil profiles enclosed with soil layers.

**C. The analysis procedure of terrain**

The digital contours maps (Digital sheet No 91/2012 and sheet No 91/2013) which cover the entire area were taken from the Survey Department of Sri Lanka and were clipped to the shape file of wetland boundaries. Then the percentages of slope gradient were calculated from Triangulated Irregular Networks (TIN) derived from Digital Elevation Model (DEM) using the ‘Spatial Analyst surface’ tools in the Arc Map 10 tool box. The DEM map derived from contour layers belonged to the area selected the ‘Raster interpolation’ in the 3D analysis tool with an output cell size of 10 m and then selected the command of ‘Topo to raster’ to create a raster layer using the vector contour layer. The slope gradient features were clipped to the boundary of the wetland.

Moreover, Soil properties of the wetland area were tested using a pre-study test (Fernando & Suranganee, 2009), Munsell Soil Color Chart and by the observation of the soil materials. Description of the soil color was tested with the depth of the soil layers, Hue Notation, Chroma values and Munsell Color Notation which indicated any soil color tested in the selected plots of the wetland.

**III. TERRAIN ANALYSIS**

The elevation of the area ranges from Minus (below to sea level) to 65 meters above the Mean Sea level (MSL). Central southern and eastern parts of the wetland have no denudated hills due to the accumulated zones of the sediments of this wetland. The central portion of the wetland reaches down to about from minus (-) to 10m elevation at the MSL while the North-eastern and South-eastern parts do extend from 10 to 65 meters elevation at the MSL (Figure 1.1).

The Digital Elevation Map (DEM) represents the terrain factor generated on the Arc GIS environment using a Triangulated Irregular Network (Figure 1.2). Figure 1.2 represents the spatial data as a series of thematic layers of elevation of this wetland area. The slope measures the rate of the change of elevation at a surface location (Wilson et al., 2007). The slope is an important factor of this wetland as it steers the implications of the sediments and the water. Despite the wetland area seeming to be a rolling ground, the elevation and the slope form a strong relationship that is controlled by the denudated hills. The area can be classified into four categories

(High, Moderate, Marginal and low slope) using the elevation values of the contour map (Survey Department, 2013). Table 1.2 shows the covered area of the classified categories of the terrain.

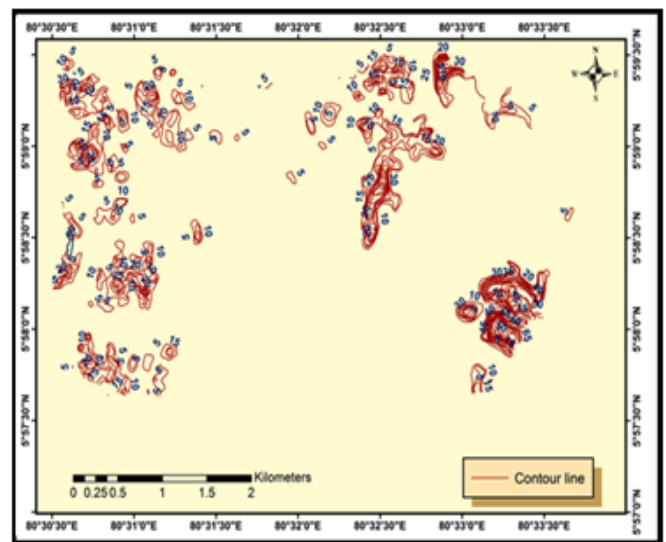


Figure 1: Elevation and dispersion of the denudated hills of the wetland area.

Source: Digital data, Survey Department of Sri Lanka, 2013

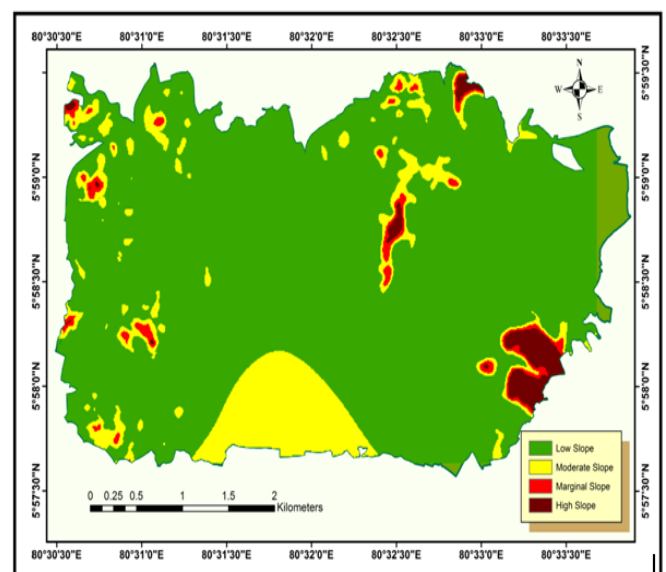


Figure 2: Digital Elevation Map of the KiralaKele wetland area.

The proportion of high suitable class between 0 and 10 elevations represents almost 85% of the entire area. However, the other three types of suitable classes have less than 15% within this area. Most of the denudated hills expose at the boundary of the wetland with randomly distributed patterns, except for the wide expansion of low elevated areas.

Table 2 – Calculated areas of the terrain’s classified classes

Suitable class	Area (acres)	Percentage
High	3565.88	84.82
Moderate	495.55	12.10
Marginal	63.19	1.52
Low	77.98	1.86

Therefore, the central, western and southern parts are regarded as more suitable for the collecting of sediments and sufficient water to long term processes of the wetland.

**A. Geomorphology**

The land formed in the area shows strong influences of both geology and denudational processes through the geological time. About nine-tenth of Sri Lanka are composed of crystalline rocks from the Precambrian age. Most of the low-lying areas along the coastal belt consist of sedimentary formations which were deposited in the Jurassic Miocene and Quaternary geological eras (Coates, 1935; Cooray, 1967). They have identified two groups of quaternary deposits as "older group" and "younger group". The older group was made of red earth, ferruginous gravel and terrace gravel formations (Swan, 1996). The substances of the younger group were shown to have Holocene deposits made up of alluvium dune sand, beach rock and wetlands as the major geomorphologic features along the coastal area. The geomorphological maps can be of great value to the accumulation of geomorphological data for the environmental planning and construction engineering (Paron et al., 2011 Claessens, Smith, & Griffiths, 2011) in the wetland area. The geomorphological maps cover the coastal areas including the Kirala Kele wetland of the southwest coast of Sri Lanka. It is conceptually based on the aerial photographs of 1:20,000 derived from the Survey Department of Sri Lanka where some unidentified locations were able to be detected by field checking (Figure 1.3).

Although origin of several landforms cannot possibly determine, their evolutional processes can be identified with the help of field data. Basically the Nilwala River has a prominent, broad meander near the Kirala Kele wetland before it reaches the Thotamuna outfall (refer to Figure 1.3). The brackish water mangroves and the mud flats are located at lower elevation and therefore are frequently subject to the inter-tidal intrusion of saline water (Panabokke C. R, 1996). Based on the absolute elevation and shape of the morphology, two geomorphological units of denudated hills can be identified as Denudated Hills 1(DH1) and Denudated Hills 2 (DH2). DH2 has low elevation compared to DH1 at the field. At the top which is typically flat measuring 5-10 meter in diameter, is irregular and has a dome shape, denudated hills have evolved in the wetland area by the fluvial-marine process. Those hills lie in association with an elevation of 5-65 meter approximately from the centre to boundary of the Kirala Kele wetland. Since the central portion of the wetland has no more hills and low elevation terrain (Minus to 10 m) it can accumulate more sediment loads through the fluvial process. As seen on the geomorphological map, low elevated denudated hills (DH2) occupy 603,399 square meters (149.1 acres) and high elevated denudated hills (DH1) cover around 565,111 square meters (139.6 acres) of the entire area. The geomorphological units of DH1 and DH2 are indicated as dark and light brown colour polygons on the geomorphological map.

The boundary of the wetland reflects nearly isolated denudated hills which formed into a shape of basin morphology surrounding the wetland. Home gardens and settlements are situated on these hills. They can be easily identified by the brown contour lines where they refer to the entire elevation of each and every geographical location. Although, this geomorphological site seems to be a remarkably similar unit, the north-eastern and south-eastern portions have some high elevated hills compared to the background profile of the wetland. Moreover, the main river of this area flows at the eastern part of Kirala Kele wetland through these denudated hills with the accumulation of more sediment load into the wetland. The middle and western parts of the wetland are dominated by low relief intensity and micro-level denudated hills.

The low elevated areas are filled with alluvium and clay sediments through the runoff on the wetland as an originated process of fluvial action. This area is characterized by light blue colour on the geomorphological map and as for the DEM map it is highlighted as light green and yellow colours, indicating that there is the dispersion of the alluvial plain over the low land areas in the wetland. As shown in the geomorphological map, the entire area was covered with 1,929,623 square meters (476.8 acre) of alluvial plains including the Kirala Kele wetland.

Even though the river is 70 kilometres long, the lower portion of the river bed has a very mild slope and approximately 30 kilometres are below the Mean Sea Level until the outfall in Thotamuna (Nihal, 1996). Due the fact that the upper portion of the watershed has a steep slope and lower portion lies on the mild slope, the flood phenomenon had occurred in the flood plain of the lower watershed of the Nilwala River before the NGFPS is implemented.

Furthermore, the fresh water that flows from the lower parts of the Rakwana hilly area to the sea through the Kirala Kele wetland is highly affected by human activities. (Agricultural, urban and industrial areas). The factors change the deposition

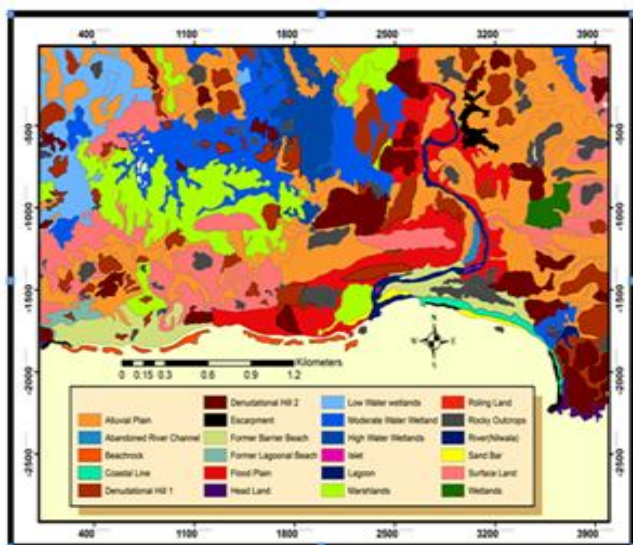


Figure 1.3 – Geomorphological map of the southwest coast of Sri Lanka

Source: Fernando & Weerakkody, 1998

ratio of the wetland and have resulted in a modification to the morphology of the Kirala Kele wetland.

### CONCLUSION

The fluvio- marine process is part of the main denudation processes in the Kirala Kele wetland area. The boundary of the wetland is comprised of isolated denudated hills which are forming into a shape of basin morphology surrounding the wetland. Silt and clay particles accumulated into this submerged wetland by the fluvial and aeolian processes after marine regression in the late Holocene period around 3000 BP, since the surface soils of all the sampling plots consist of clay and silt particles. Thus, the content and the disperse pattern of the geomorphologic units would provide a convenient platform to foster a sustainable plant community of the Kirala Kele potential ecosystem. Useful potential resources with suitable physical environment of Kirala Kele wetland can be developed as an ecotourism destination for the regional development in the southern Sri Lanka.

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