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Risk of seawater intrusion on coastal community of Bentota river basin Sri Lanka

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Abstract

Land degradation in coastal area is one of the major critical problems affecting the future economic development of Sri Lanka. Eighty percent of land in Bentota river basin has been abandoned and 25km distance along the Bentota river has already been affected by the seawater intrusion. Temporal and spatial variation of physicochemical parameters of selected dug wells, all surface water bodies and soil parameters were measured to detect the magnitude of the salinity due to seawater intrusion during August 2016 to March 2017 by using a systematic sampling method. Surface water, groundwater and soil salinity levels were comparatively very high in the river basin with respect to the WHO standards. With reference to the developed GIS salinity risk assessment weighted overlay model the highly saline, moderately saline, slightly saline and non-saline land extent with respect to the total land extent were 10.16%, 19.47%, 40.18% and 29.79% respectively. The highest economic loss was occurred due to the reduction of agricultural productions in the area (2279ha abandoned) and it was about 3,624,000 USD per year. Therefore, 52% from the total population was economically not active with the reduction of agricultural sector in the area. The total annual economic loss in the coastal community was 7,529,698.50 USD per year and it was directly happened due to the seawater intrusion.

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Keywords: coastal community; regional economy; salinity risk; seawater intrusion; water resources

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1. Introduction

Coastal ecosystems are most economically productive and densely populated regions in the world [1, 2, 3]. Fresh groundwater stockpiled in coastal aquifers creates a noteworthy resource for human and the natural setting. Several studies have reported saltwater intrusion in the Asia [4, 5] and along the Indian Ocean coastal states, including areas in India and Sri Lanka [6, 7, 8]. Major economic and environmental consequences of saltwater intrusion into freshwater aquifers and drainage basins include the degradation of natural ecosystems and the contamination of municipal, industrial, and agricultural water supplies [9]. Recent papers have shown the importance of groundwater resources that are under growing pressure in developing regions, but crucial for economic development [10, 11].

However, in Sri Lanka the coastal region encompasses 22% of the country's total land extent, 32% of the country's population, 65% of the urbanized areas, four out of six cities (population >100,000) and two third of all industrial contribution of Sri Lanka [12]. Further, abandoned unproductive land percentage has been increased in the coastal belt of Sri Lanka [7]. The coastal salinity affected area of Sri Lanka has been estimated approximately as 0.112 million ha and electrical conductivity (EC) of the respective soil extraction has been exceeded 4 $mScm^{-1}$ in those areas. In this situation more than 50% of paddy lands in coastal river basins of Sri Lanka have been abandoned and converted into other unproductive enterprises [13].

Bentota river, which is 68km long starts from Hiniduma and enters into the sea from Bentota and its total catchment area is 629 km^2. Most of the major tributaries have been located in the left bank of the river basin and the effect of saltwater is higher in this side than the right bank of the river basin [8, 14]. High tides can always be seen in the first four kilometers of Bentota river and it subsequently rises up to 0.6 to 1m. Highest seawater intrusion can be noticed in February and the salinity effect has resulted 25km along the river from Bentota estuary [14]. However, 80% of the land in the left bank of Bentota river basin has been abandoned due to sea water intrusion and it has also affected agriculture, fishing, tourism and quality of drinking water sources of surrounding areas [8].

Bentota River provides water to cultivate 2862$km^2$of paddy lands where Dedduwa and Rantotawila are the main paddy lands irrigated by it. Both of these paddy lands have been located in the left bank of the river basin. However, the Bentota river basin is below the agricultural production capacity level and there is no sustainable management system for rearrange the land use patterns in the area. Consequently, the requirement of productive land management is an essential practice in nationwide and worldwide with the escalating population and the food demand [15]. In this background this study intends to assess the sea water intrusion risk in the area and the economic impacts for the Bentota Coastal community in Sri Lanka.

2. Methods

The study was conducted in the left bank of Bentota river basin; Bentota division at Ambalangoda irrigation zone (Northern latitudes 60 27' 07.46'' to 60 25'38.49" and Eastern longitudes 800 01'35.04" to 800 08'20.98") of Sri Lanka. The total land extent of the study was 74.5km^2 and the study was conducted for 21km along the river. Population of the area is 52,727 in year 2013 including 13,632 of families. Average mean temperature in Bentota area is about 27.3^oC. The highest temperature of the area has gone up to 35^oC while the lowest is being 20^oC. A heavy rainfall is normally expected during May – September, in SouthWest monsoon period and in the other period cyclonic rain and inter monsoonal rain can be noticed. Mean total monthly rainfall in Bentota river basin is 328mm. Bentota River basin has received the highest total monthly rainfall with effect from SouthWest monsoon during the month of May and with effect of second inter monsoon during the month of October. Mean annual rainfall in the area is 3933mm with range from 3096mm to 4699mm. Bentota division is belonged to wet zone low country; WL1a and WL2a agro ecological zones. Bentota river provides water to cultivate 4200 acres (Gonagala and Pahalagamhaya) of paddy lands in Bentota division situated in the left bank of Bentota river. More paddy lands are cultivated during Maha season from September to February and cultivated paddy lands are submerged by the floods during the Yala season from March to August in most years.

Temporal and spatial variation of six physicochemical parameters such as pH, EC, total dissolve solids (TDS), Cl^-, SO_4^{2-} and NO_3^- of selected dug wells (ground water; GW), all surface water (SW) bodies and soil parameters such as EC, pH, moisture content and color were measured to detect the magnitude of the salinity due to seawater intrusion during August 2016 to March 2017. A systematic sampling method was used to select the ground water