Agriplots Linear Programming Model

Parameters

- N — Set of possible locations to install PV's
- p_i — Energy production (10^6 kWh/year) for installing PV at location $i \in$ N
- a_i — Area in dunam used for installing PV at location $i \in$ N
- c_i — influence on crops from installing PV at location $i \in$ N
- r_i — potential revenue before installing PV at location $i \in$ N
- A — Upper bound on the total area in dunam that can be used for installing PV's
- C — Minimal loss of revenue in percentage allowed as a result of influence on crops
- D — Set of Yeshuvim that contain locations
- d_j — upper bound of energy production in yeshuv $j \in$ D
- E — Set of Eshkolot that contain locations
- e_j — Wealth ratio of eshkol $j \in$ E
- F — Set of Machozot that contain locations
- f_j — upper bound of energy production in machoz $j \in$ F
- G_{max} — upper bound on the Gini coefficient value

Decision Variables

- x_i — Binary variable, equals to 1 if a PV is installed at location $i \in$ N, otherwise 0.
- y_i — Total energy produced in eshkol $i \in$ E.
- z_{ij} — Absolute difference between energy production, weighted by wealth, for pair of eshkolot i,j **ϵ** E such that i<j. equals to $|e_j \cdot y_j - e_i \cdot y_i|$.

Objective Function

$$\text{Maximize} \quad \sum_{i \in N} (x_i \cdot \mathrm{P}_i)$$

Constraints

1. $\sum_{i \in N} x_i \cdot a_i \leq A$
2. $\frac{\sum_{i \in N} x_i \cdot c_i \cdot r_i}{\sum_{i \in N} x_i \cdot r_i} \geq C$
3. $\sum_{i \in j} x_i \cdot p_i \leq d_j , \quad \forall j \in D$
4. $\sum_{i \in j} x_i \cdot p_i \leq f_j , \quad \forall j \in F$
5. $y_j = \sum_{i \in j} x_i \cdot p_i , \quad \forall j \in E$
6. $z_{ij} \geq e_j \cdot y_j - e_i \cdot y_i , \quad \forall i, j \in E: \ i < j$
7. $z_{ij} \geq e_i \cdot y_i - e_j \cdot y_j , \quad \forall i, j \in E: \ i < j$
8. $\sum_{i \in E} \sum_{j \in E, j > i} z_{ij} \leq G_{max} \cdot \sum_{i \in E} y_i , \quad \forall i, j \in E: \ i < j$
9. $x_i \in \{0,1\} \quad \forall i \in N$

Explanations

- The **objective function** maximizes the total energy production from the installed PV systems at various locations.
- **Constraint (1)** places an upper bound on the total area used for PV installations.
- **Constraint (2)** ensures that the change in revenue as a result of installing the PV's and influencing the crops remains above a certain threshold.
- **Constraint (3)** ensures that the total energy production for each Yeshuv does not exceed it's energy consumption limit.
- **Constraint (4)** ensures that the total energy production for each machoz does not exceed it's energy consumption limit.
- **Constraint (5)** assigns values to the y_i decision variables by summing the energy produced of all locations in eshkol i that had a PV installed in them ($x_i = 1$), for all i.
- **Constraint (6) + (7)** linearize the absolute values of decision variables z_{ij} so that we could use it in our LP model
- **Constraint (8) places** an upper bound on the value of the Gini coefficient, using the G_{max} parameter. The value of the Gini coefficient G is calculated with the following formula:
  $G = \frac{\sum_{i \in E} y_i}{\sum_{i \in E} \sum_{j \in E, j > i} z_{ij}}$
- **Constraint (9)** requires that each decision variable x_i is binary, meaning that a PV system is either installed or not at each location.

Table of contents (need a better name)

Value/variable in the LP model	**Value/variable in the data**
N	OBJECTID (column from dataset)
p_i	Energy production (fix) mln kWh/year (column from dataset)
a_i	Dunam (column from dataset)
c_i	Average influence of PV on crops (modified column from dataset)
r_i	Potential revenue from crops before PV, mln NIS (column from dataset)
A	Parameter decided by user
C	Parameter decided by user
D	YeshuvName (column from dataset)
d_j	energy_consumption_by_yeshuv
E	yeshuvim_in_eshkolot
e_j	energy_division_between_eshkolot
F	Machoz (column from dataset)
f_j	energy_consumption_by_machoz
G_{max}	G_max