CROP-S: A Decision Support Tool for District Level Planning of Agricultural Crops for Maximizing Profits of Farmers

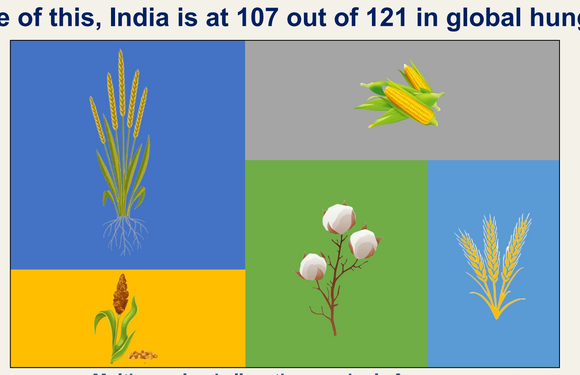
Abhishek Kumar Chaudhary, Mayank Bhardwaj

Advisor : Prof. Y. Narahari

Indian Institute of Science, Bangalore

Motivation

- India is the second largest producer of farm products
- In 2018, 50% of the Indian workforce was involved in the agriculture
- India ranks first based on the cultivated area
- In spite of this, India is at 107 out of 121 in global hunger index



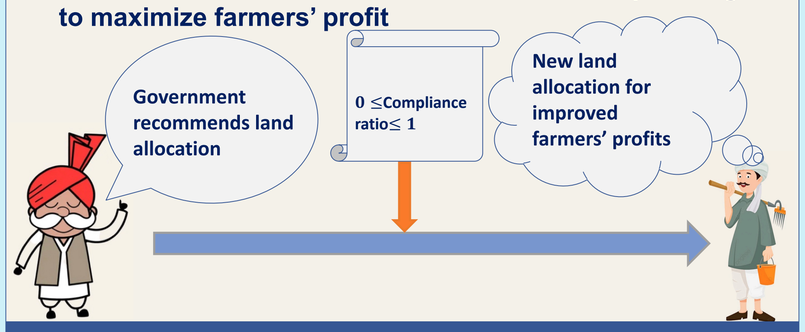
Courtesy: Google Images

Multi-crop land allocation on single farm

Source: Wikipedia and Byju.com

Goal

- Mismatch between the crops produced and the market demands lead crop dumping and crop wastage
- Design a tool which gives land allocation to alleviate the problem
- Government can make recommendation of crop acreages to maximize farmers' profit



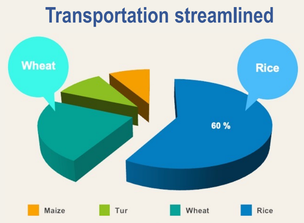
How can we achieve the goal ?

Courtesy: Google Images

Optimize storage

Transportation streamlined

Controlling imports and exports



Recommend final allocation

Background

- Crop planning is an important and well studied problem, at the micro or farm-level and at the macro or regional level
- The following approaches are wisely used in literature
  - Objectives used: Maximize revenue, profits, employment or minimize land use, water use and machinery
  - Methods used: Linear programming, quadratic programming, dynamic programming, fuzzy goal programming and agent based models
  - Constraints used: Land, labour, credit, machine, soil condition, capital and import-export bounds

The model

Workflow of the CROP project.
The orange boxes show simulated parameters and blue boxes have static parameters

Data sources

dacnet
The yield, area under production, and cost of cultivation for each district

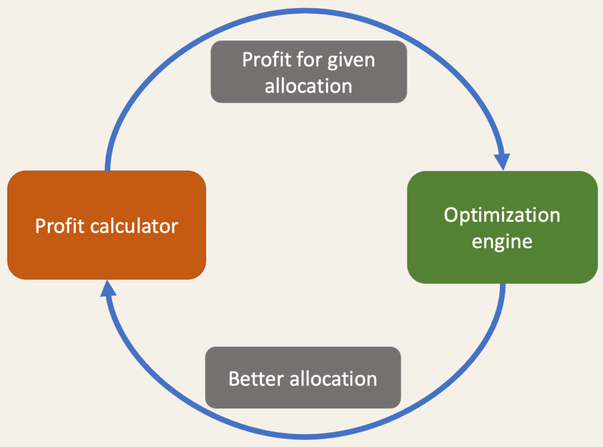
agmarknet
Price data for each farmers market

FOIS and trucksuvidha
Rail and truck transportation costs

comerce.gov.in
Procurement marketplace for inputs and services

Architecture of CROP-S

- Two CROP-S models are developed in this work.
- In-house non-linear model:
  - This model has two components as given in the figure below:

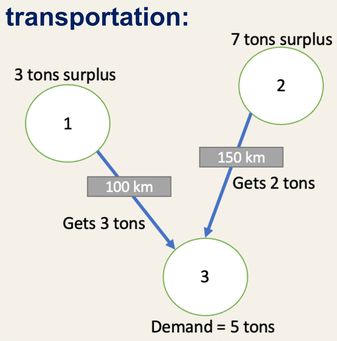


- The profit calculator uses the formula:

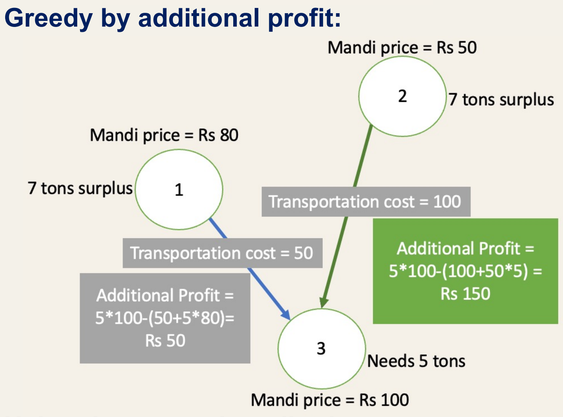
Profit = Revenue – (Transport cost + Production cost)

- Revenue of the state is obtained using the final stock in each districts and district-wise the selling price
- Production cost is calculated as district-wise sum cost of cultivation of crops and area under cultivation
- Transport cost is obtained as sum of transport cost (non-linear) of each crop between districts. Three possible transportation strategies were tried:

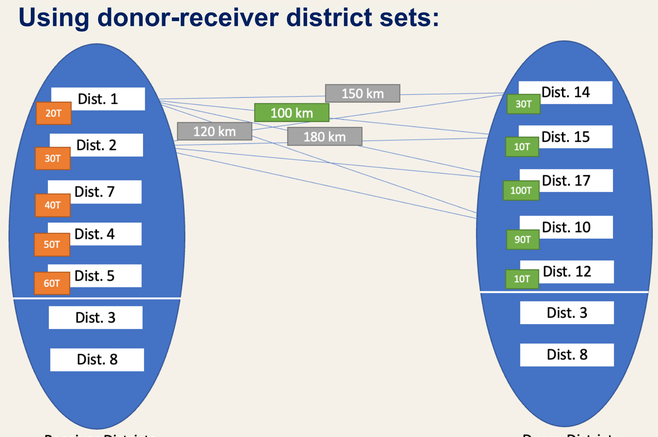
1. **Greedy transportation:**



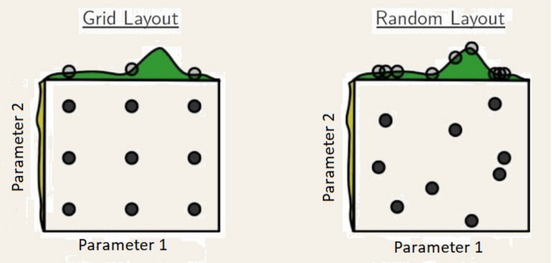
2. **Greedy by additional profit:**



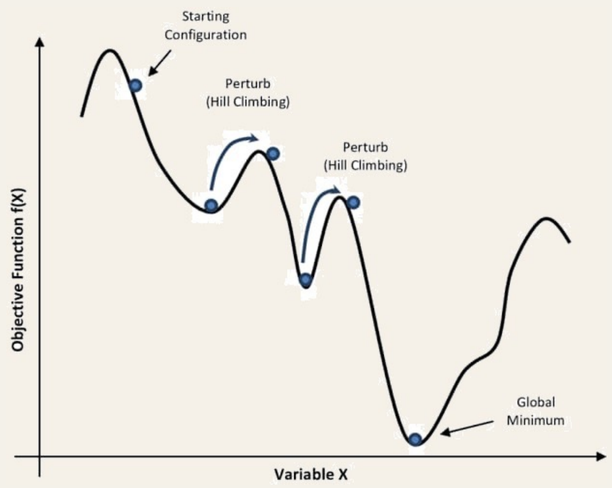
3. **Using donor-receiver district sets:**



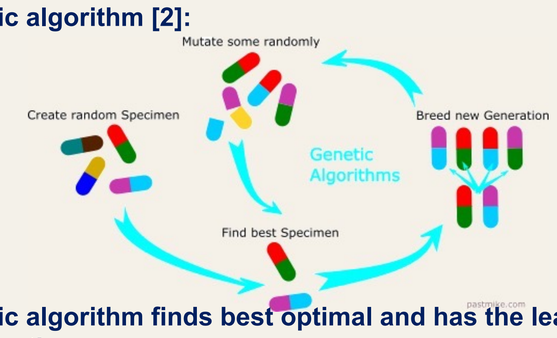
- For optimization engine 3 algorithms were tried:
- Grid search and random grid search:



- Simulated annealing [1]:



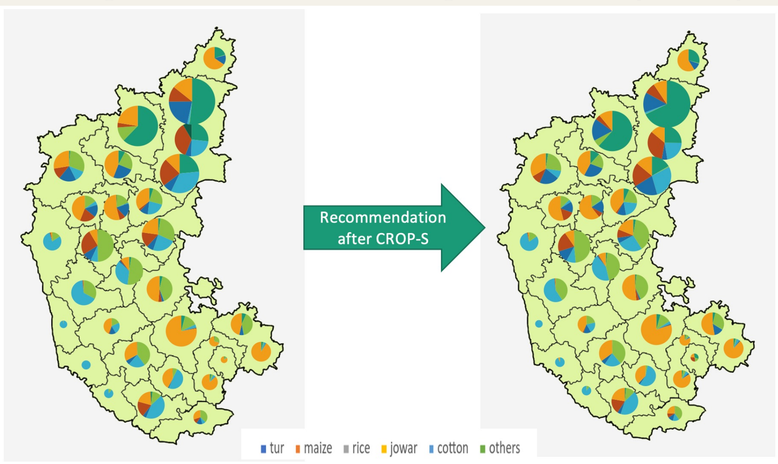
- Genetic algorithm [2]:



- Genetic algorithm finds best optimal and has the least running time
- Linear model using gurobi optimization solver
- This is a linear model with the following constraints
- Total cropped land area in each district is constant
- Stock after transportation lies between maximum and minimum demands for the each district
- Objective = Maximize(*Profit*), where profit equation is same as non-linear model

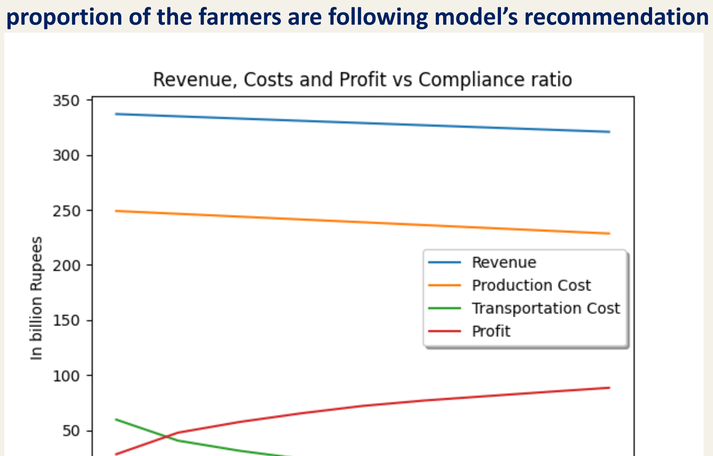
Contributions

- The paper accepted in IEEE CASE 2023 for the novel design of crop allocation engine at the district level
- Change in allocation after running CROP-S on top 12 crops:

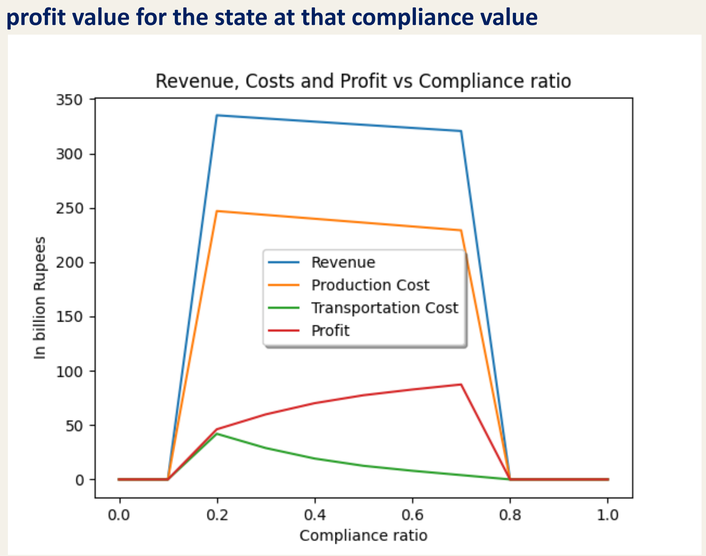


Results

- The profit increased using our model. Compliance shows what proportion of the farmers are following model's recommendation



- Shaded allocation: If the compliance value is known beforehand, we can recommend farmers a shaded allocation that maximizes the profit value for the state at that compliance value



Future work

- Adding factors like fertilizer cost, rainfall, soil conditions, credit availability, warehouse details, sale incentives
- Faster runtime using better optimization algorithm and GPUs
- Making the model more granular by going to farm level
- Adding agent based simulations to reflect rational and intelligent behaviour of individual farmers

References

[1] N. Metropolis, A. W. Rosenbluth, M. N. Rosenbluth, A. H. Teller, and E. Teller, "Equation of state calculations by fast computing machines," The journal of chemical physics, vol. 21, no. 6, pp. 1087–1092, 1953.

[2] D. Whitley, "A genetic algorithm tutorial," Statistics and computing, vol. 4, pp. 65–85, 1994.