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Predicting future food loss and waste patterns under changing socio-economic conditions

Francesco Semeria[1,2], Giacomo Falchetta[2,3], Adriano Vinca[2], Francesco Laio[1], Luca Ridolfi[1], and Marta Tuninetti[1]

[1]Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Torino, Italy
[2]IIASA - International Institute for Applied Systems Analysis, Laxenburg, Austria
[3]Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) and RFF-CMCC EIEE, Venice, Italy

Food loss and waste (FLW) represent a critical challenge to global sustainability, with significant implications for food security and environmental conservation. As about one third of the food that is produced is lost or wasted along the value chain, water, land and energy resources employed in its many stages (e.g., production, transformation, storage) are wasted together with it. Despite extensive research on this topic, a significant gap remains in understanding how FLW will evolve in the future, particularly under the influence of key drivers such as economic development, urbanization, and access to electricity. Changes in FLW patterns have far-reaching consequences for the Water-Energy-Food Nexus, particularly in regions where local resources are already under stress. Current projections frequently employ static assumptions or simplified scenarios, overlooking the dynamic socio-economic trends that have the potential to reshape FLW profiles of countries. This limitation is especially relevant in rapidly developing regions like Sub-Saharan Africa, where present per capita FLW levels are relatively low compared to high-income regions. However, rapid socio-economic transformations in these regions have the potential to drastically alter this scenario in the near future, thereby deviating from current estimates.

In order to address these challenges, a random forest algorithm was employed, leveraging data from the FAO *Food Loss and Waste Database*. The integration of these data with socio-economic predictors such as GDP, urbanisation rates, and technological adoption has enabled the development of a predictive framework capable of estimating future FLW shares at the country level. The analysis reveals diverse trajectories in FLW evolution across regions. While technological advancements and increased mechanisation in agriculture and food processing may reduce supply-side losses in rapidly developing economies, there is likely to be a reciprocal increase in consumption-side waste, which could potentially offset gains achieved through technological improvements and amplify pressures on critical resources such as water, land, and energy. These findings emphasise the urgent need for the design and implementation of sustainable transformation pathways to reduce FLW generation in agri-food systems in present and future conditions, while also addressing the existing trade-offs between FLW reduction and energy security.