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Resource allocation trade-offs in smallholder cropping systems using multi-objective optimisation

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Abstract

Decision-making in typical smallholder farms is usually comprised of multiple objectives that need to be put under consideration. These objectives are sometimes in conflict with each other. Farmers therefore aim to efficiently utilise farm resources to attain satisfaction from all its objectives. However, the problem lies in allocating the limited resources to farm operations. Admittedly, resource use varies in different cropping systems. Due to the existence of several objectives, Multiple Criteria Decision Making models are used to solve trade-off problems consisting of multiple objectives. This study applies a compromise programming model to analyse the conflicts between the economic, social and nutritional objectives of a typical resource-poor farm in eastern Uganda and develop the optimal cropping plan for the farm's cropping systems. Compromise solutions were generated following four analytical procedures, that is, individual objective optimisation to identify the ideal solution, constrained optimisation to generate a set of efficient solutions, deviations between the objective values and their ideal points were obtained and a distance measure was introduced to identify the best compromise solution. Results demonstrate how relationships between farm components and cropping systems influence farm labour demands, income and nutrition. Different trade-offs occur between the farm's objectives in the cropping systems modelled. The results show that farm income reduces as farm labour in terms of hours reduces. Additionally cropping plans that promoted better nutrition included the cultivation of crop mixtures, that is, maize and beans intercrop. On the other hand, a higher income was realised when the model allocated a larger acreage to coffee production. Furthermore, findings reveal that competition exists between allocating the farm's labour resources to produce different crops. The efficient solutions generated by the procedure provide an understanding of the trade-offs existing between conflicting farm objectives. Therefore, the model helps to assess the potential for the adjustment of other crops in achievement of objectives. Policy suggestions could focus on sustainable intensification strategies such as polycultures, to utilise available farm resources.

Keywords: Compromise solution, constrained optimisation, decision-making, efficient solutions, multiple criteria decision making, polyculture, Uganda