Bioenergy suitability modelling with geographical information system based fuzzy multi criteria analysis: A case study of Turkiye

It is now indisputable that human activity is causing global warming and replacing fossil fuels with renewable energy sources is essential to guaranteeing long-term, sustainable economic growth. Turkiye is one of the highly growing developing economies in the World which generates a large portion of its electricity and heating from fossil fuels. Turkiye's greenhouse gas (GHG) emissions per capita are below G20 average but are continuously increasing due to the use of fossil fuels, which generate over 85% of all power. Approximately 30% of Turkiye's energy came from oil, 30% from coal, and 25% from gas in 2019. Turkiye has higher than average greenhouse gas emissions and air pollution as a result of using fossil fuels. According to the Organization for Economic Co-operation and Development, Turkiye has the fastest-growing energy demand, with its total energy consumption more than doubling between 2001 and 2021. Turkiye's growing GDP and population were the main drivers of this trend, which is expected to continue in the coming decades. Based on 2022 levels, official government data predict that the nation's electricity demand will increase by an additional 55% by 2050. In line with this increasing energy demand, Turkiye imports three-quarters of its energy, including nearly all of its oil and gas needs and half of its coal, and its energy policy places a high priority on lowering imports.

In this regard, major national legal decisions seek to increase the proportion of renewable energy sources. According to a report by the Anatolian Agency, which cited the Ministry's of Energy and Natural Resources 2025 budget plan, Turkiye wants to increase the proportion of renewable energy in its electricity generation to 47.8% by 2025. Bioenergy is a form of renewable energy that is obtained from organic waste sources known as biomass, which can be used to produce transportation fuels, heat, electricity and products. Biomass is one of the most promising renewable energy sources because of its consistent supply and well-known energy conversion technologies. Numerous scholars have estimated and evaluated the bioenergy potential from biomass resources for different countries across the globe including Pakistan (Naqvi et al., 2018), India (Hiloidhari et al., 2014), Switzerland (Steubing et al., 2010), Northern European countries (Stolarski et al., 2020), Japan (Wu et al., 2020), China (Sang and Zhu, 2011) and Italy (Scarlat et al., 2013). Other studies focus on global bioenergy potential estimation (Offermann et al., 2011; Deng et al., 2015; Searle and Malins, 2015; Errera et al., 2023).

Finding appropriate sites for biomass energy set up can be challenging because social, economic, and environmental considerations must be taken into account. Numerous techniques have been employed to ascertain the best placement for either a single central plant or several decentralized plants. The most often used methods are GIS, multicriteria analysis, and mathematical programming (Zhang et al., 2011). The purpose of this study is to illustrate the usefulness of an Multi Criteria Decision Making (MCDM) methodology in a GIS processing environment that determines appropriate facility sites in Turkiye. The study integrates a type of MCDM called the Analytical Hierarchy Process (AHP), relying upon fuzzy logic and open-source GIS. The analysis aims at finding possible locations for biomass energy plants in Turkiye's regions that have available land and the necessary infrastructure, using local sustainability restrictions and criteria. Furthermore, the location's suitability and plant capacity may be significantly impacted by the high-resolution evaluation of sustainably accessible biomass. A significant amount of the Turkish bioelectricity targets and requirements could be met by the electricity produced by the prospective biomass energy plants. In order to maximize public benefit and private investment, the model might also be applied to regional and local-scale assessments that take into account government policies and biomass incentive schemes.