# ABSTRACT

Global energy demand continues to increase owing to advancements in key growth sectors of economies. Uganda's energy resources comprise: - biomass accounting for over 90% of the country's energy consumption, hydro for electricity generation, and fossil fuels. Renewable energy resources are largely undeveloped. Reliance on imported petroleum products for use in Uganda's transport sector significantly contributes to the depletion of the nation's meagre foreign exchange earnings and poses a significant risk to the nation's energy security. About 23% of total energy-related $CO_2$ emissions are attributed to the global transport sector, which relies mainly on fossil fuels. In order to comply with the requirements of the 2015 Paris Climate Agreement that was ratified by nations, Uganda inclusive, interventions to reverse this trend are of paramount importance. Biofuels (biodiesel and ethanol) are renewable transportation fuels that have attracted global interest as they have the potential to substitute petroleum fuel. Uganda's biofuels bill enacted into law in 2018 advocated for mandatory blending of fossil fuels with up to 10% of biofuels. This study evaluated the techno-economic viability of biodiesel production from second-generation feedstocks that included Castor (*Ricinus Communis*), Croton (*Croton Megalocarpus*), and Jatropha. Physicochemical characterizations were carried out on oil, B100 blend stocks, and B10 derived from these feedstocks, following ASTM D6751 standards. ASPEN Plus V11 was used in process simulation and profitability analysis. The Low Emissions Analysis Platform (LEAP) software was used to forecast energy demand and emissions due to B10 use. A cradle-to-gate life cycle assessment (LCA) was conducted following ISO 14040 and Umberto LCA modelling software. This study confirmed the compliance with ASTM D6751 quality standards for B100 (blend stocks) and B10 blends derived from the three feedstocks. About 100 million litres of B100 are required annually for B10 blending, corresponding to a feedstocks cultivation area of only 50,000 ha versus 6,900,000 ha of arable land in Uganda. B10 use in place of fossil diesel in diesel-powered vehicles can mitigate about 8.38% of $CO_2$ emissions with minimal impact on final energy demand. The assessment further established that B10 is environmentally more competitive than petroleum-diesel from a life cycle perspective. Reductions in global warming and human toxicity potentials of up to 7% for B10 biodiesel blends relative to imported petroleum diesel were obtained. Similar reductions were obtained for the other assessed mid-point impact categories. Though relatively very low in absolute terms, this reduction rate is in sync with the target annual reductions of 7.6% and 2.7% required to meet the Paris Agreement temperature targets of 1.5 $^{o}$C and 2 $^{o}$C, respectively. However, negative Net Present Values were obtained, rendering B100 and B10 uneconomical to produce. Sensitivity analyses showed that increased feedstock costs resulted in reduced NPV and vice versa for reduced feedstock costs or higher biodiesel selling prices. Therefore, this techno-economic assessment confirmed that it is technically and environmentally viable to produce biodiesel blend stocks for B10 from castor, croton, and Jatropha. The promotion of e-mobility to decarbonize Uganda's transport sector could be complemented by B10 use mainly in the existing diesel fleet. Interventions will, however, be needed to lower feedstock costs and guarantee competitive biodiesel selling prices for the economic viability of a B10 policy based on these locally available second-generation biodiesel feedstocks. The approach for evaluating the feasibility of technology and energy projects that considers technical, economic, and environmental outcomes, among other key aspects, should be promoted.



***Keywords:*** *Biodiesel; Life cycle assessment; Second-generation feedstocks; Techno-economic assessment; Transesterification; Umberto; Energy demand; Emissions; LEAP*