The movement for use of biodiesel as a fuel in India is gaining momentum. India is an agro-climatically diverse country and has 400+ varieties of oil seeds in surplus quantities, which can be used to produce biodiesel. In this study, investigations were conducted for using of Karanja biodiesel in modern transportation EURO-IV compliant CRDI SUV diesel engine, where the peak fuel injection pressure could be as high as 1600 bar. In this study, macroscopic and microscopic fuel spray characterization was carried out in a constant volume spray chamber to understand spray evolution of biodiesel blends. Engine combustion, pressure rise rate, heat release rate, mass burn fraction, regulated as well as unregulated pollutant formation in the combustion chamber was investigated comprehensively for two the Karanja biodiesel blends (KB20 and KB40) with respect to baseline mineral diesel. This study also included engine performance mapping using biodiesel blends for engine-out emissions, power output and torque characteristics, specific fuel consumption and lubricating oil degradation with usage. 13- Mode emission test was conducted using European Stationary Cycle (ESC) for comparing mass emission of pollutants from biodiesel blends and baseline mineral diesel. After the completion of performance, combustion and emission investigations, effect of biodiesel blends on long-term material compatibility of biodiesel with different materials used in the engine was investigated, specially on iron and copper containing components. For this, a long-term endurance test in two phases spanning over 274 hours on mineral diesel and biodiesel (KB20) was carried out. The engine was fully disassembled after completion of each phase and carbon deposits on the critical engine components and their wear were recorded for comparison. Lubricating oil samples were drawn from the oil sump after a regular interval in each phase of durability test and results were critically examined for various parameters to determine the impact of biodiesel on lubricating oil's health and residual useful life. In summary, biodiesel blend (B20) could be used in a CRDI engine without any significant engine performance, emission, combustion, durability and lubricating oil degradation issues, however ECU calibration is essential for optimum engine performance and emission, the engine is fuelled with biodiesel and its blends.