Solving Hunger
with Optimization

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01 BUSINESS PROBLEM

Harvest Hope

The Harvest Hope Food Bank (HHFB) in South Carolina serves food in 20 counties across the state, and feeds over two million people, and donated over 25 million pounds of food.

ONLY 60%

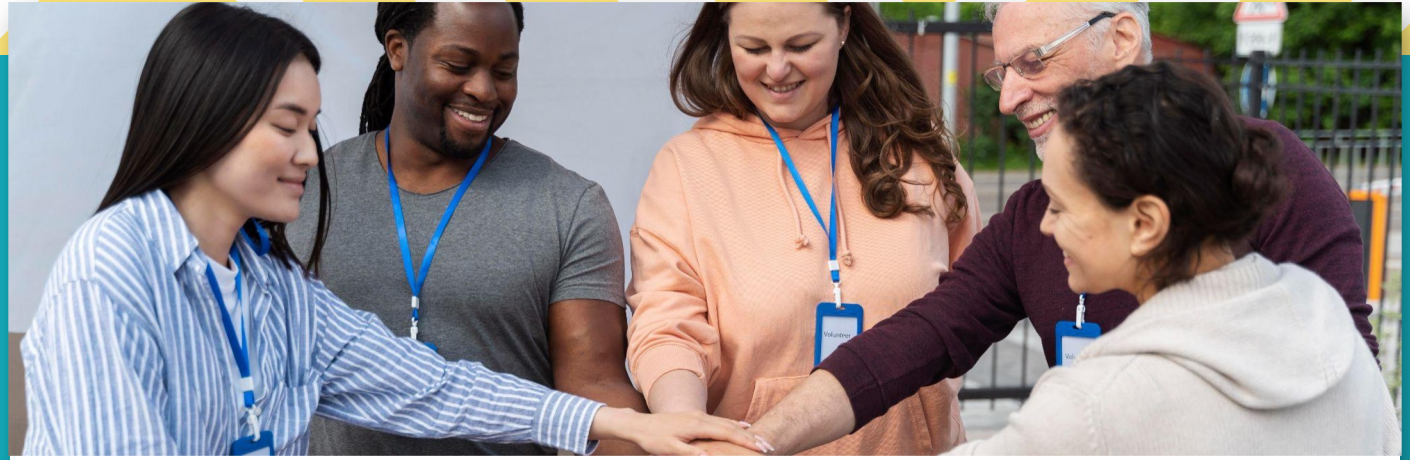
of current demand is satisfied

The question is:

How can we use linear programming to solve this problem?

Problem

- The food bank receives its donations through its fundraising events
- This article describes an optimization model to determine the optimal amount of events the food bank should host every year to maximize donations
- This will consequently feed more people in South Carolina



02 Model Description

PARAMETERS

m_i : Number of meals yield per event of promotional initiative i

l_i : Lower bound on the number of events of promotional initiative i

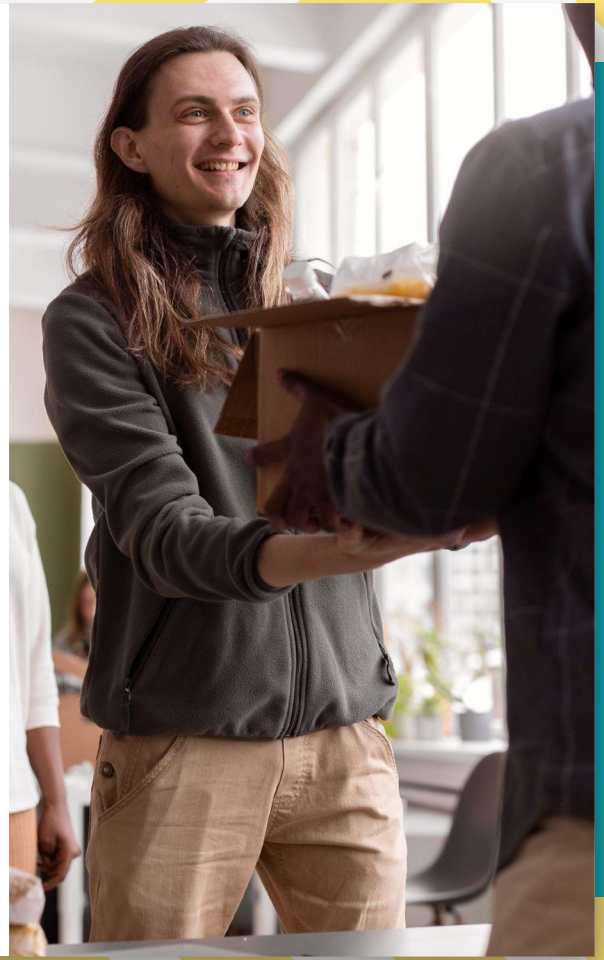
u_i : Upper bound on the number of events of promotional initiative i

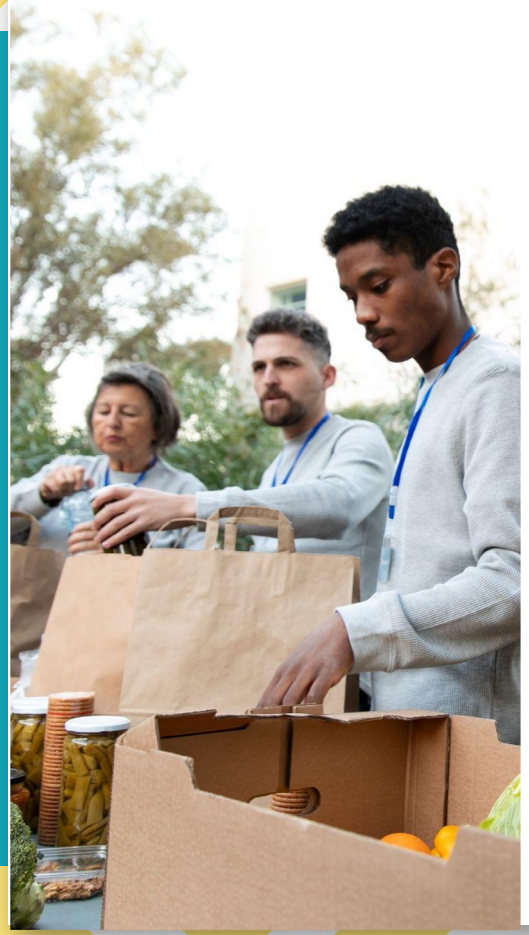
r_{ij} : Number of units of resource pool j required per event of promotional initiative i

R_j : Annual availability of units of resource for resource pool j

DECISION VARIABLES

$\mathbf{X_i}$: Number of events of promotional initiative i held per Year (i= 1 to 34)





OBJECTIVE FUNCTION

$$\textbf{Max } \sum m_i X_i$$

Maximize the total meals yield acquired in a year through promotional initiatives

SUBJECT TO:

Resource Constraints

$\Sigma r_{ij} X_i < R_j$

Lower and Upper Bounds

$l_i =< X_i =< u_i$

Nonnegativity

All $X_i >= 0$ and integer

03
Building Our Model

INPUT DATA

					Calculations
Event Name	*Average food pounds raised per event*	*Average USD raised per event ($)*	*Maximum number of events in a year*	*Minimum number of events in a year*	*Meals yield per event*
Food drives	300	0	4200	1	230.7692308
Media event I	20000	100000	3	1	515384.6154
Church drives I	128000	8897	9	1	142946.5385
Church drives II	0	825	3	1	4125
Media event II	8000	750	2	1	9903.846154
Auction I	0	58721	3	1	293605
Auction II	0	1200	3	1	6000
Auction III	0	5000	1	1	25000
Auction IV	0	4500	12	1	22500
Dinner and blues event	0	15000	1	1	75000
Dinner and jazz event	0	22618	3	1	113090
Concert event I	2500	0	3	1	1923.076923
Concert event II	600	2548	4	1	13201.53846
Concert event III	2042	12015	3	1	61645.76923
Zoo event	3000	400	18	1	4307.692308
5K run I	0	18000	2	1	90000
5K run II	0	13000	3	1	65000
5K run III	0	3384	6	1	16920
Golf tournament I	0	10000	3	1	50000
Golf tournament II	0	4005	1	1	20025
Company event I	0	3723	8	1	18615
Company event II	125	300	36	1	1596.153846
Retail event	0	1500	3	1	7500
Matching gift	0	20000	3	1	100000
Sales drive I	0	200000	10	1	1000000
Sales drive II	0	4586	6	1	22930
Food competition I	0	3000	2	1	15000
Food competition II	0	5000	1	1	25000
Social media drive I	0	26000	1	1	130000
Social media drive III	0	1500	1	1	7500
Social media drive III	0	14700	12	1	73500
Pledge event I	0	5085	12	1	25425
Pledge event II	0	82000	2	1	410000
Pledge event III	0	65000	1	1	325000

MODEL

Objective Function				
Maximise Total Annual Meals Yield	18546444.43	=SUMPRODUCT(I3:I36,G3:G36)		
Constraints				
Resource Pool	*Utilisation*	*Relationship*	*Maximum Capacity*	*LHS formula*
Paid staff	4737.535204	<=	21600	=SUMPRODUCT($B$43:$B$76,$I$3:$I$36)
Volunteers	6026.251108	<=	30000	=SUMPRODUCT($C$43:$C$76,$I$3:$I$36)
Chief executive officer	248.4027573	<=	400	=SUMPRODUCT($D$43:$D$76,$I$3:$I$36)
Marketing manager	885.0137863	<=	1000	=SUMPRODUCT($E$43:$E$76,$I$3:$I$36)
Information systems (IS) manager	420.6041359	<=	500	=SUMPRODUCT($F$43:$F$76,$I$3:$I$36)
Events coordinator	2640.208272	<=	5400	=SUMPRODUCT($G$43:$G$76,$I$3:$I$36)
Donor relations coordinator	375.0068932	<=	800	=SUMPRODUCT($H$43:$H$76,$I$3:$I$36)
Board members	1094.215165	<=	1200	=SUMPRODUCT($I$43:$I$76,$I$3:$I$36)
External equipment	2274.798621	<=	3600	=SUMPRODUCT($J$43:$J$76,$I$3:$I$36)
Internal equipment	4500	<=	4500	=SUMPRODUCT($K$43:$K$76,$I$3:$I$36)
Supplies cost	16508.79321	<=	100000	=SUMPRODUCT($L$43:$L$76,$I$3:$I$36)
Storage/Handling cost	200000	<=	200000	=SUMPRODUCT($M$43:$M$76,$I$3:$I$36)
Prepared meals for crew and volunteers	2797.631709	<=	5000	=SUMPRODUCT($N$43:$N$76,$I$3:$I$36)

Sensitivity Analysis

- If the constraint for Internal Equipment Utilization is relaxed, meals yield can be increased by 25.13 meals per forklift hour up to 584 hours.

- If the constraint for storage handling is relaxed, meals yield can be increased by 3.61 meals up to $11,368

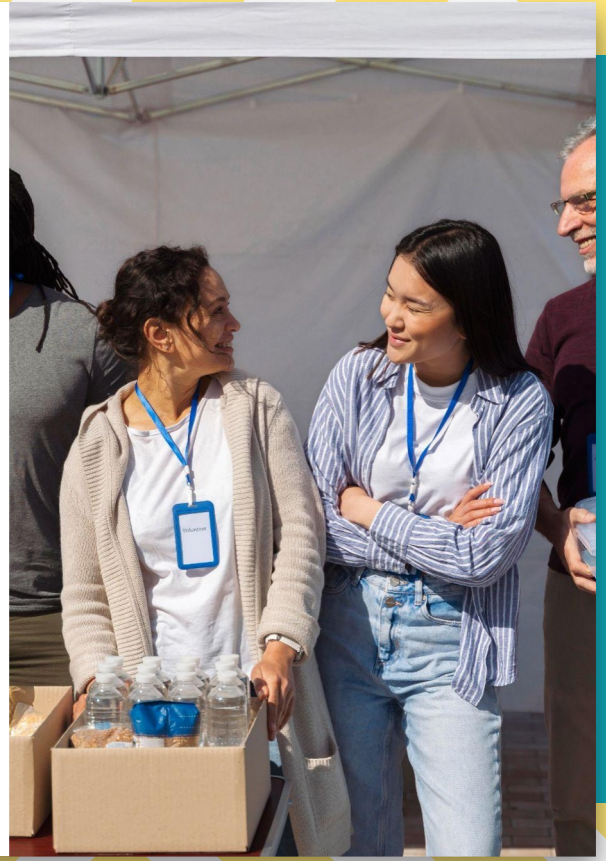
Sensitivity Analysis

After studying the binding constraints of our model, our recommendation would be to increase the number of maximum allowable events for:

Media event I, Church drives I, Church drives II, Auction I, Auction III, Dinner and blues event, Dinner and jazz event, Concert event III, Zoo event, 5K run I, 5K run II, 5K run III, Golf tournament I, Golf tournament II, Company event I, Retail event, Matching gift, Sales drive I, Sales drive II, Food competition I, Food competition II, Social media drive I, Social media drive III, Social media drive III, Pledge event I, Pledge event II, Pledge event III

04

Results & **Benefits**



IMPACT ON THE FOOD BANK

OPTIMAL RESOURCES

The model helped inform the organization on what the optimal number of volunteers was for every event. This helped reduce the risks of having too many volunteers for each event, and helped the managerial team plan ahead of time

OF EVENTS

This model guided the organization on which and how many events should be executed every year in order to receive the maximum amount of donations

INFORMATION ON INITIATIVES

This model provided a wealth of information to the management team on its initiatives, including which events were the least impactful, and which resources were contributing to which events by how much

1.72 MILLION

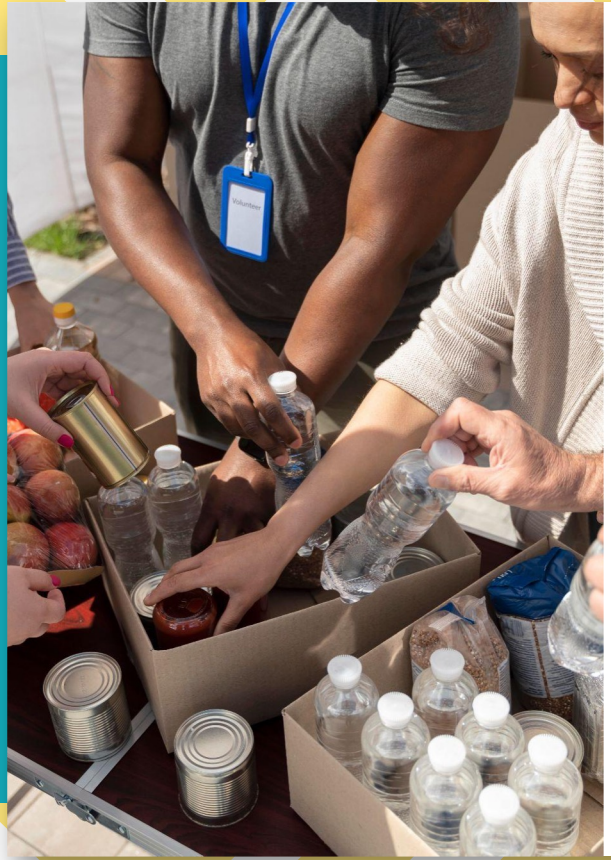
Additional meals per year because of this initiative, which is a 41% increase in meals

MODEL IMPACT

Original annual meals yield:
4,154,769

Optimized annual meals yield:
18,546,444

Improvement: 346.39%



05

Real-life **Application**

UMD End Hunger Campaign

Using the logic used in model 1, we have developed a model for the University of Maryland. The 11 schools under University of Maryland organize a number of events every year to raise money and food for donations to the low-income community in the DMV area.

The 11 schools have resource constraints and maximum number of events allowed. Since UMD wants all the schools involved in this campaign, every school has to host at least 1 event in the year.

INPUT DATA

Input					**Calculations**
Event Name	*Average food pounds raised per event*	*Average USD raised per event ($)*	*Maximum number of events in a year*	*Minimum number of events in a year*	*Meals yield per event*
College of Agriculture and Natural Resources	300	0	4200	1	230.7692308
School of Architecture	20000	100000	3	1	515384.6154
College of Arts and Humanities	128000	8897	9	1	142946.5385
Robert H. Smith School of Business	0	825	3	1	4125
College of Computer Science	8000	750	2	1	9903.846154
College of Education	0	58721	3	1	293605
A. James Clark School of Engineering	0	1200	3	1	6000
Philip Merrill College of Journalism	0	5000	1	1	25000
College of Information Studies	0	4500	12	1	22500
School of Public Health	0	15000	1	1	75000
School of Public Policy	0	22618	3	1	113090

MODEL

OBJECTIVE FUNCTION

Maximize Total Annual Meals Yield	3,233,677.58

CONSTRAINTS

Resource Pool	Utilization	Relationship	Maximum Capacity
Paid staff	1189.03	<=	12000
Volunteers	1215	<=	20000
Internal equipment	1000	<=	1000
Supplies cost	3674.78	<=	30000
Handling and inventory cost	1707.89	<=	18000
Snacks for staff	895.78	<=	5000

CONCLUSION

- Linear Optimization was applied to this problem to solve Harvest Hope Food Bank's meals gap
- This has the propensity to increase annuals meals yield by 346% for HHFB.
- This model was then applied to the University of Maryland's End Hunger Campaign, which can provide meals to more low-income people in the DMV area.

THANK YOU!