ABSTRACT

Tea sector plays a major role in Sri Lankan economy contributing to 13 % of the export earnings and creating employment opportunities in the country. The impacts of tea production on the environment has increased over the years in Sri Lanka. Therefore, this study was carried out with the objective of identifying the impact of orthodox black tea production on water resources using water footprint assessment method. The study boundary includes cultivation of tea crop and processing stages of fresh tea leave in order to produce orthodox black tea for bulk packing. Two agro-ecological regions; WU_{2a} (3 sampling sites; Dick Oya, Waltrim and Henfold) and WM_{1a} (2 sampling sites; Panilkanda and New Deniyaya) were selected for the study while focusing on both operational and supply chain water footprint. Further, green, blue and grey components of the operational water footprint were considered.

Green water footprint was calculated using effective rainfall obtained from USDA Soil Conservation Service equation of the CROPWAT model. Evapotranspiration values derived from Penmann-Monteith equation were used in the calculation when the effective rainfall is higher than the evapotranspiration. FAO/AGLW formula available in CROPWAT model was also used to calculate the effective rainfall and the results were compared.

Water consumption in boilers and during domestic water uses were taken into account in calculating blue water footprint. Water pollution due to nitrogen fertilizer application and discharge of industrial wastewater from the tea factories were calculated to assess the grey water footprint.

The water footprints calculated for 1 kg of black tea are 20,306 L and 30,203 L for WU_{2a} and WM_{1a} agro-ecological regions, respectively. The operational water footprint contributes to 99 percent to the total water footprint while only 1 percent of contribution is coming from supply chain water footprint. The water footprint from WU_{2a} consists of 19,422 L/kg of green, 602 L/kg of grey and 9 L/kg of blue while WM_{1a} has 29,428 L/kg of green, 525 L/kg of grey and 7 L/kg of blue water footprints.

Rainfall and land productivity are the major influencing factors to the green water footprint of black tea which has 96 percent of contribution to the total water footprint. WM1a agro-ecological region has resulted a high value of water footprint due to high quantity of rainfall received during 2016 and low land productivity of Panilkanda. Since, rainfall cannot be controlled, the green water footprint could be reduced by improving land productivity of the estates. It was also found that the green water footprint is highly sensitive to the methodology adopted in calculating the effective rainfall. The analysis of green water footprint using FAO/AGLW method was lower than the values obtained from USDA method. Therefore, the selection of the best appropriate method should be carried out in a careful manner.

Grey water footprint is the second highest contributor to the total water footprint of black tea emphasizing that black tea production has impacts on water pollution during both cultivation and fresh tea leave processing stages. Runoff from chemicals (fertilizer, weedicides and pesticides) which are used during cultivation stage and wastewater from tea leave processing stage have accounted to the grey water footprint. Incorporating proper crop and land management practices, application of TRI recommended quantities

of chemicals during cultivation stage together with soil sample measurement and treatment of wastewater generated from tea leave processing could reduce the pollutant component of the water footprint.

Blue water footprint has the least contribution to the total water footprint. The water consumption in boiler and overhead water consumption were considered in the study. Improving the water distribution efficiency and attitudes of employees towards water conservation could further reduce the blue water footprint of black tea. Further, supply chain water footprint accounts for 1 percent (258 L/kg) of the total water footprint which is almost negligible.

Freshwater eutrophication and freshwater eco toxicity are the major impact categories of black tea production through its life cycle assessment. The use of fertilizer, pesticides and weedicides during crop cultivation stage has caused impacts on freshwater. Further, black tea production has a low impact on climate change and this is due to the exclusion of transport aspect in life cycle assessment. The freshwater impact categories were analyzed using global scale databases in ReCiPe method and as a result, the values of impact categories do not represent the local geographical scenarios.

The tea industry of Sri Lanka is having a high potential to improve its yield while reducing impacts to the water resources through proper management of tea crop, input chemicals and wastewater discharged.