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 ∈ N
- a_i — Area in dunam used for installing PV at location i ∈ N
- c_i — influence on crops from installing PV at location i ∈ N
- r_i — potential revenue before installing PV at location i ∈ 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 ∈ D
- E — Set of Eshkolot that contain locations
- e_j — Wealth ratio of eshkol j ∈ E
- F — Set of Machozot that contain locations
- f_j — upper bound of energy production in county j ∈ 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 ∈ N, otherwise 0.
- y_i — Total energy produced in eshkol i ∈ 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. $$\sum_{i \in N} x_i \cdot \mathrm{a}_i \leq A$$
2. $$\frac{\sum_{i \in N} x_i \cdot \mathrm{c}_i \cdot \mathrm{r}_i}{\sum_{i \in N} x_i \cdot \mathrm{r}_i} \geq \mathrm{C}$$
3. $$\sum_{i \in j} x_i \cdot \mathrm{p}_i \leq \mathrm{d}_j, \qquad \forall j \in \mathrm{D}$$
4. $$\sum_{i \in j} x_i \cdot \mathrm{p}_i \leq \mathrm{f}_j, \qquad \forall j \in \mathrm{F}$$
5. $$\mathrm{y}_j = \sum_{i \in j} x_i \cdot \mathrm{p}_i, \qquad \forall j \in \mathrm{E}$$
6. $$\mathrm{z}_{ij} \geq \mathrm{e}_j \cdot \mathrm{y}_j - \mathrm{e}_i \cdot \mathrm{y}_i, \qquad \forall \mathrm{i}, j \in \mathrm{E}:\ \mathrm{i} < \mathrm{j}$$
7. $$\mathrm{z}_{ij} \geq \mathrm{e}_i \cdot \mathrm{y}_i - \mathrm{e}_j \cdot \mathrm{y}_j, \qquad \forall \mathrm{i}, j \in \mathrm{E}:\ \mathrm{i} < \mathrm{j}$$
8. $$\sum_{i \in E} \sum_{j \in E, j > i} \mathrm{z}_{ij} \leq G_{max} \cdot \sum_{i \in E} \mathrm{y}_i, \qquad \forall \mathrm{i}, j \in \mathrm{E}:\ \mathrm{i} < \mathrm{j}$$
9. $$x_i \in \{0,1\} \quad \forall i \in \mathrm{N}$$

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