IOWA STATE UNIVERSITY

Natural Resource Ecology and Management[1], Agricultural & Biosystems Engineering[2], Horticulture[3]

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Iowa UrbanFEWS
Food-Energy-Water Systems Integration

Climate-Smart Vegetable Production: The Environmental Attributes of Vegetables Produced in Conventional, Local, and Home Garden Food Systems in the Midwest US

Background

- A 45% reduction in carbon (C) emissions is needed over the next 10 years to limit global temperature increase to < 1.5°C [1]
- Food systems cause ~26% of global C emissions [2]
- More than 50% of the world population is urban [3]
- Urban consumers make up 67% of farm food sales [4]
- Food in the US food travels ~6,760 km through the food cycle [5]

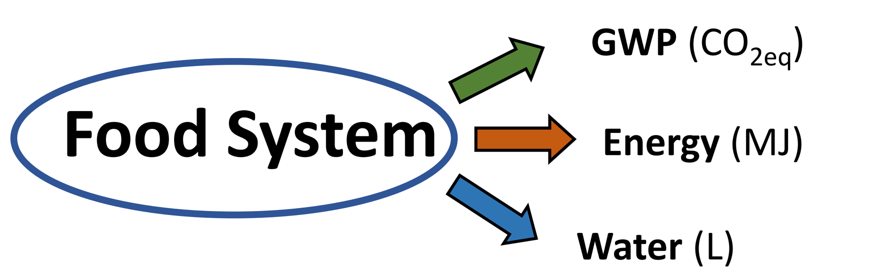

Figure 1. LCA food system outputs for Global Warming Potential (GWP) in CO_2 equivalents, energy use in megajoules and water in liters, accounted for throughout the food system cycle.

Objectives

Des Moines, Iowa, USA food system used to represent the rain-fed Midwest:

- Food system LCA for conventional vegetables (large scale production) developed and compared to two alternatives: A local commercial system (medium scale), and a home garden system (small scale)
- A set of 18 vegetables grown and sold commercially in Iowa selected and used to develop comprehensive analyses of greenhouse gas emissions, energy consumption, and water use for each of the three food systems
- Vegetables compared to determine climate-smart production and consumption across scales

LCA Assumptions

Table 1. Vegetables selected based on commercial production in Iowa [6] and relative importance in typical US diets [7]. CleanMetrics models were adjusted for regional and scale differences in pesticide, fuel, water, and electricity for water pumping usage based on assumptions from i) A horticulture extension specialist (pesticide, fuel) ii) USDA state agricultural census data (water, electricity). Transportation estimates for the large-scale scenario are all based on the US state/county with highest production for each vegetable listed below.

Vegetable	Large-Scale Production Location
Beans, snap	Miami-Dade, Florida
Broccoli	Monterey, California
Cabbage, head	Santa Barbara, California
Carrots	Santa Barbara, California
Cauliflower	Santa Barbara, California
Corn, Sweet	Contra Costa, California
Cucumbers	Miami-Dade, Florida
Lettuce, head	Monterey, California
Lettuce, leaf	Monterey, California
Lettuce, romaine	Monterey, California
Onion, dry	Santa Barbara, California
Peas	Renville, Minnesota
Peppers, bell	San Benito, California
Potatoes	Bingham, Idaho
Pumpkin	Santa Barbara, California
Spinach	Santa Barbara, California
Squash	Santa Barbara, California
Tomato	Colusa, California

Food System Overview

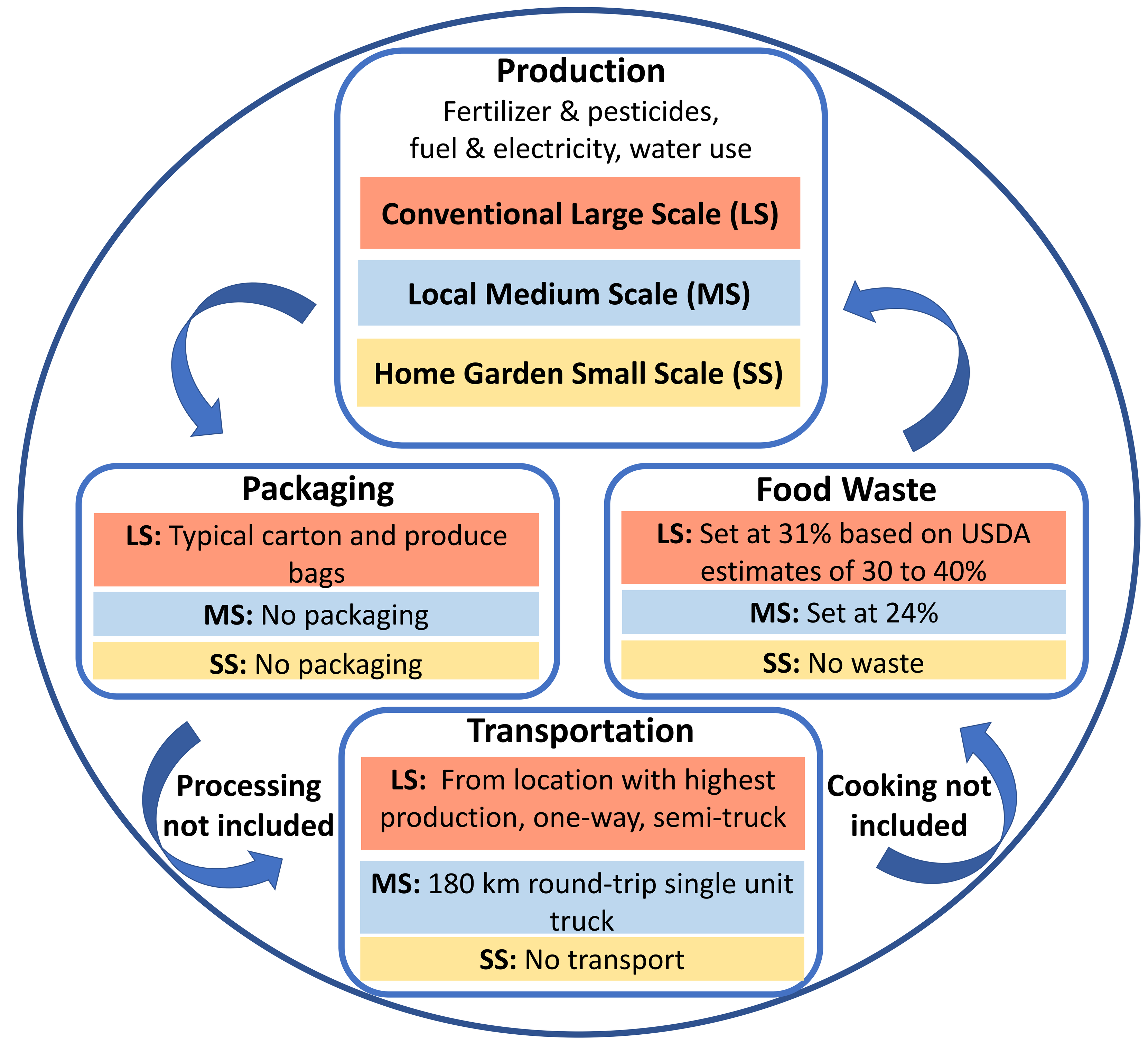

Figure 2. System boundaries for LCA of 18 fresh market vegetables at three food system scales: Large scale (**LS**, conventional), medium scale (**MS**, local commercial), and small scale (**SS**, home garden) . The system boundary is cradle to grave excluding processing and cooking steps not relevant for many fresh vegetables.

GWP by Food System Component

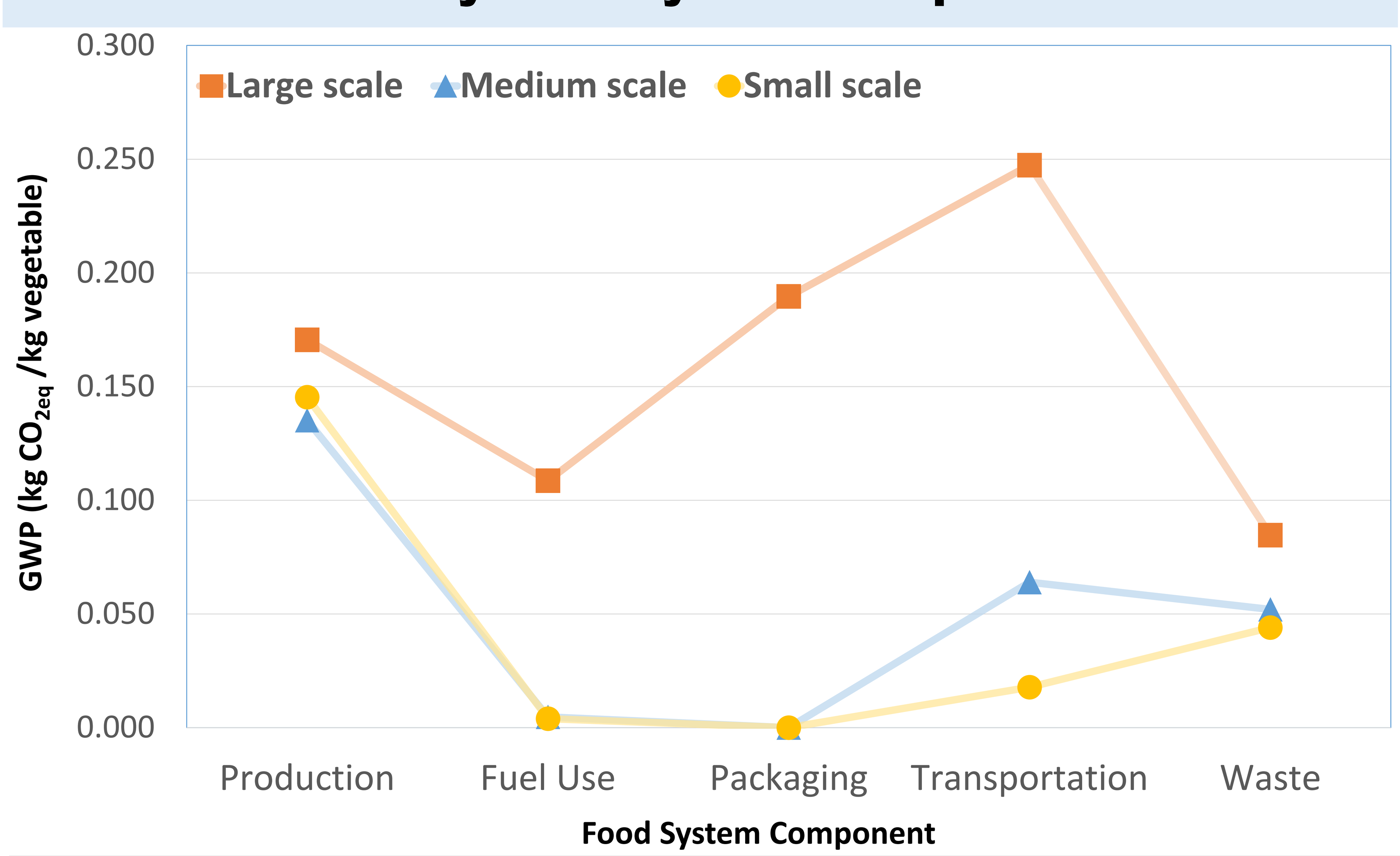

Figure 3. GWP for production was relatively consistent across food system scale scenarios, varying more significantly by vegetable type. GWP for all other system components decrease as scale decreases.

GWP by Food System Scenario and Vegetable Type

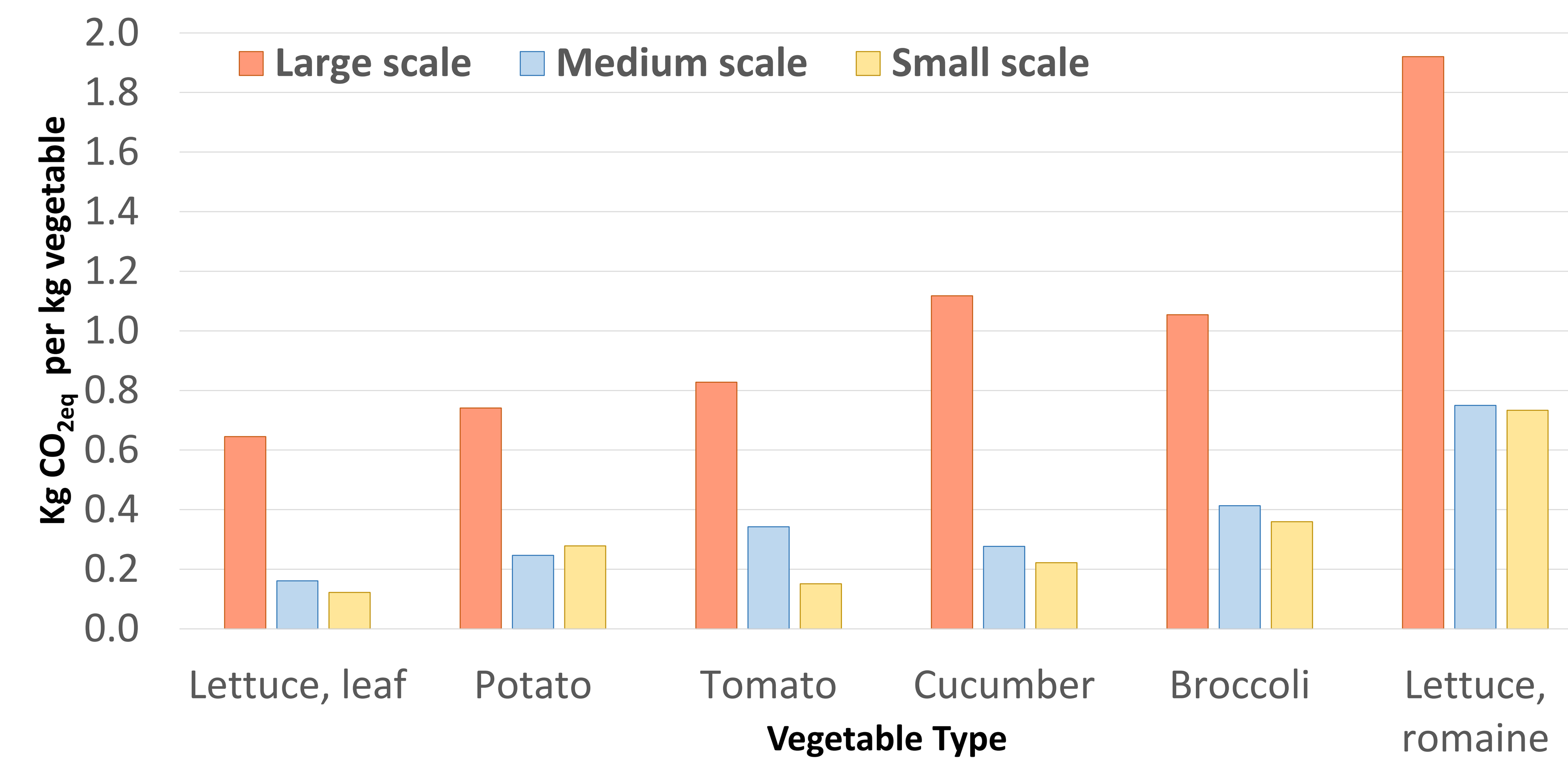

Figure 4. Vegetables used as examples here are listed by food system scenario according to the total GWP per kg of fresh vegetable, from least to greatest carbon equivalents per kg of each vegetable.

GWP, Energy and Water Use by Food System Scale

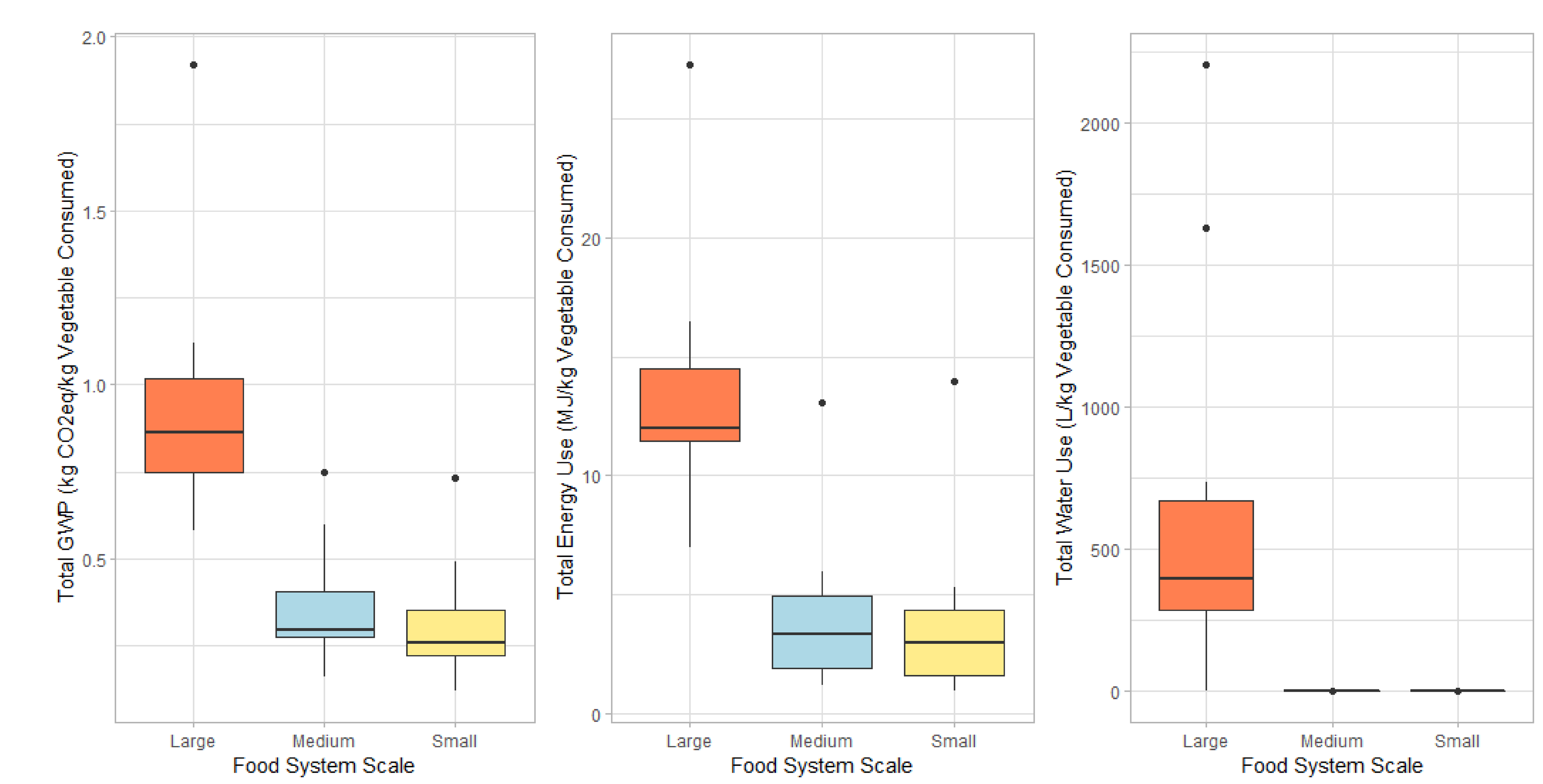

Figure 5. The LS scenario produced greater GWP and used more energy and water than the MS or SS food system scenarios. The SS scenario was lower on average than the MS scenario, though the results varied by vegetable type. Variation across vegetable types are shown using boxes for 50% of values and whiskers to represent the maximum and minimum (excluding outliers).

Preliminary Conclusions

- The large-scale vegetable production scenario produced the greatest GWP, energy and water use across all food system components and vegetable types analyzed.
- Future research will include an LCA of the entire Des Moines food system comparing large-scale and medium-scale local scenarios across food types through Iowa State University's Iowa UrbanFEWS research project [8].

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Sources: [1] IPCC, 2018; [2] Poore & Nemecek, 2018; [3] Kulak, Graves & Chatterton, 2013; Knight & Riggs, 2010; [4] Dimitri et al., 2019; [5] Weber and Matthews, 2008; [6] USDA Census of Agriculture State, 2017; [7] USDA Loss- Adjusted Food Availability, USDA Economic Research Service, 2016; [8] http://urbanfews.cber.iastate.edu

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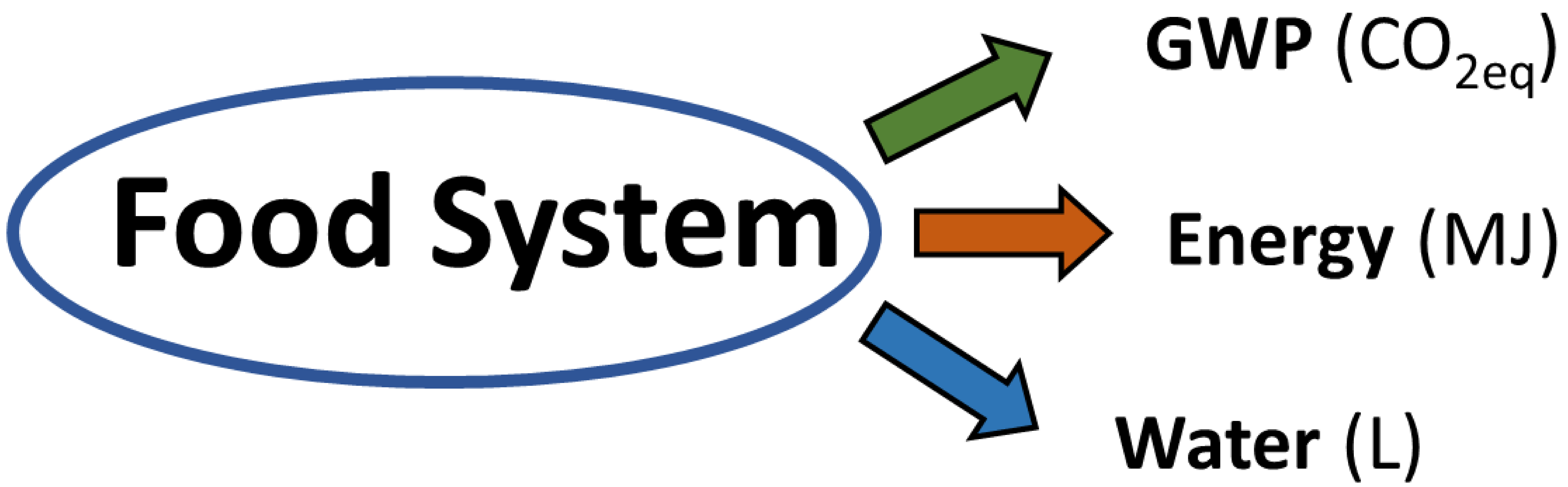

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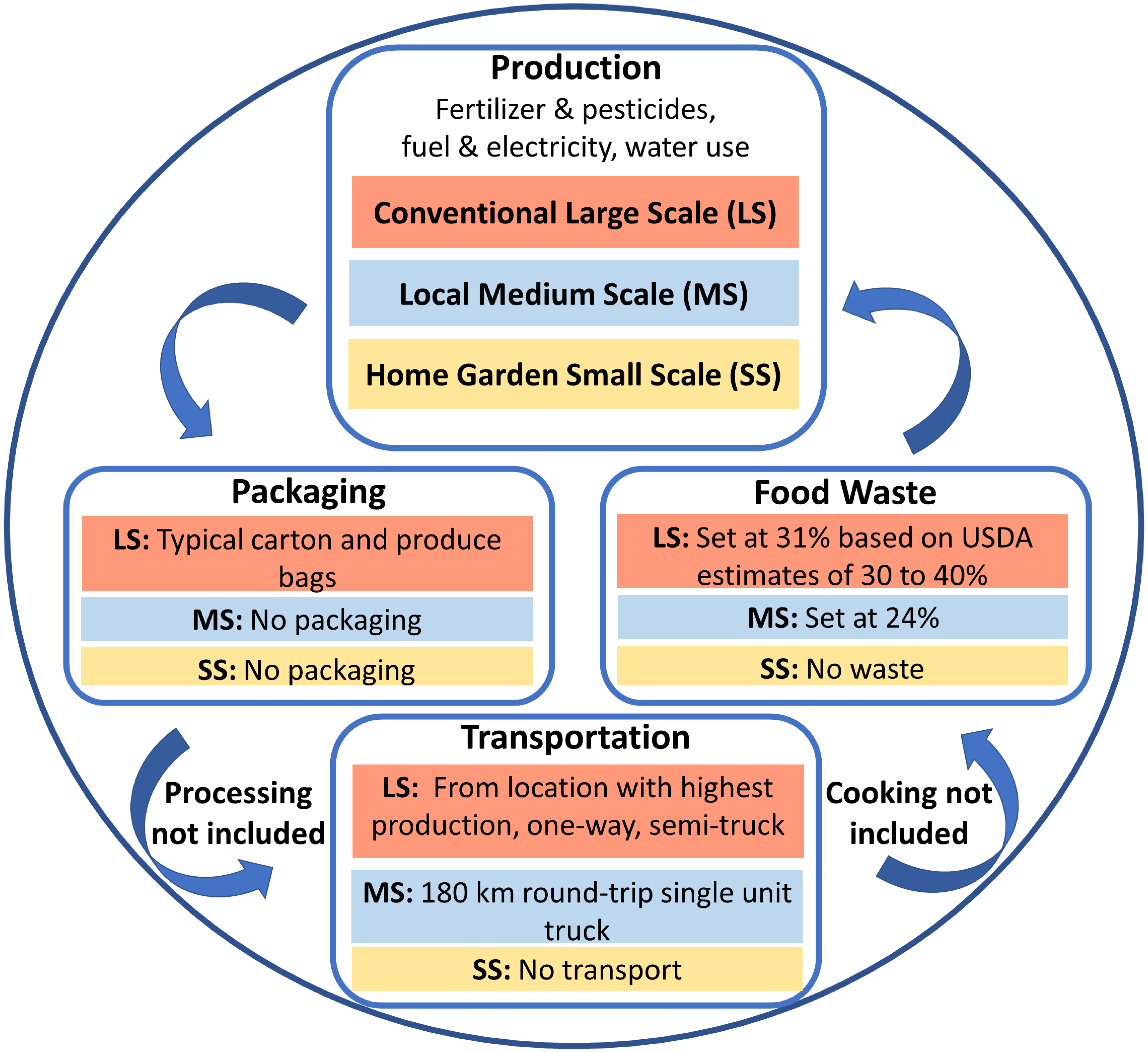
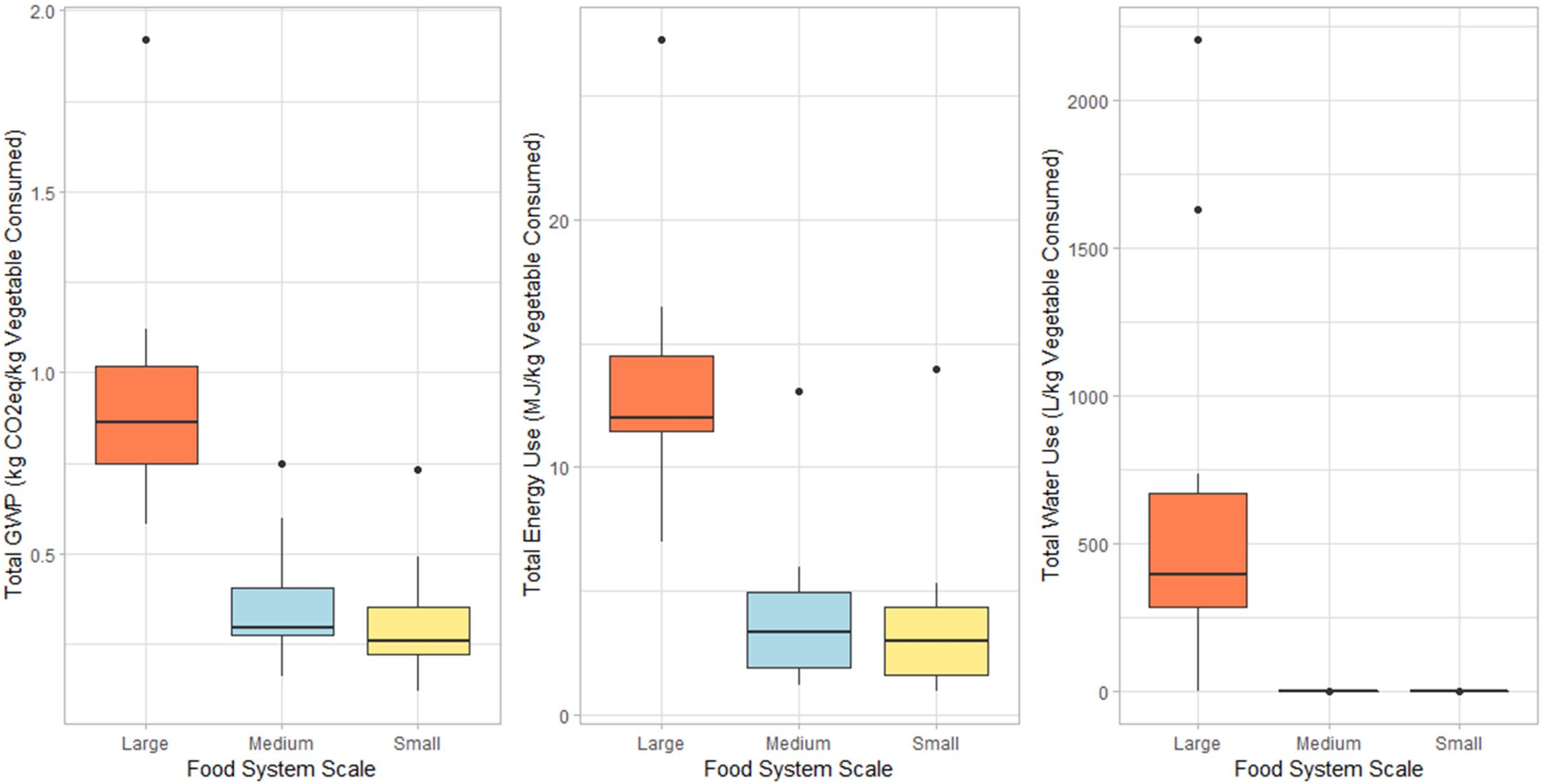


Results



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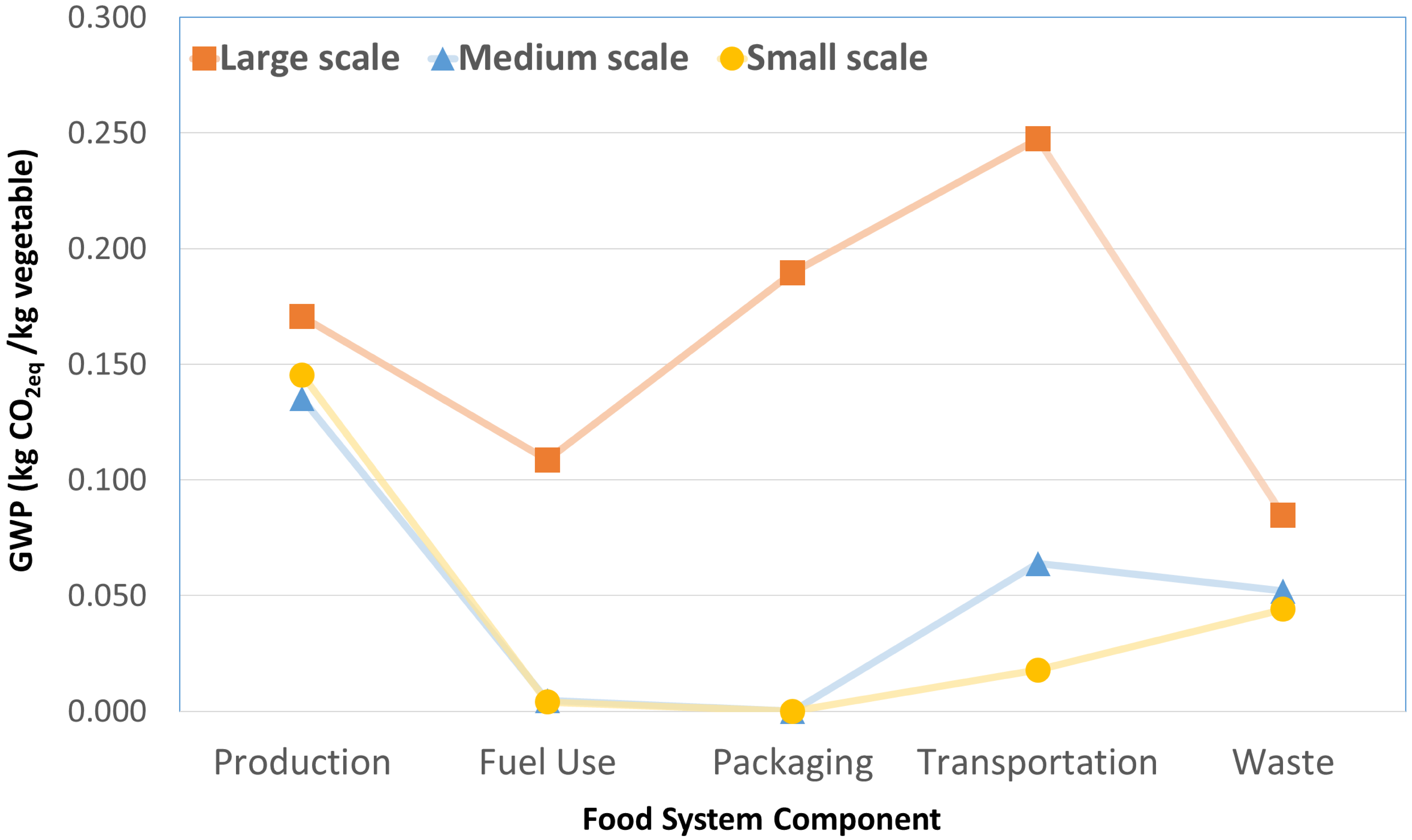
Results & Conclusions



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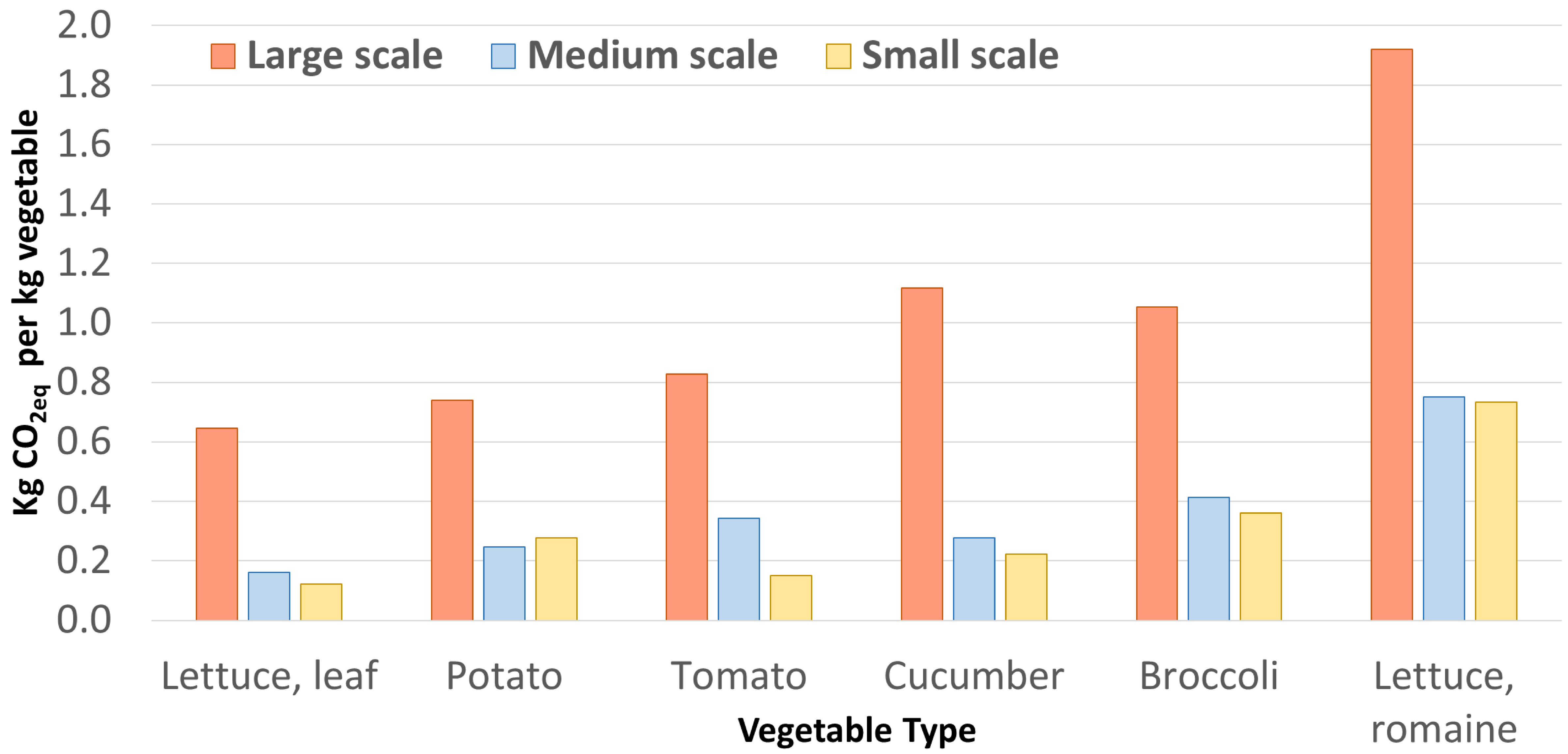

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