Building Value Across the Carinata Supply Chain

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SPARC Leadership Team

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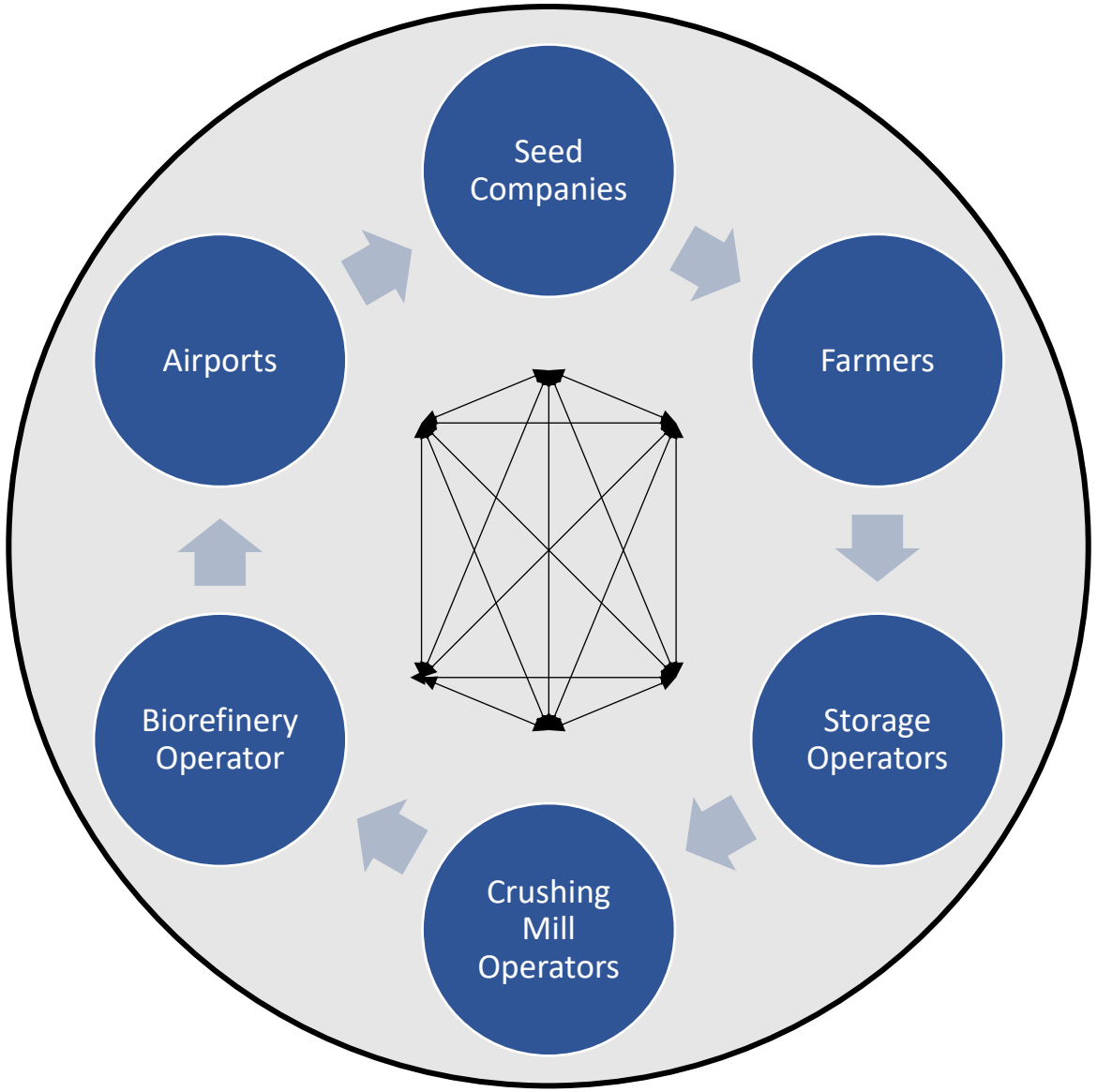
USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

What is a Supply Chain?

Per Investopedia, a supply chain is a network between a company and its suppliers to produce and distribute a specific product to the final buyer.

Carinata Supply Chain



What is a Value Chain?


Perhaps the first thing to understand is that the value chain really covers a broader scope of business activity than the supply chain, but the supply chain is of central importance to a successful value chain.
Supply Chain Secrets

Site Suitability Analysis

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Modeling site suitability and production potential of carinata-based sustainable jet fuel in the southeastern United States

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ABSTRACT

The aviation sector is currently responsible for 2.6% of global carbon emissions. Carbon emissions of the aviation sector are expected to increase by 3–4% each year due to the rising demand for air travel. The use of bio-jet fuel derived from carinata (*Brassica carinata*) is a potential solution for mitigating carbon emissions from the aviation sector. This study determines suitable sites for growing carinata across three southeastern states of Georgia, Alabama, and Florida. Suitable edaphic (average soil storage, soil organic carbon, root zone depth) and climatic variables (temperature) along with historical land use trajectories were used for determining the land suitability for carinata production. The weights of the edaphic variables were decided by surveying experts using the Analytical Hierarchy Process. This study also determined the susceptibility of frost events in growing season of carinata from 2010 to 2017. Finally, the composite risk was calculated by multiplying the probability of potential damage risk and probability of land risk. Considering minimum risk level of 5%, about 45.56% (0.77 million ha) of land in Georgia, 0.81% (0.01 million ha) land in Alabama and about 3.04% (0.05 million ha) of land in Florida is suitable for growing carinata. Depending upon the composite risk level and expected carinata yields, the total production potential of carinata was between 1.87 and 3.91 million metric tons which was sufficient for producing between 980 and 2045 million liters of bio-jet fuel sufficient enough to replace 1.4%–2.33% of the current jet fuel consumption in the United States. Our study will feed into current policy debate about reducing carbon footprint of the aviation sector in the United States and promote development of bio-economy for rural America.

Up to 2.33% of conventional aviation fuel could be replaced nationwide.

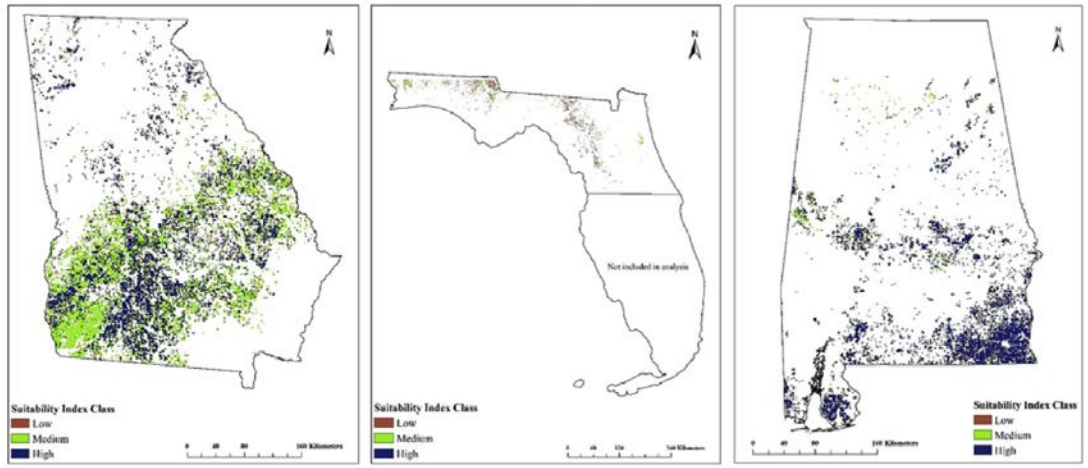

Fig. 5. Spatial distribution of land suitability categories for carinata production in Georgia, Florida, and Alabama. The reported suitability maps are based on edaphic conditions only without accounting for weather and land use history.

Techno-Economic Analysis

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ORIGINAL RESEARCH

Break-even price and carbon emissions of carinata-based sustainable aviation fuel production in the Southeastern United States

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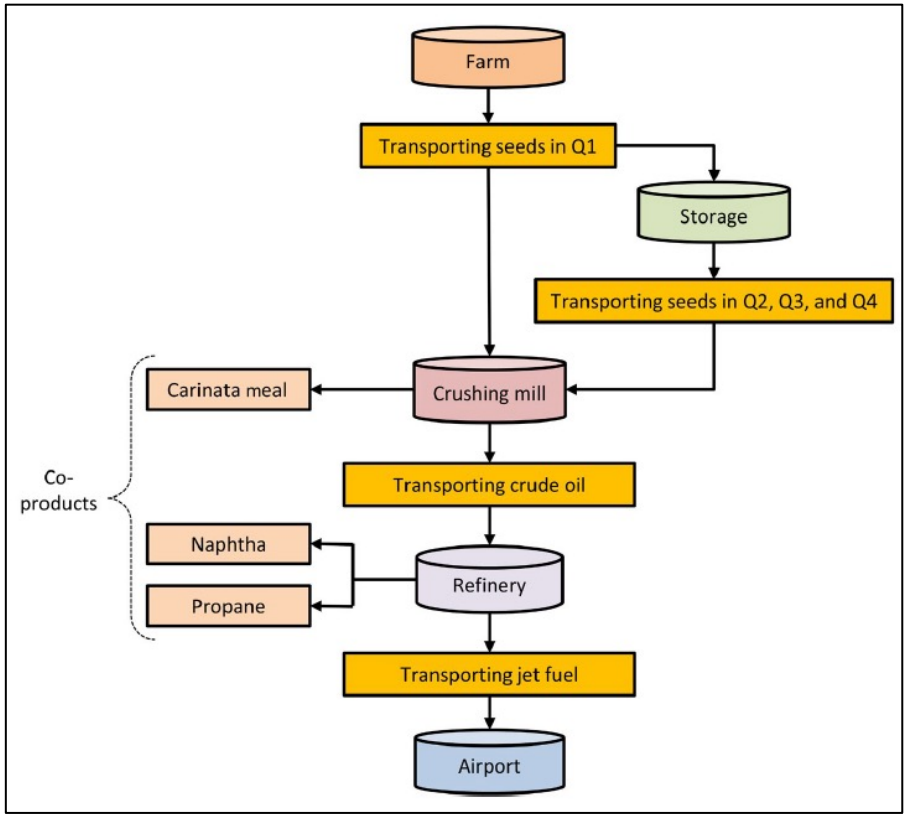
Abstract

The production of biomass-based sustainable aviation fuel (SAF) is gaining traction to reduce the carbon footprint of the aviation sector. We performed a techno-economic analysis to estimate the break-even price and life cycle carbon emissions of the SAF derived from carinata (*Brassica carinata*) in the Southeastern United States. Carinata has the potential as a feedstock for SAF production in the selected region due to higher yield, low fertilizer use, co-product generation (animal feed, propane, and naphtha), and compatibility with current farming practices. The system boundary started at the farm and ended when the SAF is delivered to an airport. Without co-product credit or other subsidies such as Renewable Identification Number (RIN) credit, carinata-based SAF was more expensive (\$0.85 L^{-1} to \$1.28 L^{-1}) than conventional aviation fuel (\$0.50 L^{-1}). With co-product credit only, the break-even price ranged from \$0.34 L^{-1} to \$0.89 L^{-1}. With both co-product and RIN credits, the price ranged from -\$0.12 to -\$0.66 L^{-1}. The total carbon emission was 918.67 g CO_2e L^{-1} of carinata-based SAF. This estimate provides 65% relative carbon savings compared with conventional aviation fuel (2618 g CO_2e L^{-1}). Sensitivity analysis suggested a 95% probability that relative carbon savings can range from 61% to 68%. Our study indicates that carinata-based aviation fuel could significantly reduce carbon emissions of the aviation sector. However, current policy support mechanisms should be continued to support manufacturing and distribution in the Southeastern United States.

KEYWORDS

agriculture, aviation, bioenergy, economic analysis, life cycle assessment, sustainability

Relative carbon savings can range from 61% to 68% at a competitive prices with governmental and market incentives.



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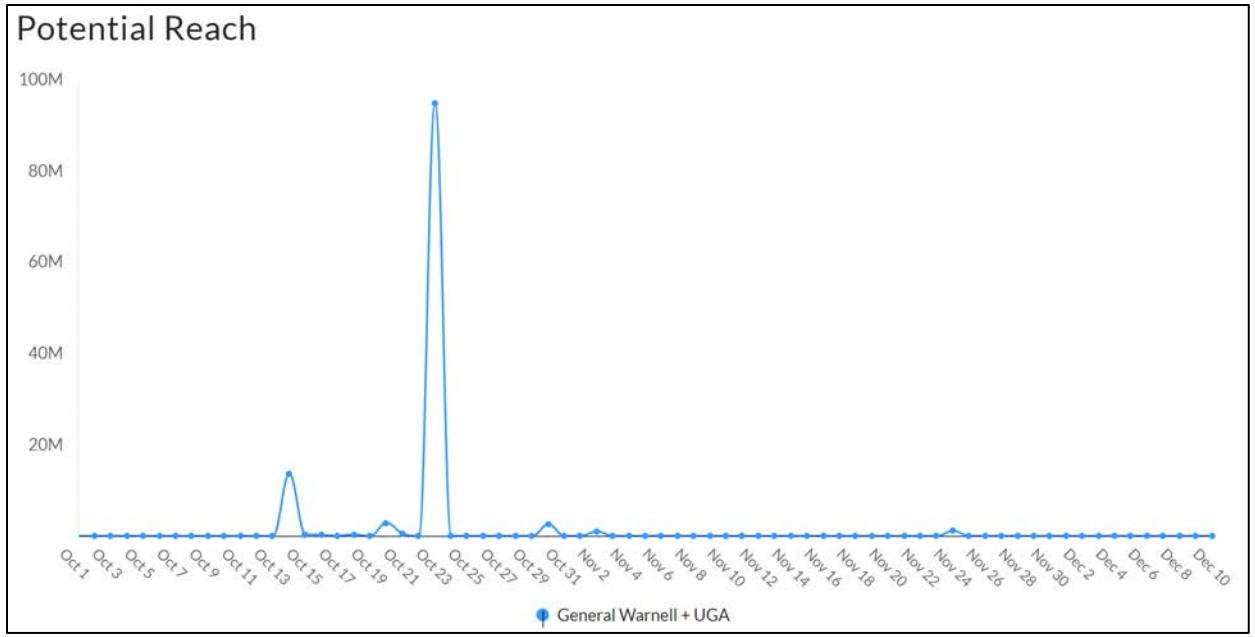
Science & Technology

Plant-based jet fuel could reduce emissions by 68%

October 14, 2021 · by Allyson Mann

A jet refuels. (Getty Images)



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Sustainable Aviation Fuel Production from Brassica Carinata in the Southern United States

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A Virtual Special Issue
Sustainable Jet Fuel Production from Brassica Carinata in the Southern United States

Dr. Puneet Dwivedi, Guest Editor
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The aviation sector emits 2.4% of the global anthropogenic carbon dioxide emissions. The use of jet fuel derived from bioenergy feedstocks is vital for reducing the aviation sector's carbon footprint. This is especially true in the United States, as the country consumes about 25% of the total jet fuel consumed globally, out of which about a third is consumed across thirteen southern states. In this context, *Brassica carinata* provides an opportunity for reducing the carbon footprint of the aviation sector at the regional level and beyond. The oil obtained from carinata seeds could be refined to produce jet fuel and other valuable bioproducts. Additionally, carinata is a non-food crop, and being a winter crop, it does not compete with other summer crops in the Southern United States. Therefore, over 100 collaborators from ten public institutions and four industry partners are undertaking research, extension, and education efforts under the aegis of SPARC (Southeast Partnership for Advanced Renewables from Carinata) to assess the economic, environmental, and social feasibility of incorporating carinata into current crop rotations in the Southern United States. The focus is also on establishing sustainable supply chains of carinata-based jet fuel by developing public-private partnerships. This special virtual issue provides scientific grounding for carinata-based jet fuel production in the Southern United States. It focuses on the agronomy, economics, and environmental impacts of carinata-based jet fuel production in the region.

SPARC

Carinata & Soil Carbon Dynamics

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ORIGINAL RESEARCH article
Front. Energy Res., 13 April 2022 | https://doi.org/10.3389/fenrg.2022.837883

Check for updates

Modeling Yield, Biogenic Emissions, and Carbon Sequestration in Southeastern Cropping Systems With Winter Carinata

John L. Field[1,2]*, Yao Zhang[2], Ernie Marx[2], Kenneth J. Boote[3], Mark Easter[2†], Sheeja George[4], Nahal Hoghooghi[5], Glenn Johnston[6], Farhad Hossain Masum[7], Michael J. Mulvaney[8], Keith Paustian[2,9], Ramdeo Seepaul[4], Amy Swan[2], Steve Williams[2], David Wright[4] and Puneet Dwivedi[7]

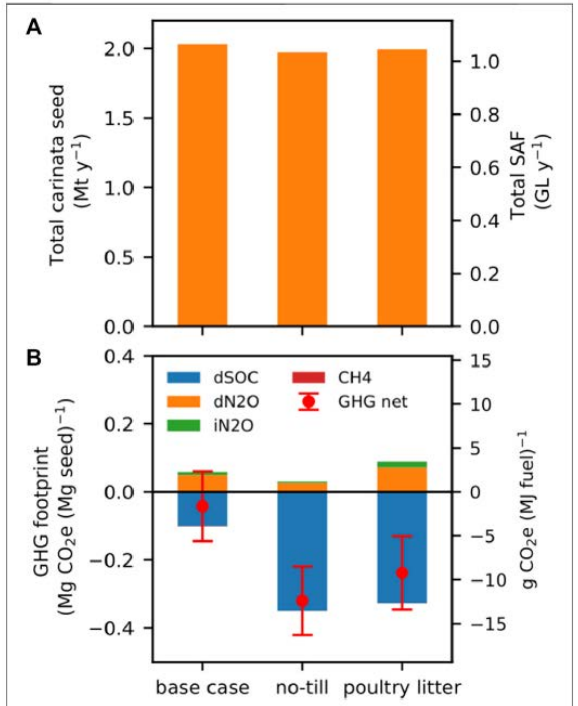
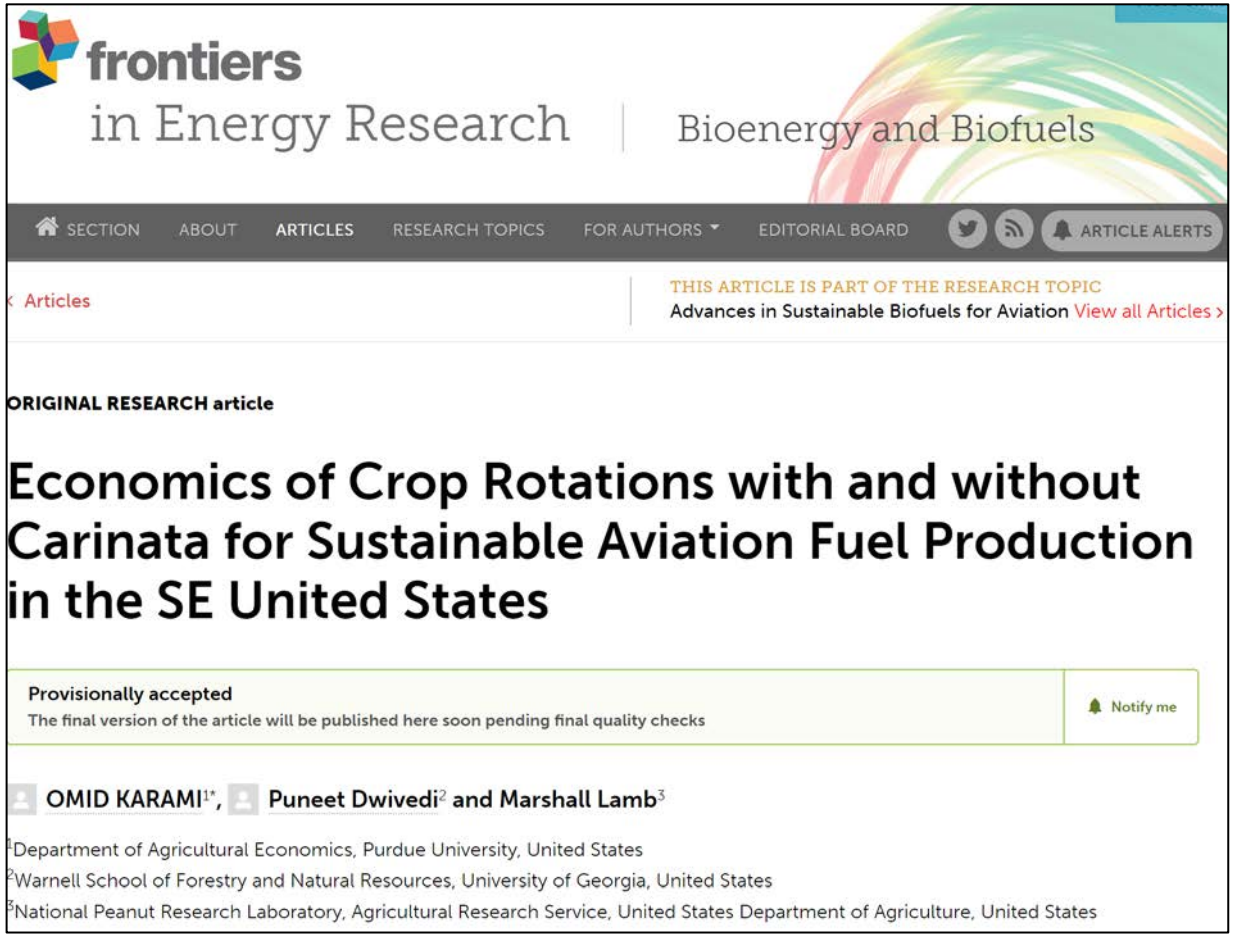


FIGURE 6 | Performance of different carinata management scenarios in terms of **(A)** total annual seed yield and associated SAF potential from the study region, and **(B)** the associated soil GHG footprint per Mg of seed production, also expressed in units of global warming intensity (g CO_2e (MJ fuel)$^{-1}$) for the resulting carinata–SAF. Red error bars denote ±2SD of field-to-field variability. These results focus on the local soil GHG balance only; neither upstream emissions from nitrogen production and farm operations nor the alternate fate of poultry litter are included.

Growing carinata using climate-smart practices saves more carbon over time.

Farm Economics



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ORIGINAL RESEARCH article

Economics of Crop Rotations with and without Carinata for Sustainable Aviation Fuel Production in the SE United States

Provisionally accepted
The final version of the article will be published here soon pending final quality checks

Notify me

OMID KARAMI[1*], Puneet Dwivedi[2] and Marshall Lamb[3]

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Carinata can decrease the risk level of crop rotations by 8.1%, only if a contract price of $440.9/t is offered.

Adoption of Carinata at the Farm Level

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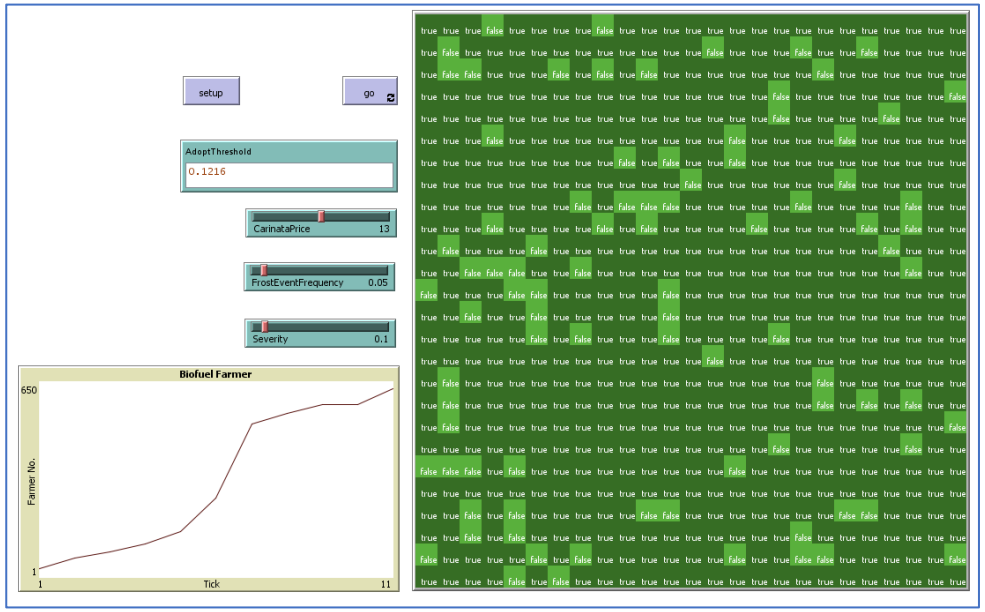
RESEARCH ARTICLE | Open Access

Ascertaining Land Allocation Decisions of Farmers about the Adoption of Carinata as a Potential Crop for Sustainable Aviation Fuel Production in the Southern United States

Kazi Masel Ullah, Puneet Dwivedi

First published: 11 April 2022 | https://doi.org/10.1111/gcbb.12945



We developed a spatially explicit agent-based model for ascertaining the adoption rate of carinata among the farmers. Each farmer's adoption behavior was modeled using the profitability difference between traditional crop rotations (with and without carinata at various contract prices), the adoption rate of neighboring farmers, and their land allocation decisions from managing a risky portfolio of enterprises.

Carinata Value Supply Chain (roads)

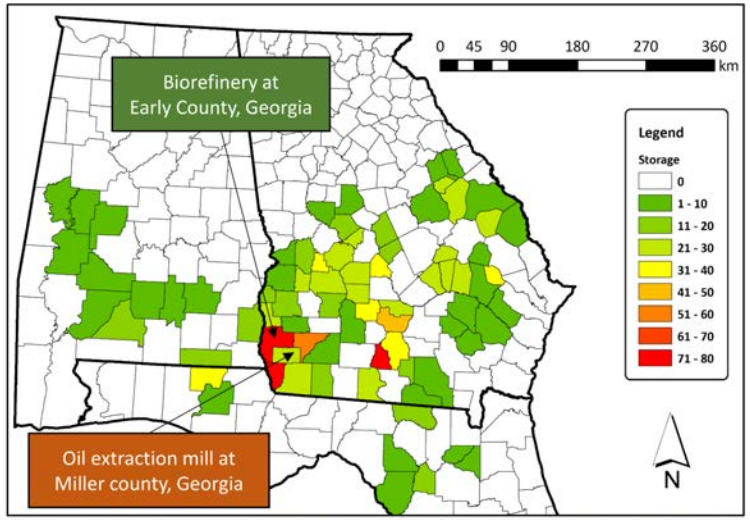


Figure 4: Location of storage, oil extraction mill, and biorefinery. Note: No oil extraction mill or biorefinery was created in Alabama and Florida.

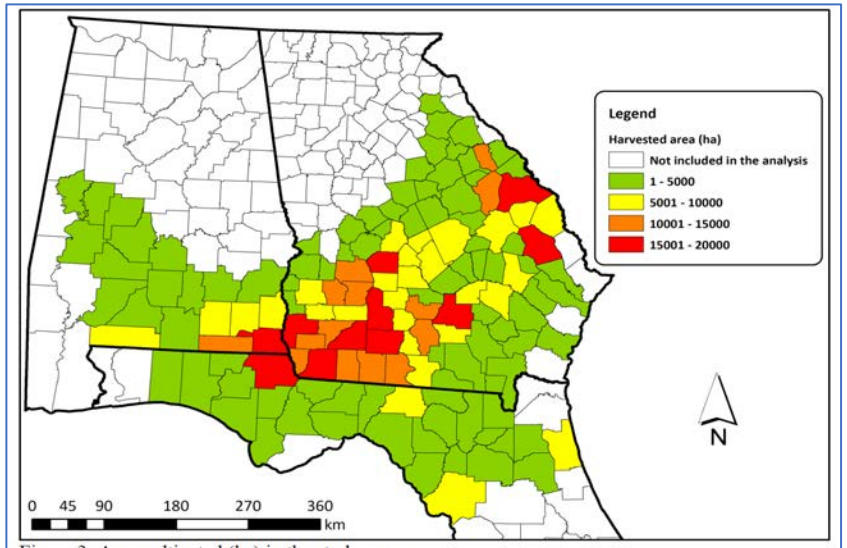


Figure 3: Area cultivated (ha) in the study area.

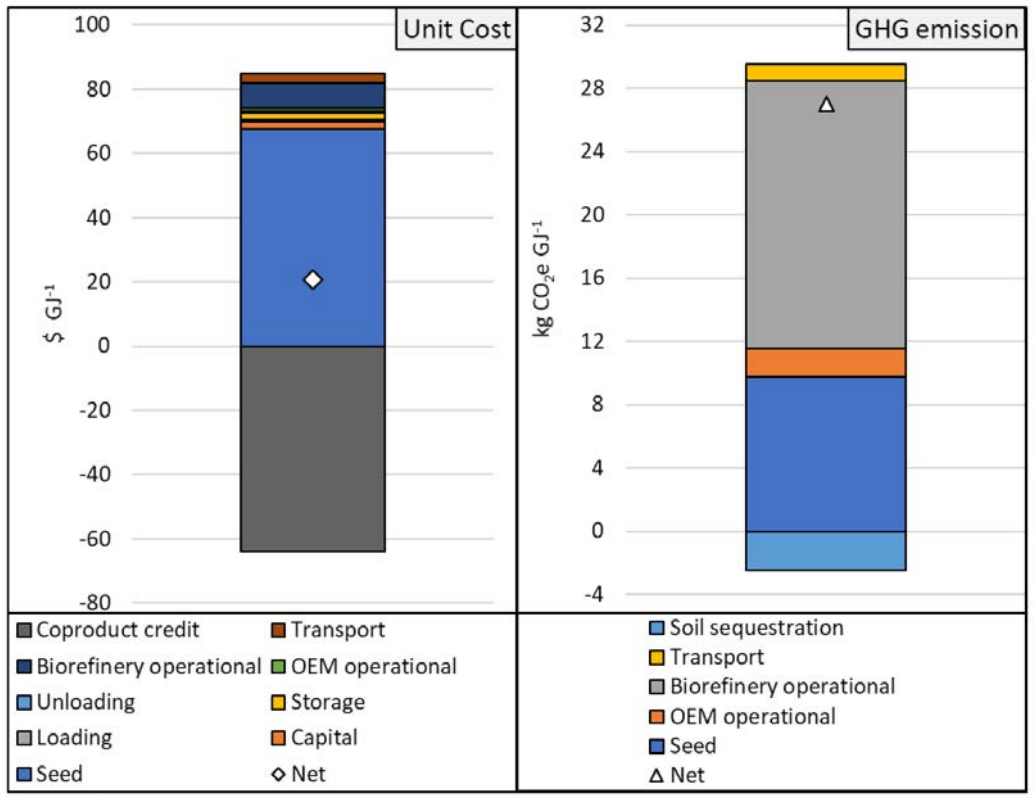
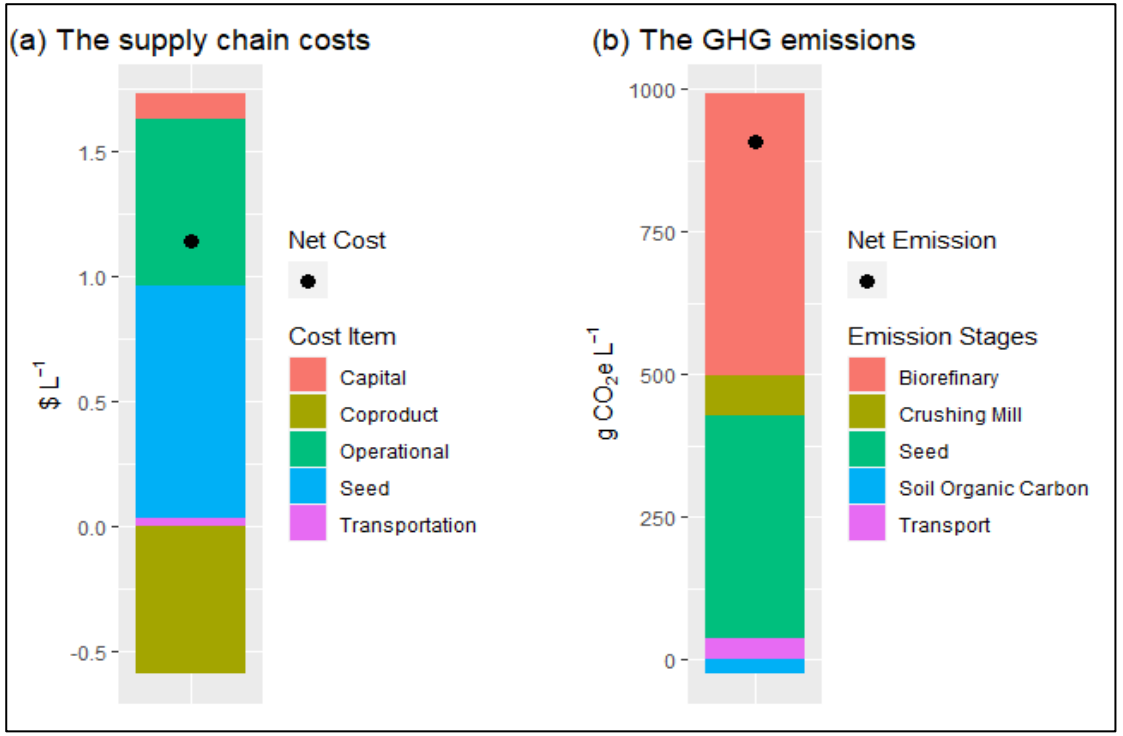


Figure 06: Unit cost and GHG emissions of SAF throughout the supply chain. CAF price and GHG emissions were $12.56 GJ^{-1} and 65.85 kg CO_2e GJ^{-1}, respectively.

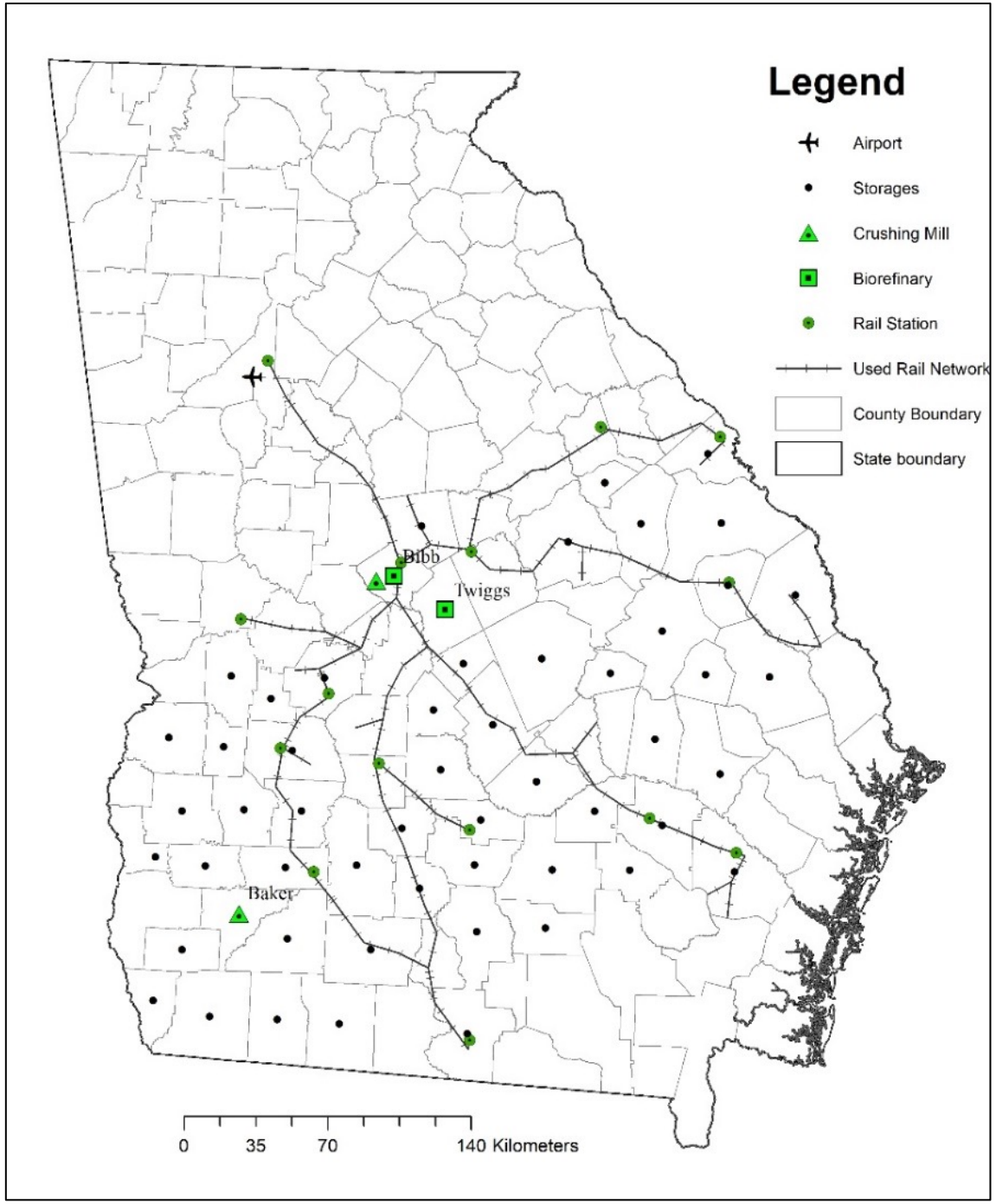
Paper in review: Renewable and Sustainable Energy Reviews

Developed a mathematical model (MILP) for ascertaining area harvested, location and # of storage units, location and # of crushing mills, location and # of biorefineries to supply carinata-based SAF to four airports (Miami, Orlando, Atlanta, and Birmingham).

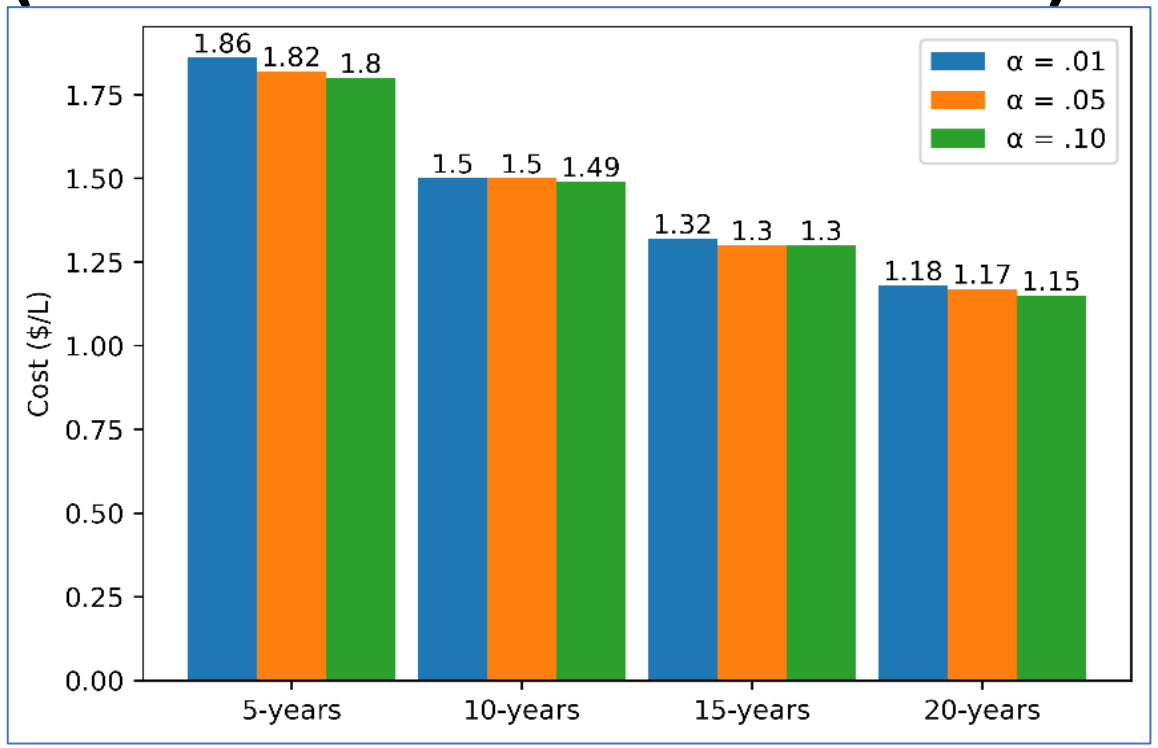
Carinata Value Supply Chain (various transport modes)



The supply chain costs and GHG emissions at various stages of supply chain productions and facilities for per liter of SAF production. The gross cost and net cost are estimated with coproduct credit and without coproduct credit, respectively. The gross emission and net emission are estimated with Soil Organic Carbon sequestration and without Soil Organic Carbon sequestration, respectively.

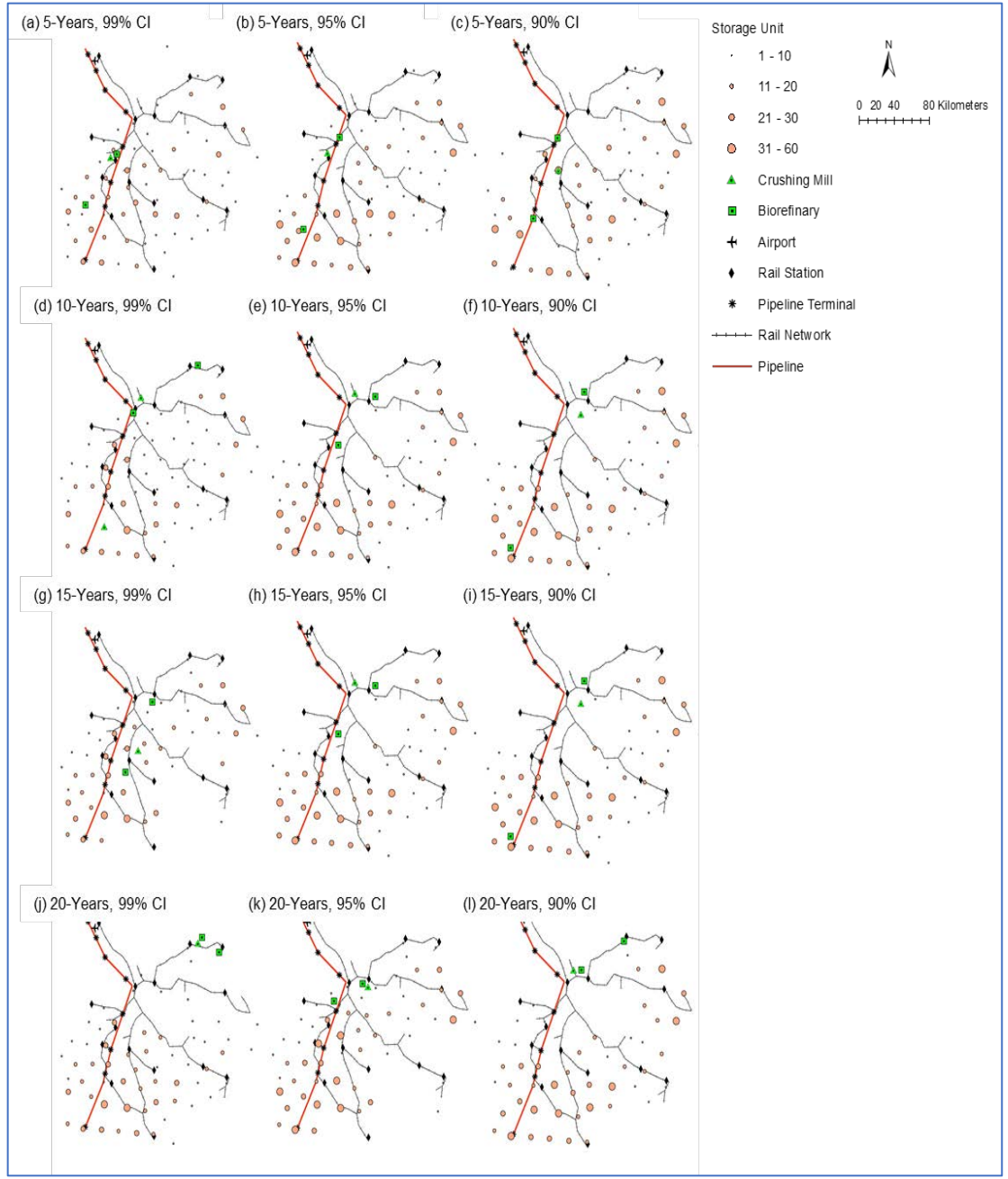


Carinata Value Supply Chain (with Stochastic Yields)

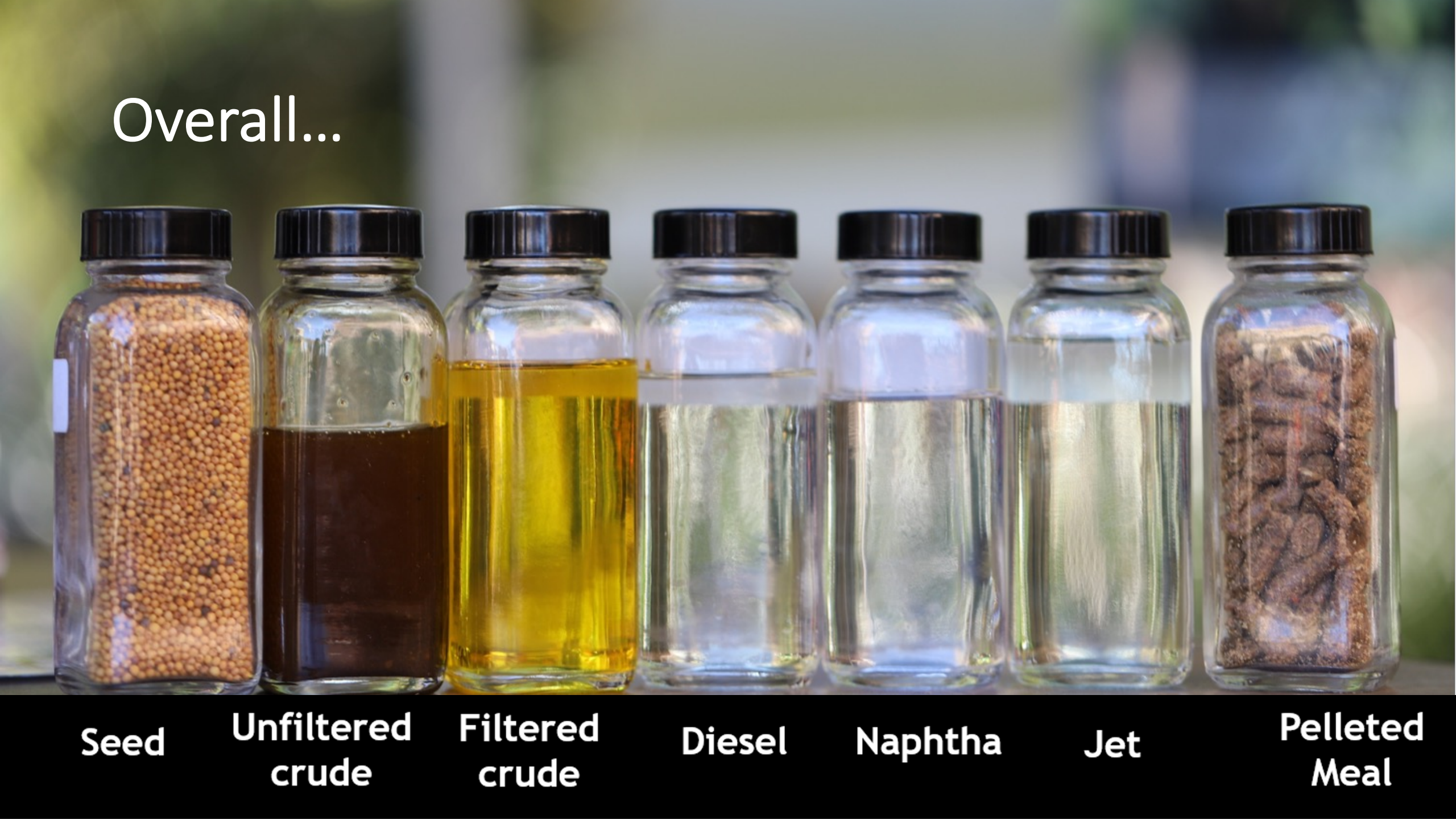


The costs of producing SAF at four simulation periods under three probabilities.

The location of facilities at different years of simulation period with three confidence interval (CI) scenarios.



Overall…


Seed
Unfiltered crude
Filtered crude
Diesel
Naphtha
Jet
Pelleted Meal

Personal reflections…

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