

# Modeling a Distribution Network of Agricultural Products in Panama

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# Outline

- Motivation
- Methodology
- Model Developed
- Results
- Conclusions and future research



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# Motivation

- Panama has been considered a logistics center point for the American Continent.
- Agriculture and other related activities are the main sources of employment in the rural areas of Panama.
- Provides the 19% of total employment nationwide.
- The Province of Chiriquí provides more than 80% of the agricultural produce consumed in Panama.
- The Province of Panama is the largest market with 1.71 million habitants
- This carriers transport the products of more than 60% of total producers and the remaining 40% is transported by private companies.



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# Motivation

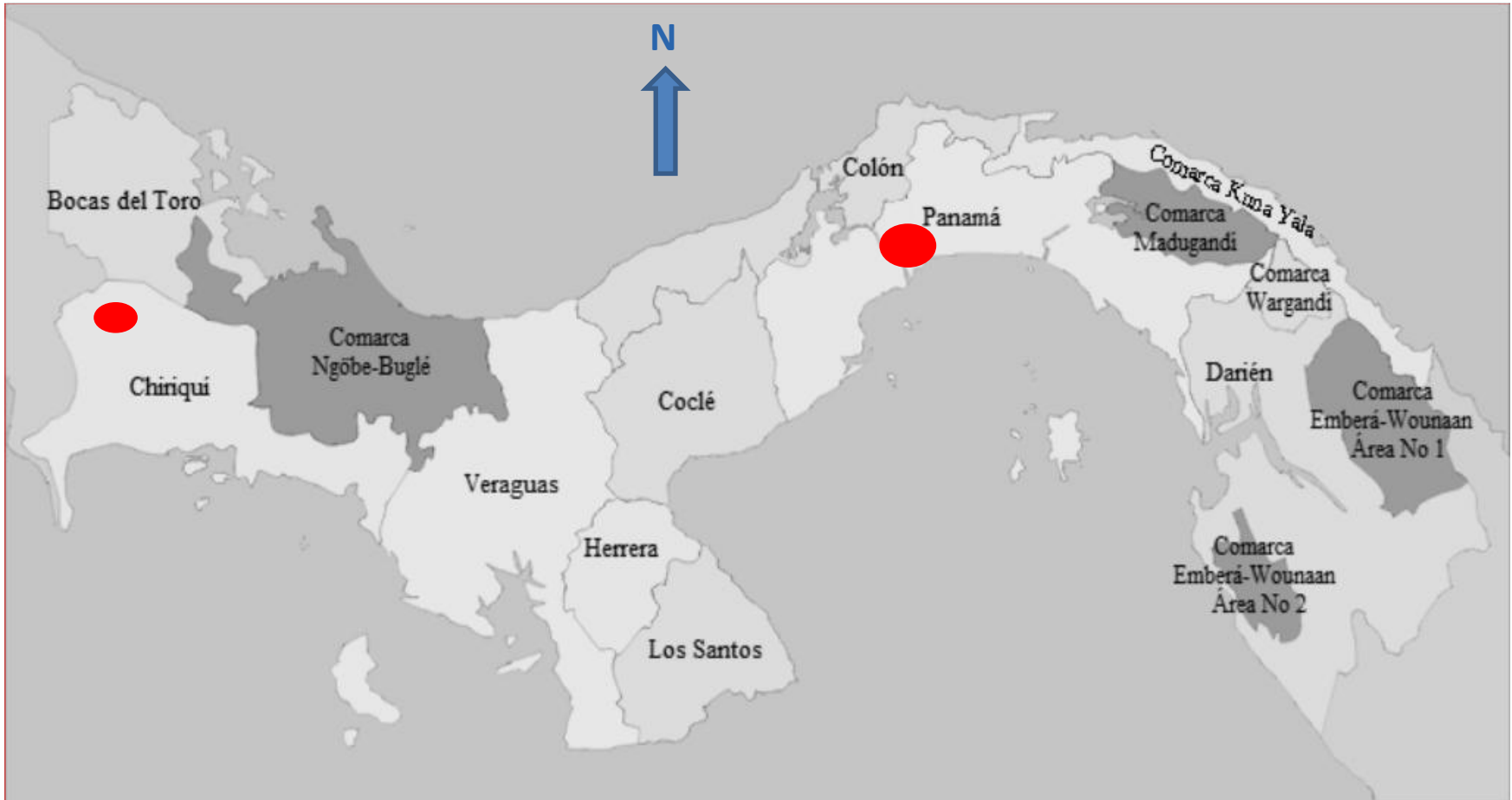
- In addition, there are losses of 40% of transported products. Therefore, these wastes in produce are transferred to the final customer.
- Lack of attention has been provided to the analysis, modeling and optimization of the internal agricultural supply chain.
- No previous study about the distribution network of agricultural products has been conducted in Panama.
- It is a partial result for an undergoing project funded by SENACYT
- The model presents the “AS IS” situation of the distribution network
- To have your feedback on improving the model both in the formulation and solution methodology.



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# Geographical description



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# Objective

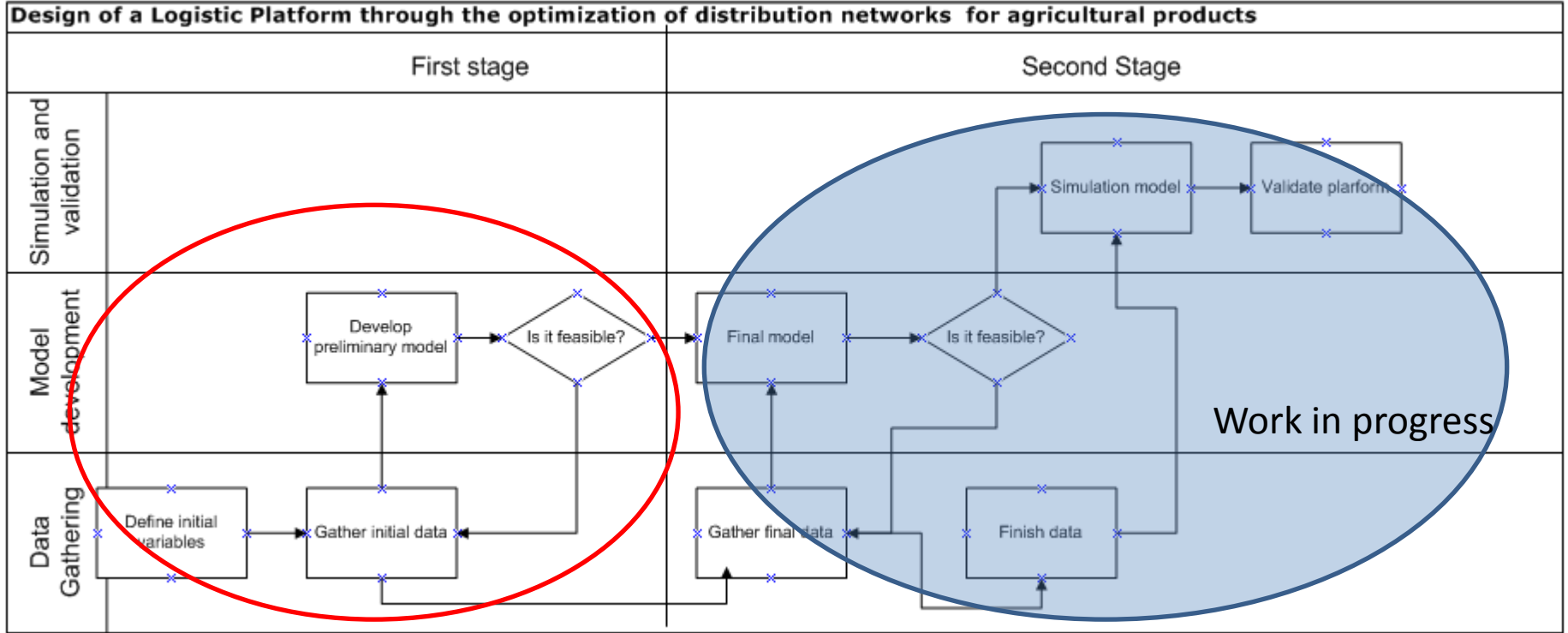
- To present an optimization model to find
  - the minimum cost of satisfying the demand of agricultural products
  - the minimum transportation cost of a vehicle assignment policy for the allocation of products.



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# Methodology



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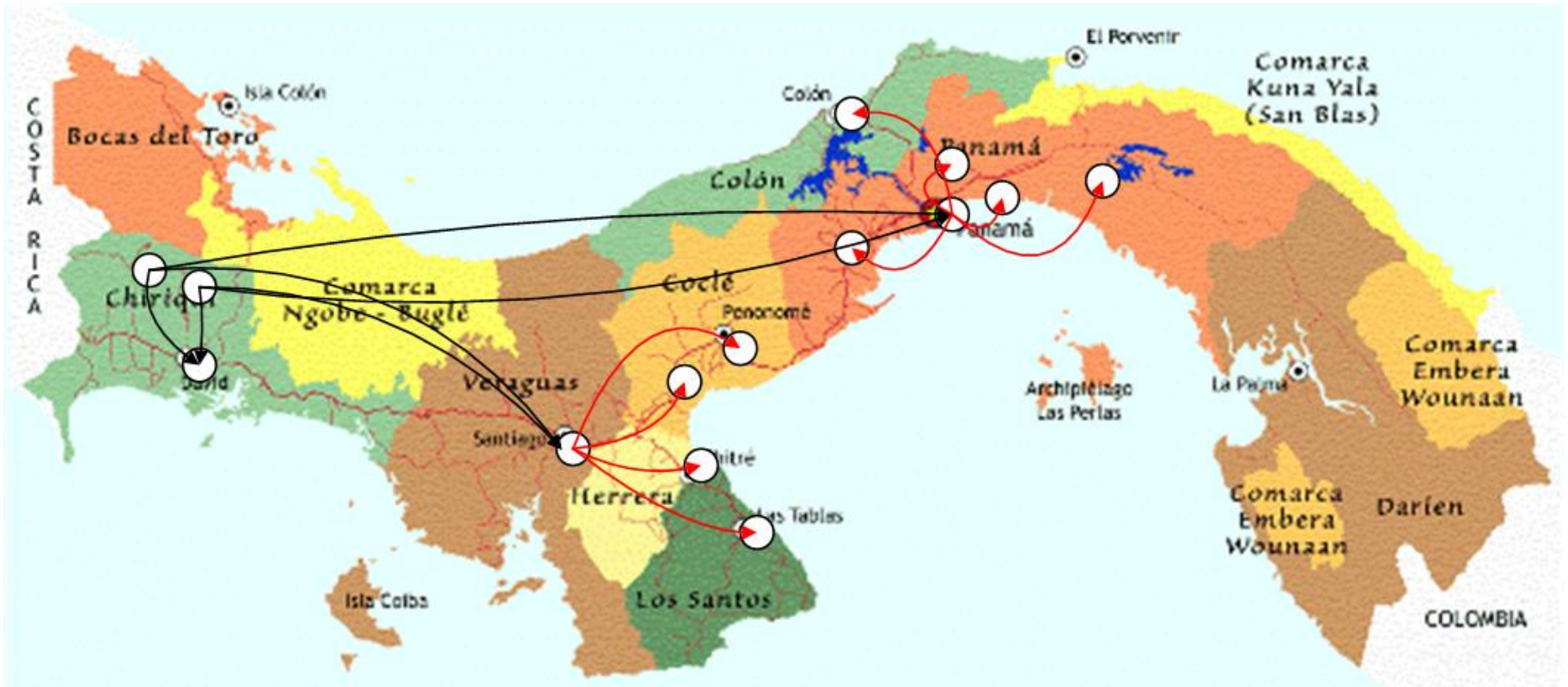
## Model assumptions:

- Only one product is to be studied. In this case the product will be lettuce.
- Supplies and demands at different sources, transshipments and destinations will be considered weekly.
- No inventories are allowed in intermediate points.
- Only three types of vehicles will be considered: pick-ups, trucks and trailers.
- All costs, demands, supplies and availability of vehicles are known.
- No unloading and discharging times are considered.
- The unit load considered is a 40-pound lettuce crate.
- No returning of products.
- The cost is divided on two: the transportation cost, that considers production and loading costs, and the vehicle related cost that considers fuel, operation costs and depreciation.
- Production cost is constant and does not depend on the final destination. Thus, it is a fixed cost and has no influence on the model.





# The model



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# The model

## Model parameters

- $Z$  : Total weekly cost of the transportation policy.
- $N^{(k)}_i$  : Amount of vehicles type  $k$  available at point  $i$ .
- $A^{(k)}$  : Capacity of vehicle type  $k$  in terms of unit loads.
- $S_i$  : Weekly supply of point  $i$ .
- $D_j$  : Weekly demand at point  $j$ .
- $W_i$  : Weekly capacity of the distribution or transshipment points.
- $m$  : Number of origins.
- $n$  : Number of destinations.
- $L$  : Number of distribution centers.
- $K$  : Vehicle types, in this case pick-ups, trucks and trailers.



# The model

$$\min Z = \sum_i \sum_j C_{i,j} x_{i,j} + \sum_i \sum_j \sum_k b_{i,j}^{(k)} y_{i,j}^{(k)}$$

Subject to:

Weekly capacity of the sources:  $\sum_i x_{i,j} \leq S_j \quad \forall j$

No inventory in the transshipment points:  $\sum_i x_{i,l} = \sum_j x_{l,j} \quad \forall l$

Weekly capacity of the distribution points:  $\sum_l x_{i,l} \leq W_i$

Weekly availability of vehicles:  $\sum_k \sum_j y_{i,j}^{(k)} \leq N_i^{(k)} \quad \forall k, j$

Weekly transportation capacity of the vehicles at every distribution point:

$$\sum_j A^{(k)} y_{i,j}^{(k)} - \sum_j x_{i,j} \geq 0$$

All variables are integer and bounded by their upper limits:

$$x_{ij}; y_{ij}^{(k)} \in I; \quad \forall \begin{cases} i = 1, \dots, n \\ j = 1, \dots, m \\ l = 1, \dots, L \\ k = 1, \dots, K \end{cases}$$

# Results

Table 5: Optimal Solution

<u>Objective Function</u>	\$ 80,790
For delivering 19,200 Lettuce Crates per week	
<u>Using</u>	At a total weekly cost of:
23 <u>Pick-ups</u>	\$ 415.00
36 <u>Trucks</u>	\$ 1,825.00
10 <u>Trailers</u>	\$ 3,950.00

*\*Solved using Solver with Simplex LP*



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# Results

Table 1: Crates Moved ( $X_{ij}$ )

From/To	David	Santiago	Chitré	Las Tablas	Aguadulce	Penonomé	Chorrera	Mercado	San Miguelito	Panamá Este	Colón	Total	Supply ( $S_i$ )
Boquete	0	770	0	0	0	0	0	5,500	0	0	0	6,270	6,500
Cerro Punta	2,000	1,980	0	0	0	0	0	3,200	0	0	0	7,180	8,000
Mercado	0	0	0	0	0	0	1,200	0	1,400	600	1,000	4,200	5,500
Santiago	0	0	750	200	250	350	0	0	0	0	0	1,550	3,200
Total	2,000	2,750	750	200	250	350	1,200	8,700	1,400	600	1,000	19,200	23,300
Demand ( $D_j$ )	2,000	2,750	750	200	250	350	1,200	8,700	1,400	600	1,000		

Table 2: Pick-ups used

From/To	David	Santiago	Chitré	Las Tablas	Aguadulce	Penonomé	Chorrera	Mercado	San Miguelito	Panamá Este	Colón	Total	Available Pickups ( $N_{ij}$ )
Boquete	0	9	0	0	0	0	0	0	0	0	0	9	12
Cerro Punta	1	0	0	0	0	0	0	0	0	0	0	1	15
Mercado	0	0	0	0	0	0	7	0	0	6	0	13	45
Santiago	0	0	0	0	0	0	0	0	0	0	0	0	20
Total	1	9	0	0	0	0	7	0	0	6	0	23	



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# Results

Table 3: Trucks used

From/To	David	Santiago	Chitré	Las Tablas	Aguadulce	Penonomé	Chorrera	Mercado	San Miguelito	Panamá Este	Colón	Total	Available Trucks (N <sub>i</sub> )
Boguete	0	2	0	0	0	0	0	6	0	0	0	8	8
Cerro Punta	0	0	0	0	0	0	0	9	0	0	0	9	9
Mercado	0	0	0	0	0	0	4	0	6	2	0	12	12
Santiago	0	0	3	1	1	2	0	0	0	0	0	7	10
Total	0	2	3	1	1	2	4	15	6	2	0	36	

Table 4: Trailers used

From/To	David	Santiago	Chitré	Las Tablas	Aguadulce	Penonomé	Chorrera	Mercado	San Miguelito	Panamá Este	Colón	Total	Available Trailers (N <sub>i</sub> )
Boguete	0	0	0	0	0	0	0	4	0	0	0	4	4
Cerro Punta	2	2	0	0	0	0	0	1	0	0	0	5	5
Mercado	0	0	0	0	0	0	0	0	0	0	1	1	2
Santiago	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	2	2	0	0	0	0	0	5	0	0	1	10	



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## Results

- A solution is provided with a distribution policy consisting on the amounts to be moved from origins to destinations and vehicles to be used.
- The result provides, in addition to the minimum cost of the transportation policy, the optimum type, amount of cost of vehicles to be used.
- Any distribution policy should consider:
  - the supplies and demands
  - the facilities for transportation, storage and distribution.
  - The equipment needed to move the products



# Conclusions

- The data validation to formulate and evaluate the model is constrained due to the lack of knowledge in the agriculture side and coordination, data compilation, and clear strategy in the governmental side.
- There are no congruence between data from the producers and official institutions. Thus, it is very difficult to validate the results of the model.
- Finally, it is necessary for the different organizations involved in the agro-food supply chain, to work in a more united manner since it is important to maintain the supply chain efficient and effective for all, producers, suppliers, and final consumers.



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## Future work

- The data has to be updated frequently and more variables and constraints need to be tested in the model. For instance, to see what might happen if time and more frequencies are added.
- The next step is to try different logistics platforms and compare their recommended policy with the “AS IS” situation.
- It is necessary to add more products, which increases the complexity of the problem, adding a number of variables and constraints proportional to the amount of products.
- It is necessary to include an additional objective since it is important to maximize the value of the cargo in each transport, because the cargo in each transport has to be the optimal combination of products.
- Henceforth, the problem becomes a multicriteria, multicommodity minimum flow problem with equipment assignment.



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# Thanks, Questions?

## Modeling a distribution network of agricultural products in Panama

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