

# ABSTRACT

## **Background / Purpose**

Agriculture provides the major source of livelihood and contributes to the economy for most of the developing nations. As an agrarian economy, India relies on agricultural production to meet the food demand for the rapidly growing population that puts considerable pressure on resource availability. In India, paddy is one of the principal staple food crops which utilizes heavy resources for production. Hence, efficient consumption of agricultural resources is crucial to minimize the corresponding depletion.

## **Methodology / Research Design**

In order to assess farm efficiency, the Data Envelopment Analysis (DEA) approach has been used in this research. Agricultural production often generates imprecise data. To overcome impreciseness, the collected data has been represented in fuzzy sets, employing a Fuzzy DEA (FDEA) approach. In recent years, the focus to augment Greenhouse Gas (GHG) emissions in the agricultural production efficiency measurements has been emphasized across the world. This research, therefore, includes an eco-efficiency measurement approach to consider the GHG emissions as undesirable output in the DEA framework. These respective farm efficiency measurements are also influenced by crucial exogenous factors. Commonly, a two-stage approach is followed using DEA and regression analysis to show the role of associated factors. This research proposes an alternative approach that focuses on the prediction of the most salient factors by combining the efficiency measurement with Machine Learning (ML) algorithms. The research was carried out on the paddy cultivators in the sub-Himalayan region of Eastern India.

## **Findings / Policy implications**

The findings suggested wide variation in the efficiency of farmers with space to recommend better resource use management. The FDEA approach measured efficiency at different possibility levels and the results indicated better farm efficiency evaluation. The results of the eco-efficiency estimation considering undesirable output showed lower environmental performances of the paddy farmers. The ML application predicted the farmers with land ownership, access to short-term funds, higher education, and years of farm experience to be more efficient. This research may help policy formulations to promote short-term funds availability for timely purchase of inputs, agricultural extensions programs for improved technological adoption, and farmer-to-farmer knowledge-sharing platforms to share the experience of efficient farmers with the inefficient ones, minimizing the over-utilization of resources.

**Keywords:** *Resource Efficiency; Data Envelopment Analysis (DEA); Fuzzy DEA; GHG emissions; Eco-efficiency; Machine Learning (ML); Eastern India*

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