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Agricultural-Industrial Symbiosis and Energy-Water-Food Nexus: Decision-Making for Sustainability Transition

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Short Communication

Over the last few decades, attentions in the industrialized countries have focused on sustainable agriculture and the promotion of renewable energy development. Bioenergy, i.e. bioethanol, biodiesel, and biogas, which plays an important role in climate change mitigation and energy security enhancement, has attracted more and more attentions recently [1]. Energy, water and food are inextricably linked and interacted through bioenergy which is a bridge between agricultural system and industrial system. Consequently, the agricultural-industrialcomplex, so-called "agricultural-industrial symbiosis", can be formed. Water is an input for producing agricultural products along the whole agro-food supply chain and for energy production (e.g. cooling and other operations), there is a large amount of water consumption in the whole life cycle of agricultural goods (i.e. crops and biomass) and energy products (i.e. electricity and heat). Energy is also prerequisite for supply power to produce and distribute water and food: to pump water from groundwater or surface water sources, to power tractors and irrigation machinery, and to process and transport agricultural goods [2]. Similarly, food-system-involved materials/goods, i.e.crops, biomass, crop residues, kitchen waste, and manure produced in agricultural system can be used to produce energy (i.e. biofuels and electricity) for enhancing energy security and distributing water and food [3]. The concepts of "energy security", "water security", and "food security" should be considered simultaneously when designing the agricultural-industrial system in the early design stage. Therefore, measuring energy-water-food nexus is beneficial to understand well the interdependences and interactions among these three issues.

There are usually various scenarios for agricultural-industrial symbiosis in the early design stage, and they perform different with respect to energy security, water security and food security. Energy security, water security and food security are usually three conflict issues, and the decision-makers/stakeholders usually have to make compromise decisions when selecting the best or the most suitable scenario or optimizing these three objectives simultaneously. Accordingly, Multi-Criteria Decision Making (MCDM) and Multi-Objective Optimization (MOO) can be employed to address this. In addition, uncertainties existed agricultural-industrial symbiosis including the lack of knowledge and the variations of data due to the external systems [4] are the most severe problems in MCDM and MOO. Fuzzy set theory and interval theory are suggested to solve the MCDM and MOO problems with uncertainties. All in all, the improved MCDM and MOO methods with fuzzy set theory and interval theory should be developed for selecting the best or the most suitable scenario or optimizing the agricultural-industrial symbiosis in future for achieving smart agricultural-industrial complex.

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