

# Sustainable solutions for FL&W related problems: case studies in Colombia

Gonzalo Mejía, PhD

Associate professor

Co-director of the MIT – FAROL

Unisabana Research for Translational  
Science

Faculty of  
**Engineering**



Universidad de  
**La Sabana**



# Food Loss and Waste

In Colombia, 34% of food destined for human consumption is lost and wasted.



- In Colombia, 9.8 million tons of food are lost and wasted every year (DNP, 2022)
- A Colombian wastes between 55 and 65 kilos of food a year. And 60% of the waste corresponds to fruits and vegetables (DNP, 2022).



# Other Countries (Comparison)



Population (Millions)	51,52	126,7	214,3	45.81
Area (Mill Km2)	1.14	1.97	8.51	2.78
Food Waste (Mill Tons)	9.8	20.4	46	16
Food Waste (%)	34%	34%	30%	30%







# Food Waste

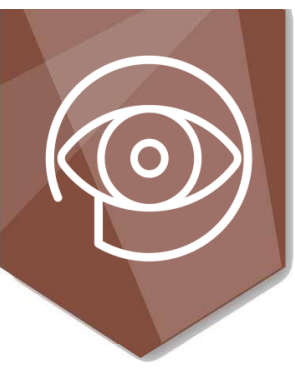
Food Waste in Colombia (DNP)		
Fruits and Vegetables	6.1 mill tons	62%
Roots and tubers	2.4 mill tons	25%
Others	1.3 mill tons	13%
Total	9.8 mill tons	100%

Waste by stage of the food chain:

Loss and waste by stage of the food chain	
Agricultural Production	40.5%
Distribution & Retail	20.6%
Post-harvest and storage	19.8%
Consumption	15.6%
Industrial Processing	3.5%



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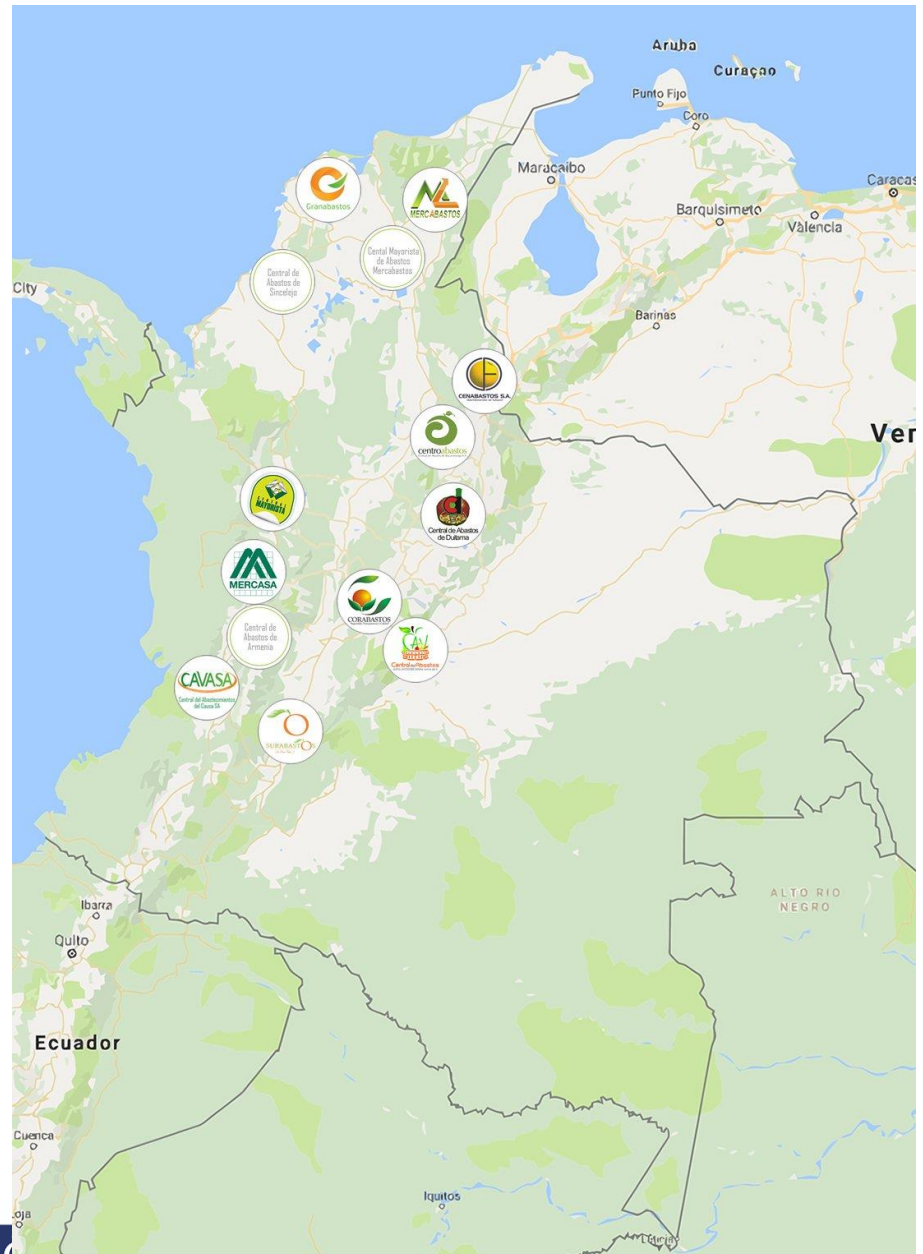
# Supply Centers

13

Large Central Markets

30.000  
Tons / Day

50% of the country's food production



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# Corabastos in Bogotá (capital of the country)



2°

The second largest central market in Latin America and the most important in Colombia

10.500  
Tons / Day

and up to 200,000 visitors (Semana, 2023)

420.000  
m<sup>2</sup>

5-10 tons of food are wasted **every day.**



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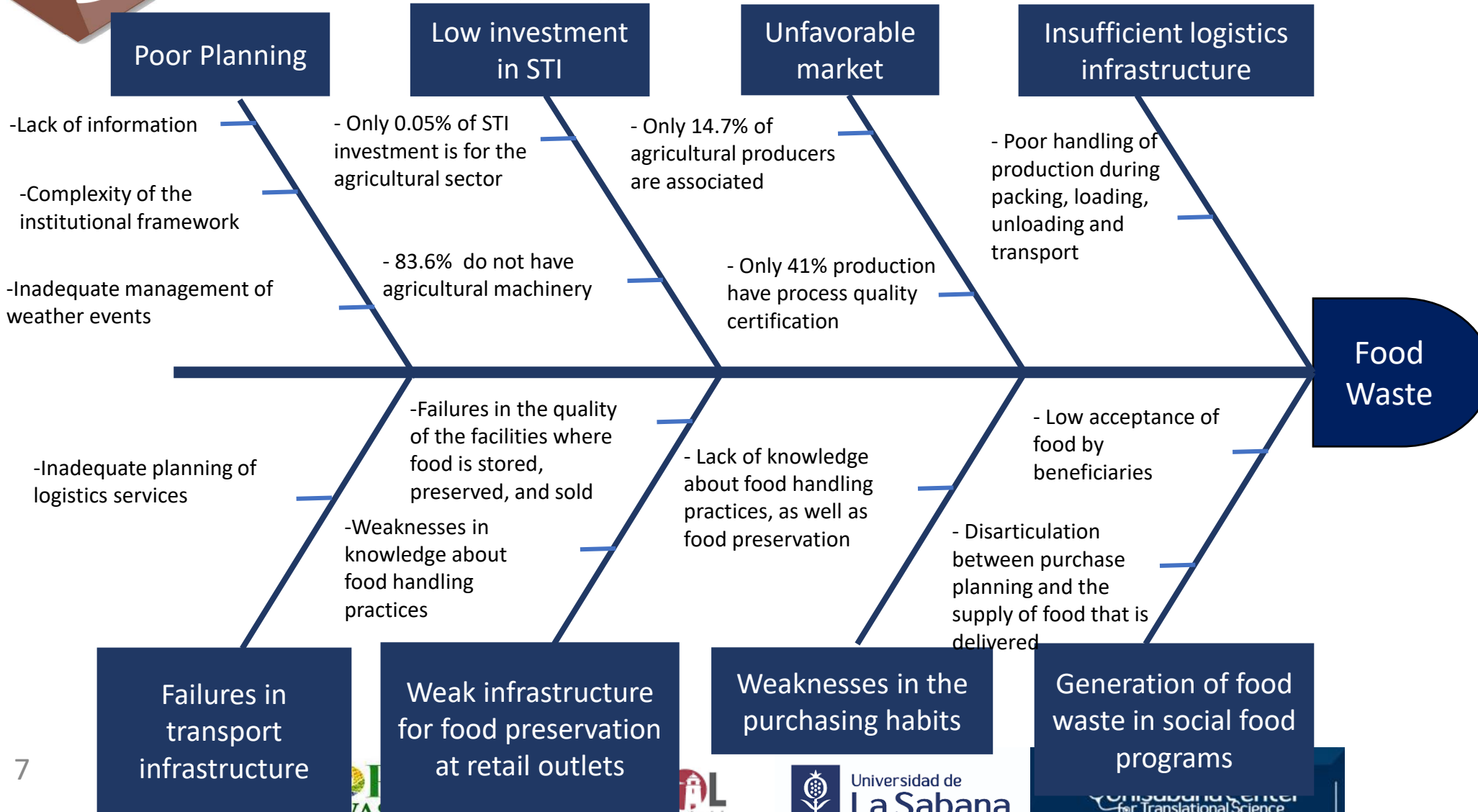
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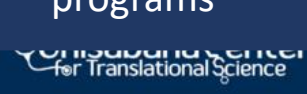


# Causes and Effects



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# Case studies

AI and OR Methods in Logistics and Supply Chain







# 1. Improving the logistics of the Food Bank of Bogotá

- The Banco de Alimentos de Bogotá (Bogotá Food Bank) plays an important role in addressing food insecurity and reduce waste in the Colombian capital.



Arroyo, Castellanos, & Reina. (2023)





# 1. Improving the logistics of the Food Bank of Bogotá

- The planning of distribution routes is a major problem
- Excessive handling creates FL&W
- The Food Bank needs a low cost and effective solution



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ALIMENTOS  
BOGOTÁ®

Arroyo, Castellanos, & Reina. (2023)





# 1. Improving the logistics of the Food Bank of Bogotá

- Design of routes for distribution
- Three step procedure
  - Clustering (AI unsupervised learning)
  - Routing (OR tools)
  - Assignment of days to routes (algorithms)



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Luz Helena Arroyo et al. (2023)



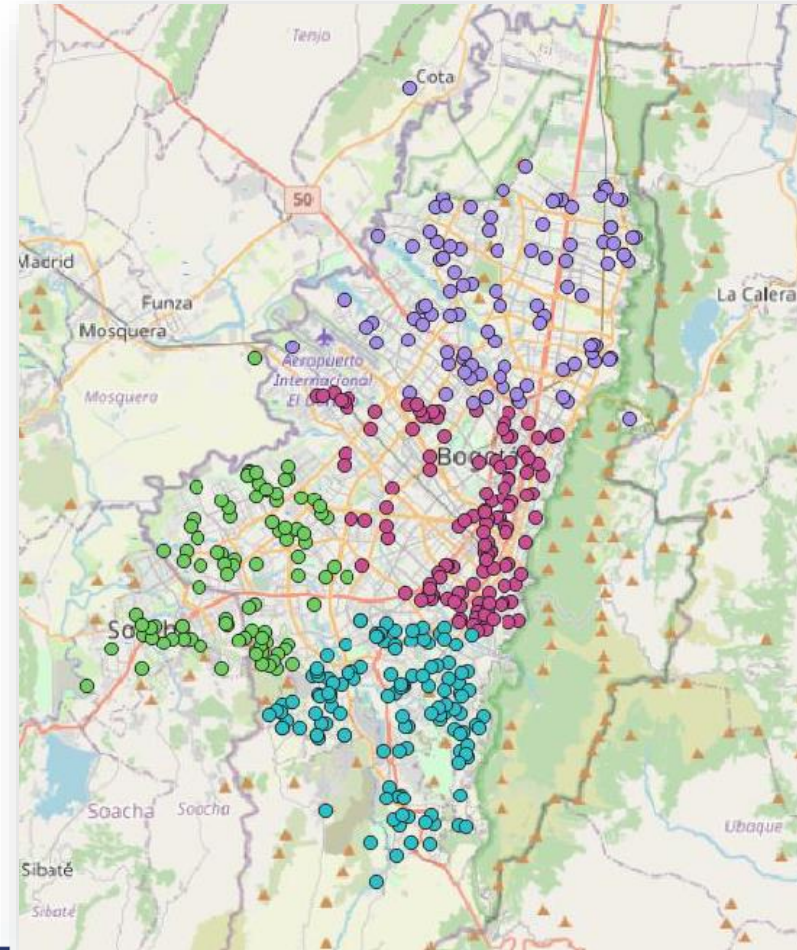




# 1. Improving the logistics of the Food Bank of Bogotá

1. Clustering (unsupervised learning)
  - K-means algorithm
  - Four distribution zones

Luz Helena Arroyo et al. (2023)





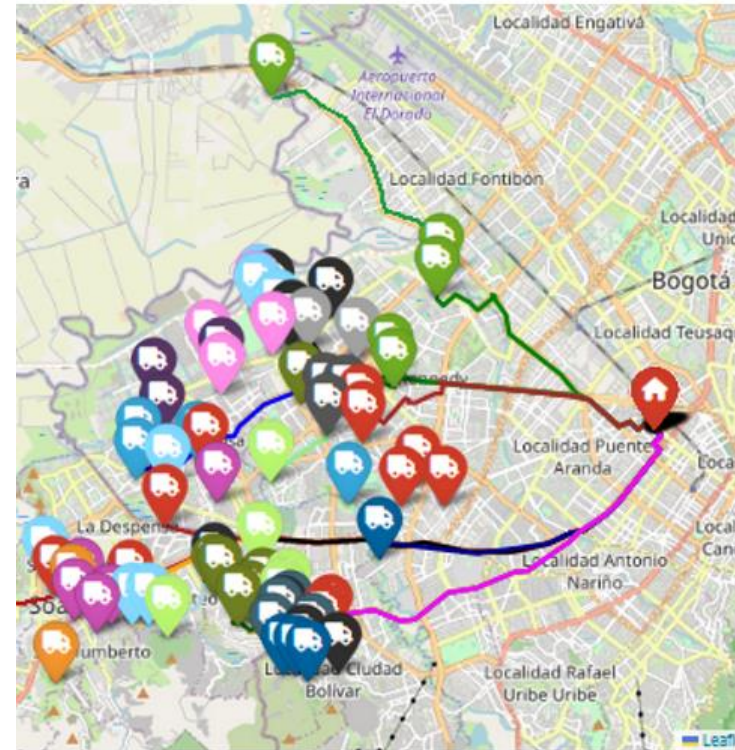
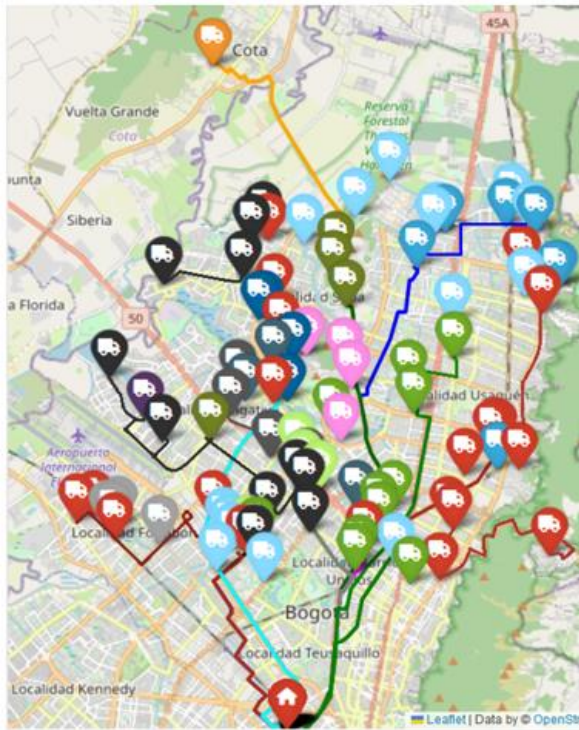


North

## 2. Routing (OR-tools)

Central

South West





# Implementation

- Currently under implementation
- Potential savings in fuel and labor (24%)





# Strategic Supply Chain Planning for Food Hubs in Central Colombia: An Approach for Sustainable Food Supply and Distribution

Gonzalo Mejía

Jairo Alberto Jarrín

Daniela Granados

Erika Molano, Alejandra Castellanos y Natalia Mayorquín

The screenshot shows the article page on the Applied Sciences journal website. The article title is "Strategic Supply Chain Planning for Food Hubs in Central Colombia: An Approach for Sustainable Food Supply and Distribution". The authors listed are Gonzalo Mejía, Daniela Granados-Rivera, Jairo Alberto Jarrín, Alejandra Castellanos, Natalia Mayorquín, and Erika Molano. The article is published in Applied Sciences, 2021, 11(4), 1792. The page includes a sidebar with navigation options like "Submit to this Journal" and "Review for this Journal", and an "Article Menu" section with the Academic Editor Farouk Yalaoui.



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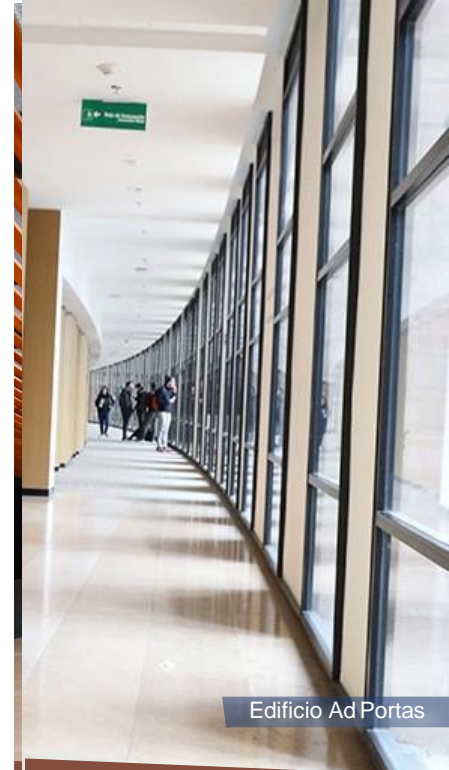


# Food supply chain



How can we bring fresh food from the countryside to the cities in sustainable way?

Currently producers rely on intermediation



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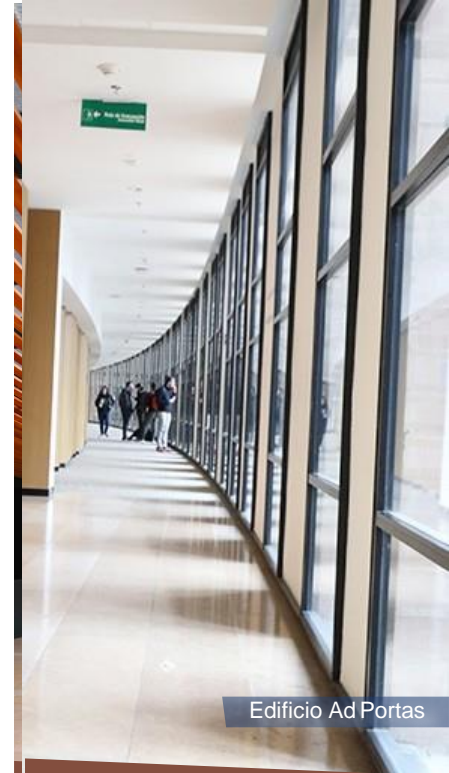




# A proposal based on food hubs

Why there's intermediation in emerging countries?

R/ Because this is the best alternative (yet)



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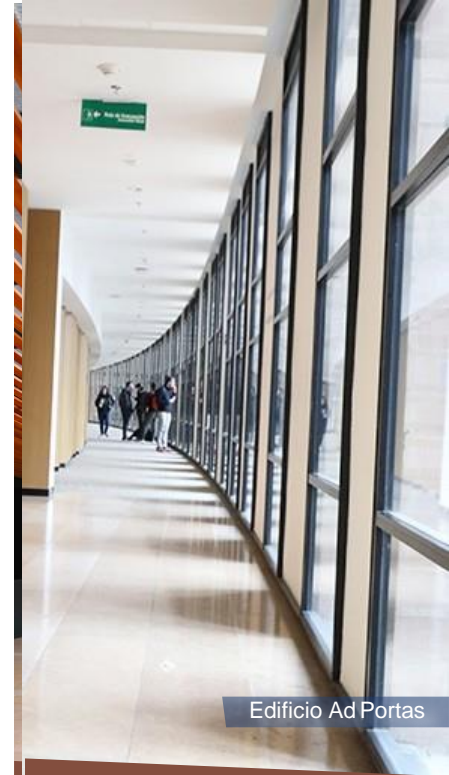


# We need a holistic approach



That benefits all the stakeholders

...including middlemen and consumers



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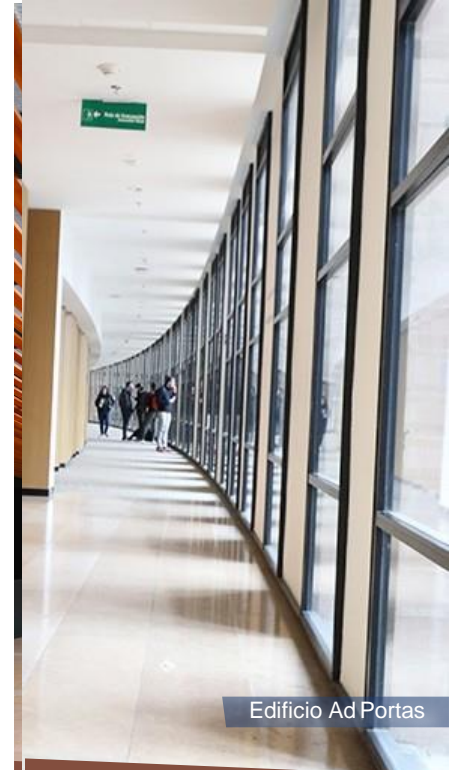


# Food hubs



- Why the proposal?
- It would consolidate the production supply
- It would generate savings in transportation
- It would improve the handling and manipulation of the product
- It would involve all (or almost all) the actors in the chain

<https://lasillavacia.com/silla-llena/red-rural/la-crisis-de-la-papa-hay-salidas-faciles-77352>



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# Mixed Integer Programming Model

Decision variables:

- Hubs to open.
  - Quantities to send from the producer to the hubs and demand points.
  - Quantities to send from the hubs to the demand points.
- Number of vehicles to be sent from the hubs to the demand points.



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(1)

$$\text{Max} \sum_{k \in K} \sum_{h \in H} \sum_{j \in J} \sum_{v \in V} \text{margin}_k s'_{khjv}$$

Revenues

Costos  
operación

$$\left( \sum_{h \in H} c_h x_h + \sum_{l \in L} \sum_{h \in H} \sum_{j \in J} \sum_{v \in V} \hat{c}_v \text{truck}_{vhjl} \right)$$

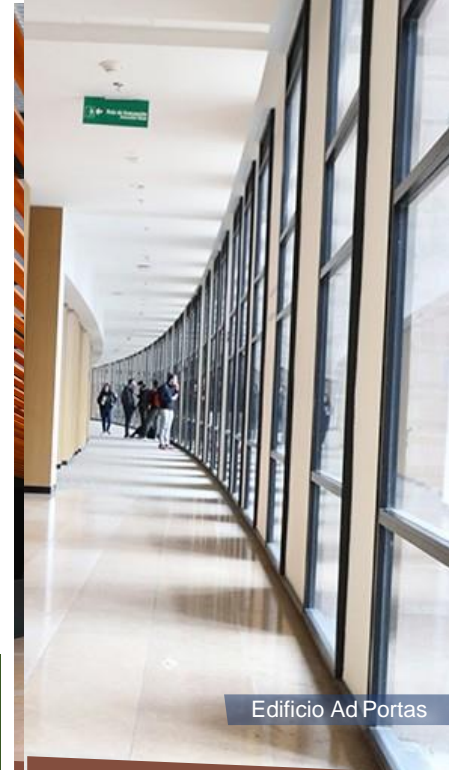
Costos  
transporte

$$+ \sum_{k \in K} \sum_{h \in H} \sum_{j \in J} \sum_{v \in V} c_v d_{hj} s'_{khjv}$$

Costos  
variables

Emission  
costs

$$- \sum_{l \in L} \sum_{h \in H} \sum_{j \in J} \sum_{v \in V} c'_v e_v d_{hj} \text{truck}_{vhjl}$$



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# Subject to:

$$y_{ih} = \frac{\frac{v_h}{d_{ih}^\gamma} x_h}{\sum_{h' \in H} \frac{\hat{w}_{h'}^\delta}{d_{ih'}^\gamma} x_{h'} + \sum_{j \in J} \frac{w_j^\delta}{\hat{d}_{ij}^\gamma}} \quad \forall i \in I; h \in H \quad (2)$$

$$o_{ki} y_{ih} = s_{kih} \quad \forall k \in K; i \in I; h \in H \quad (3)$$

$$\sum_{h \in H} s_{kih} + \hat{s}_{ki} = o_{ki} \quad \forall i \in I; k \in K \quad (4)$$

$$\sum_{k \in K} \sum_{i \in I} s_{kih} \leq q_h x_h \quad \forall h \in H \quad (5)$$



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# Subject to:

$$\sum_{i \in I} s_{kih} \geq \sum_{j \in J} \sum_{v \in V} s'_{khjv}$$

$$\forall k \in K; h \in H \quad (6)$$

$$\sum_{k \in K} a_{kl} s'_{khjv} \leq q'_v \text{truck}_{vhl}$$

$$\forall v \in V; h \in H; l \in L; j \in J \quad (7)$$

$$\sum_{k \in K} a_{kl} s'_{khjv} \geq q'_v (\text{truck}_{vhl} - (1 + \min_v))$$

$$\forall v \in V; h \in H; l \in L; j \in J \quad (8)$$

$$\sum_{v \in V} s'_{khjv} \leq p_{hj} \sum_{i \in I} s_{kih}$$

$$\forall k \in K; h \in H; j \in J \quad (9)$$

$$x_h \in \{0,1\} \quad \text{truck}_{vhl}, \hat{s}_{ki}, y_{ih}, s_{kih}, s'_{khjv} \geq 0$$

$$\forall v \in V; h \in H; l \in L; j \in J; k \in K \quad (10)$$

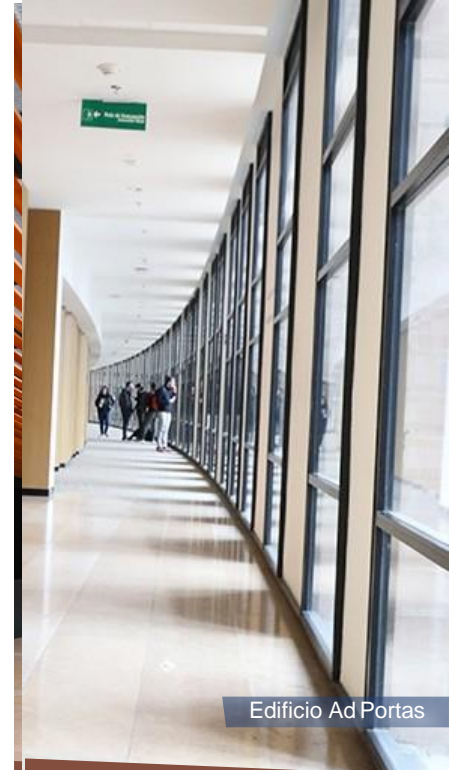
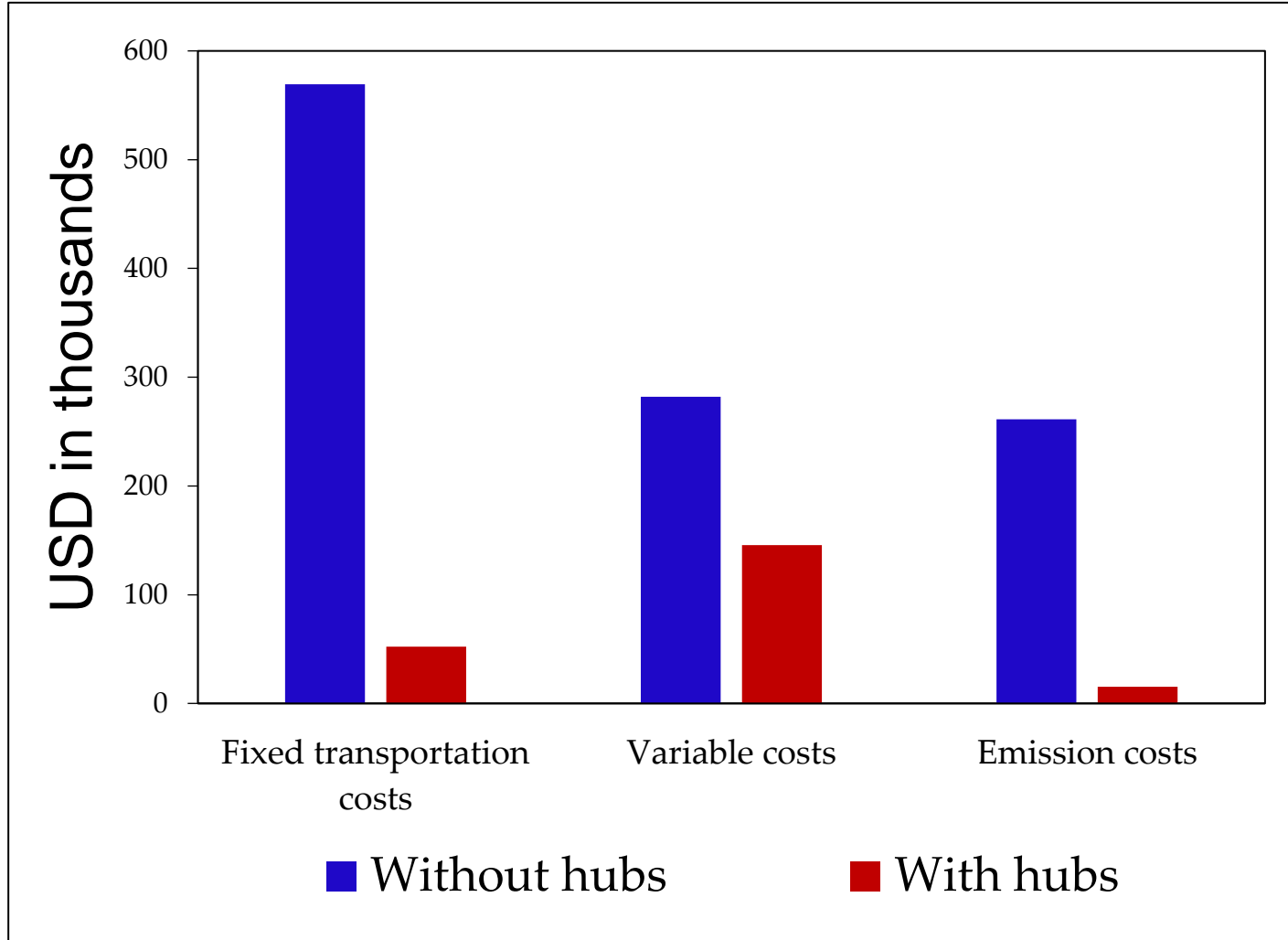


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# Resultados



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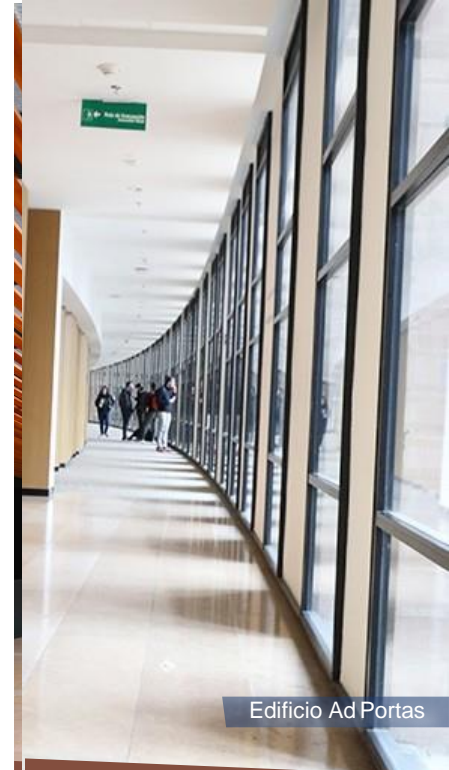
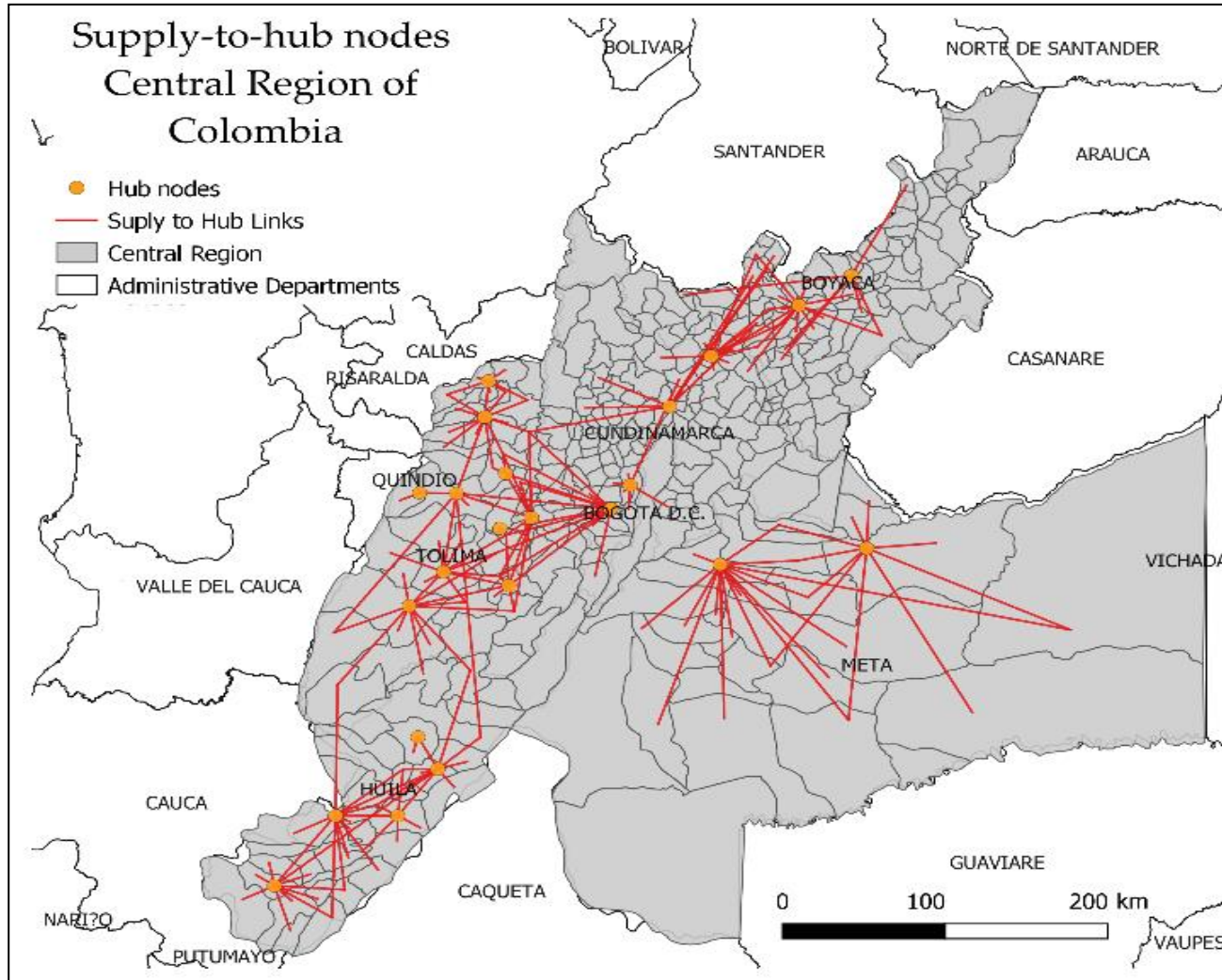


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# Results



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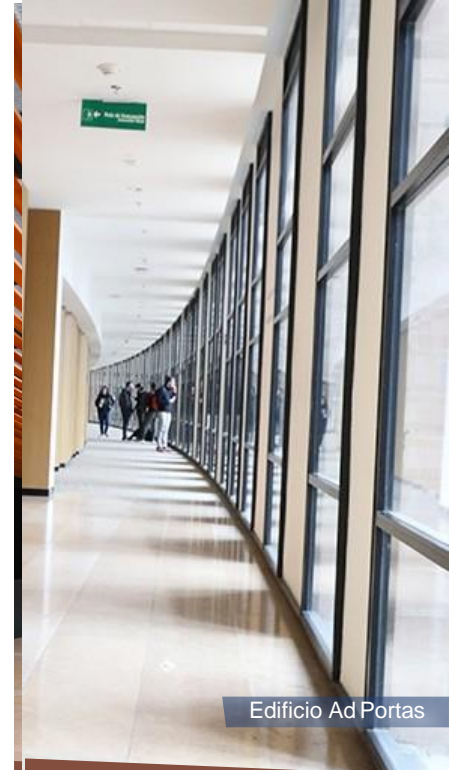
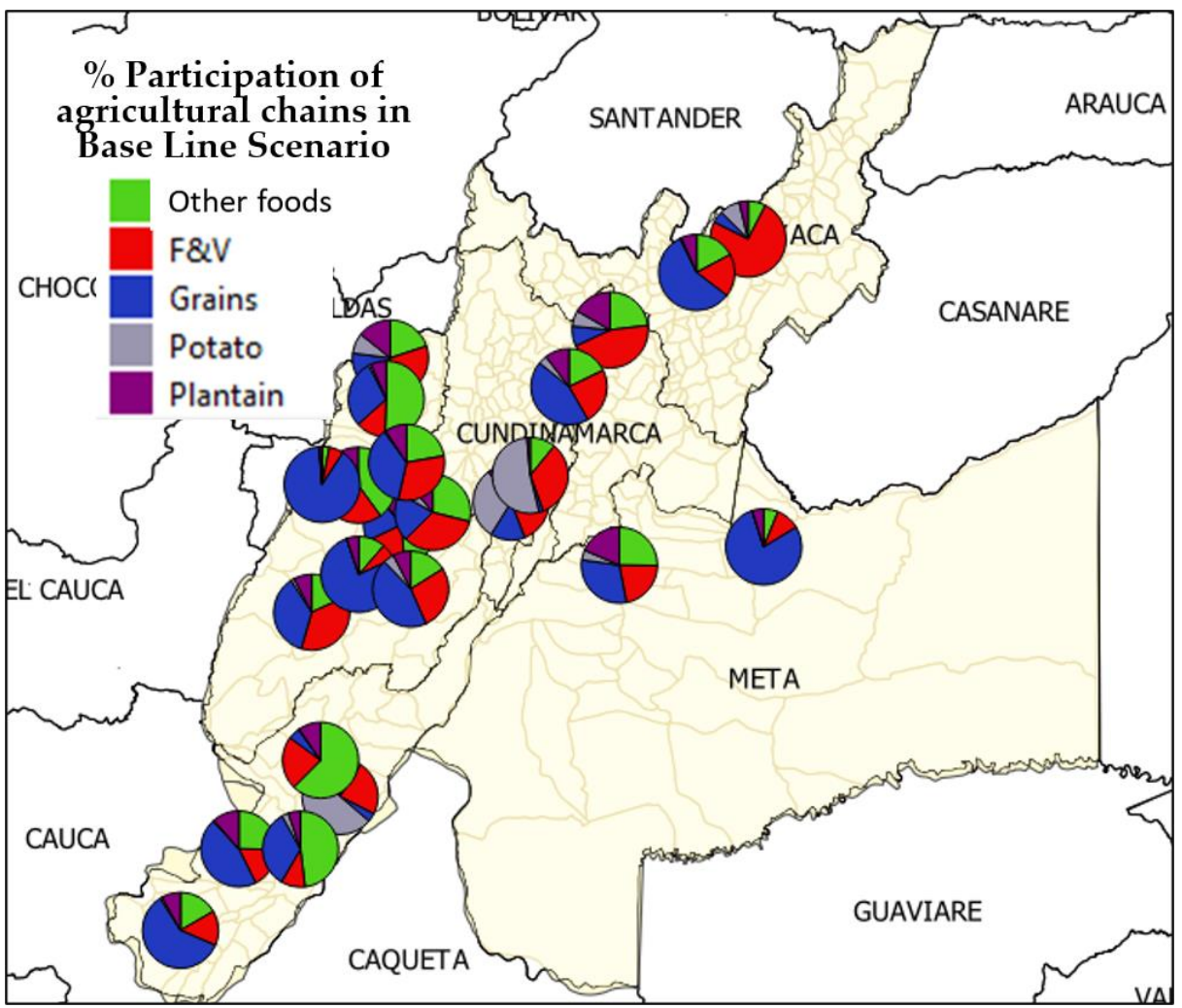
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# Results



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# Results

- Estimates of 8000 tons /week can be traded through the 20 hubs.
- The strategy can be profitable and sustainable.
- But politics play a major role.







# We help develop the food security master plan



Mesas Territoriales  
**Plan de Abastecimiento  
Alimentario de la  
Región Central**

**Chia- Cundinamarca**  
Martes 8 de Octubre  
Lugar: Auditorio David Mejía  
Universidad de la Sabana  
Hora: 8:00 am

#ParaAlimentarnosMejor





# Team

## UCTS-GIBP-GIPA-GISI

### SALUD MENTAL Y COMUNICACIÓN

Víctor García, B.A. en Periodismo, M.A., Ph.D.  
Facultad de Comunicación



### ENFERMEDADES NO TRANSMISIBLES

Diego Jaimes, M.D.MSc  
Internista, Reumatólogo -  
Epidemiólogo Clínico  
Facultad de Medicina



### CUIDADO CRÍTICO

Éder Cáceres, M.D., Esp. Cuidado  
Neurocrítico, cPh.D  
Clínica Universidad de La Sabana



### CALIDAD MICROBIOLÓGICA DE AGUAS

Alejandro Acosta, B.Sc., Dr.Sc.  
Facultad de Ingeniería



### CADENA DE SUMINISTRO DE ALIMENTOS, LOGÍSTICA Y DISTRIBUCIÓN

Gonzalo Mejía, Ing., M.Sc., Ph.D.  
Facultad de Ingeniería



### ENFERMEDADES INFECCIOSAS

Luis Felipe Reyes, M.D., Esp. Cuidado  
Crítico, Ph.D., M.Sc  
Facultad de Medicina



### ALIMENTOS FUNCIONALES Y MICROBIOTA

Ma. Ximena Quintanilla, Ing., Ph.D.  
Facultad de Ingeniería

### GESTIÓN ADMINISTRATIVA

Ana María Crispín, Enfermera, Esp. Cuidado  
Crítico Adulto  
UCTS



### SPONSOR DEL PROYECTO

Luz Indira Sotelo, Ing. Alimentos, Ph.D.  
Dirección de Investigación



### GESTIÓN DE INVESTIGACIÓN

Nury Nathalia Olaya, Microbióloga, M.Sc  
Ciencias Biológicas, Ph.D Ciencias  
biomédicas y biológicas.  
UCTS





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Gonzalo Mejía  
gonzalo.mejia@unisabana.edu.co

