PROBLEM STATEMENT

Linear Programming Model for Operational Optimization of Agricultural Profit considering Hydroclimatic Data.

BRIEF & OBJECTIVE

We worked on a hydroclimatic monitoring system integrated with linear programming(LP) methods to optimize agricultural output and improve water management in the region. We integrated the hydroclimatic monitoring system and the LP method to optimize agricultural net benefits in scenarios of rainfall delay or reduction.

Linear programming (LP) has superb usability in these studies, with the problem formulation adapted to different objectives such as (1) maximizing net economic benefits; (2) reducing crop production costs; (3) indicating resources allocation; and (4) improving economic and environmental indicators

DATA: CROP PRODUCTION YIELD

Farm or Municipality	Crop	Cycle type	Evaluated period (fortnight after sowing)	Production cost (R$ ha-1)	Labor needs (h day-1 ha-1)	Tractor and truck needs (h day-1 ha-1)	Sprayer needs (h day-1 ha-1)	Hervester needs (h day-1 ha-1)	Expected yield (kg ha-1)
Sama[f]	Soybean	short	0*	106.0	1.0	0.0	0.0	0	0.0
			1	728.3	2.3	0.0	1.0	0	0.0
			2	485.9	2.0	0.0	1.3	0	0.0
			3	386.5	1.7	0.0	1.0	0	0.0
			4	443.1	1.3	0.0	1.0	0	0.0
			5	337.3	1.3	0.0	1.3	0	0.0
			6	165.3	1.0	0.0	1.0	0	0.0
			7	105.2	1.0	0.0	1.0	0	0.0
			8	259.5	2.7	0.7	0.7	1	5500.0
		average	0*	106.0	1.0	0.0	0.0	0	0.0
			1	586.1	2.0	0.0	0.9	0	0.0
			2	536.4	1.9	0.0	1.0	0	0.0
			3	133.0	1.3	0.0	1.3	0	0.0
			4	352.4	1.4	0.0	0.9	0	0.0
			5	345.5	1.1	0.0	0.9	0	0.0
			6	281.0	1.1	0.0	1.1	0	0.0
			7	257.5	1.4	0.0	1.1	0	0.0
			8	134.7	0.9	0.0	0.9	0	0.0
			9	382.3	3.9	0.7	1.3	1	5040.0
		long	0*	106.0	1.0	0.0	0.0	0	0.0
			1	680.5	2.5	0.0	1.0	0	0.0
			2	575.1	2.0	0.0	1.0	0	0.0
			3	222.0	1.5	0.0	1.5	0	0.0
			4	212.6	1.0	0.0	1.0	0	0.0
			5	342.2	1.0	0.0	0.5	0	0.0
			6	210.6	1.0	0.0	1.0	0	0.0
			7	227.8	1.0	0.0	1.0	0	0.0
			8	89.8	0.5	0.0	0.5	0	0.0
			9	331.2	1.5	0.0	1.5	0	0.0
			10	242.2	2.5	1.0	0.5	1	4200.0

DATA: CROP PRODUCTION YIELD

Farm or Municipality	Crop	Cycle type	Evaluated period (fortnight after sowing)	Production cost (R$ ha-1)	Labor needs (h day-1 ha-1)	Tractor and truck needs (h day-1 ha-1)	Sprayer needs (h day-1 ha-1)	Hervester needs (h day-1 ha-1)	Expected yield (kg ha-1)
Floryl[f]	Soybean	short	1	3100.0	na	na	na	na	na
			8	na	na	na	na	na	3900.0
	Maize 1st season	average	1	2500.0	na	na	na	na	na
			9	na	na	na	na	na	10800.0
DRB MOR[f] and DECSD[f]	Cotton	long	1	11959.5	na	na	na	na	na
			14	na	na	na	na	na	5250.0
	Bean 1st and 2nd season	average	1	5788.2	na	na	na	na	na
			7	na	na	na	na	na	4200.0
	Maize 1st and 2nd season	long	1	4724.7	na	na	na	na	na
			12	na	na	na	na	na	10200.0
	Soybean	average	1	4416.1	na	na	na	na	na
			9	na	na	na	na	na	5100.0
	Wheat	average	1	381.8	na	na	na	na	na
			8	na	na	na	na	na	4200.0
Busato[f]	Cotton	long	1	9969.0	na	na	na	na	na
			14	na	na	na	na	na	5250.0
	Maize 1st and 2nd season	long	1	4599.9	na	na	na	na	na
			12	na	na	na	na	na	10200.0
	Soybean	average	1	3091.5	na	na	na	na	na
			9	na	na	na	na	na	4800.0
Barreiras[m], Correntina[m], and Santa Rita de Cássia[m]	Cotton	long	1	6847.1	na	na	na	na	na
			14	na	na	na	na	na	5250.0
	Bean 1st and 2nd season	average	1	1183.5	na	na	na	na	na
			7	na	na	na	na	na	4200.0
	Maize 1st and 2nd season	long	1	4103.0	na	na	na	na	na
			12	na	na	na	na	na	10200.0
	Soybean	average	1	2844.7	na	na	na	na	na
			9	na	na	na	na	na	5100.0

DATA: CONSTRAINT EQUATIONS

Farm or Municipality	Irrigated Area (Hectares)	Rainfed Area (Hectares)	Water Grant (m^3 day^{-1})	Evaluated Crop	Season	Labor Availability (h day^{-1})	Tractor Availability (h day^{-1})	Truck Availability (h day^{-1})	Sprayer Availability (h day^{-1})	Harvester Availability (h day^{-1})
Sama [f]	1221.10	878.50	39,297.50	Soybean	2018/19	160	16	16	32	16
Floryl [f]	950.00	120.00	68,437.00	Maize [1–2]; Soybean	2019/20	Not applicable				
DRB MOR [f]	4267.00	646.00	101,760.00	Cotton; Bean [1–2]; Maize [1–2]; Soybean; Wheat	2017 [aw]; 2017 [ss]; 2018 [aw]; 2018 [ss]; 2019 [aw]; 2019 [ss]					
DECDS [f]	3299.00	0.00	156,552.00							
Busato [f]	4246.80	676.00	23,240.00	Cotton; Maize [1–2]; Soybean	2019/20					
Barreiras [m]	42,760.00	291,948.00	4,586,256.52	Cotton; Bean [1–2]; Maize [1–2]; Soybean	2018 [ss]; 2019 [aw]; 2019 [ss]; 2020 [aw]; 2020 [ss]; 2021 [aw]					
Correntina [m]	15,008.00	408,022.00	2,444,307.23							
Santa Rita de Cássia [m]	60.00	7293.00	44,000.00							

DATA: CONSTRAINT EQUATIONS

Farm or Municipality	Minimum *ETo*	Maximum *ETo*	Minimum Rainfall	Maximum Rainfall
	(mm fortnight^{-1})	(mm fortnight^{-1})	(mm fortnight^{-1})	(mm fortnight^{-1})
Sama [f]	45.2	96.9	0.0	172.8
Floryl [f]	42.7	86.7	0.0	142.8
DRB MOR [f]	46.2	107.5	0.0	142.8
DECDS [f]	43.1	89.9	0.0	232.2
Busato [f]	41.1	94.7	0.0	168.8
Barreiras [m]	54.7	88.6	0.2	103.7
Correntina [m]	54.5	84.8	0.2	108.7
Santa Rita de Cássia [m]	59.0	91.6	0.0	101.5

LP FORMULATION

Objective Function

Maximize:- Net Benefit (NB) = $\sum R_{ijkl} \times X_{ijkl} - \sum C_{ijkl} \times X_{ijkl}$

Where $\mathbf{R_{ijkl}}$ is the unitary revenue value (BRL ha−1) and $\mathbf{C_{ijkl}}$ is the unitary production cost (BRL ha−1).

$Xijkl$ (in hectares) is the optimum value for the planted area;

i= crop name, **j**= crop cycle type, **k**= Farm or Municipality, **l**= sowing period

X_{ijkl} **:** SsSA8= Soybean short cycle SAMA 8 fortnight,

- **Ssfl8** = Soybean Short cycle Floryl 8 fortnight
- **Mafl9** =Maize average cycle Floryl 8 fortnight
- **Cldmd14** = Cotton Long cycle DRB MOR and DECSD 14 fortnight
- **Mlb12** = Maize long Busato 12 fortnight
- **Babcs7** =Bean Average Barreirasm, Correntinam, and Santa Rita de Cássiam 7 fortnight

SAMA: Sama, **Fl:** Floryl, **DMD:** DRB MOR and DECSD**, B:** Busato**, BCS:** Barreiras, Correntina, and Santa Rita de Cássia

OBJECTIVE FUNCTION:

- **NB(SAMA) = (** 6984.75*SsSA8 + 6400.57*SaSA9 +5333.81*SlSA10 **) - (**259.52*SsSA8 + 382.26*SaSA9 + 242.15*SlSA10 **)**
- **NB(FL) = (** 4769.7*Ssfl8 + 6647.25*Mafl9 **) - (** 3100*Ssfl8 + 2500*Mafl9 **)**
- **NB(DMD) = (** 32713.16*Cldmd14 + 11206.22*Badmd7 + 5773.56*Mldmd12 + 5854.7*Sadmd9 + 3763.73*Wadmd8 **) - (**11959.48*Cldmd14 + 5788.16*Badmd7 + 4724.72*Mldmd12 + 4416.13*Sadmd9 + 381.83*Wadmd8 **)**
- **NB(B) = (** 7982.33*Clb14 + 7345.32*Mlb12 + 6710.1*Sab9 **) - (** 9969.03*Clb14 + 4599.85*Mlb12 + 3091.52*Sab9 **)**
- **NB(BCS) = (** 34831.93*Clbcs14 + 13694.54*Babcs7 + 6811.97*Mlbcs12 + 6977.56*Sabcs9 **) - (**6847.07*Clbcs14 + 1183.51*Babcs7 + 4102.99*Mlbcs12 + 2844.72*Sabcs9**)**

Net Benefit = **(** 6984.75*SsSA8 + 6400.57*SaSA9 +5333.81*SlSA10 + 4769.7*Ssfl8 + 6647.25*Mafl9 + 32713.16*Cldmd14 + 11206.22*Badmd7 + 5773.56*Mldmd12 + 5854.7*Sadmd9 + 3763.73*Wadmd8 + 7982.33*Clb14 + 7345.32*Mlb12 + 6710.1*Sab9 + 34831.93*Clbcs14 + 13694.54*Babcs7 + 6811.97*Mlbcs12 + 6977.56*Sabcs9 **) - (** 259.52*SsSA8 + 382.26*SaSA9 + 242.15*SlSA10 + 3100*Ssfl8 + 2500*Mafl9 + 11959.48*Cldmd14 + 5788.16*Badmd7 + 4724.72*Mldmd12 + 4416.13*Sadmd9 + 381.83*Wadmd8 + 9969.03*Clb14 + 4599.85*Mlb12 + 3091.52*Sab9 + 6847.07*Clbcs14 + 1183.51*Babcs7 + 4102.99*Mlbcs12 + 2844.72*Sabcs9 **)**

LP FORMULATION

Constraints and Solutions Method:-

- **Labour needs:**
  Total labour need for growing different crops at different cropping cycle at various locations should be less than the total labour available

- **Tractor needs:**
  Total labour need for growing different crops at different cropping cycle at various locations should be less than the total labour available

- **Sprayer needs:**
  Total labour need for growing different crops at different cropping cycle at various locations should be less than the total labour available

- **Harvester needs:**
  Total labour need for growing different crops at different cropping cycle at various locations should be less than the total labour available

LP FORMULATION

Constraints and Solutions Method:-

Crop Water Demand:-

$$CWDX_{ijkl} = \sum X_{ijkl} \times ETc \times Kr$$

$CWDX_{ijkl}$ -Crop water demand

ETc - crop evapotranspiration(mm day^{-1})

Kr- constant

$$ETc = ETo \times Kc_{ijkl}$$

ETo- reference evapotranspiration(mm day^{-1})

Kc_{ijkl}-crop coefficient

The constraint is that the crop water demand should be less than or equal to the total water available which is a sum of both irrigation water grant and rainfall received.

LP FORMULATION: WATER CONSTRAINT VALUE

Table 3. Crop, cycle type, duration *Kc*, *Kr*, and ranging sowing time.

Crop	Cycle Type	Cycle Duration (Fortnight, or 15 Days)	Initial *Kc*	Average *Kc*	Final *Kc*	*Kr* [44]	Range Sowing Time (Fortnight–Month) [42]
Soybean	short	8	0.60	0.70	0.80	0.80	1–10 to 2–02
	average	9					
	long	10					
Maize 1st season	average	9	0.65	1.00	0.60	0.88	1–10 to 2–02
	long	12	0.60		0.50		
Maize 2nd Season	average	9	0.65	1.00	0.60	0.88	1–05 to 2–06
	long	12	0.60		0.50		
Cotton	long	14	0.50	0.90	0.38	0.80	1–11 to 2–02
Bean 1st season	average	7	0.70	1.20	0.60	0.87	1–10 to 2–02
Bean 2nd season	average	7	0.70	1.20	0.60	0.87	1–04 to 2–06
Wheat	average	8	0.70	1.20	0.40	0.85	1–08 to 2–09

Table 3. Crop, cycle type, duration *Kc*, *Kr*, and ranging sowing time.

Crop	Cycle Type	Cycle Duration (Fortnight, or 15 Days)	Initial *Kc*	Average *Kc*	Final *Kc*	*Kr* [44]	Range Sowing Time (Fortnight–Month) [42]
Soybean	short	8	0.60	0.70	0.80	0.80	1–10 to 2–02
	average	9					
	long	10					
Maize 1st season	average	9	0.65	1.00	0.60	0.88	1–10 to 2–02
	long	12	0.60		0.50		
Maize 2nd Season	average	9	0.65	1.00	0.60	0.88	1–05 to 2–06
	long	12	0.60		0.50		
Cotton	long	14	0.50	0.90	0.38	0.80	1–11 to 2–02
Bean 1st season	average	7	0.70	1.20	0.60	0.87	1–10 to 2–02
Bean 2nd season	average	7	0.70	1.20	0.60	0.87	1–04 to 2–06
Wheat	average	8	0.70	1.20	0.40	0.85	1–08 to 2–09

LP FORMULATION : CONSTRAINTS

Water Demand (mm ha day-1)

- SsSA8*4.429714286 + SaSA9*4.429714286 + SlSA10*4.429714286 **<= 14772.95 (SAMA)**
- Ssfl8*3.963428571 + Mafl9*3.269828 **<= 8067.7 (FL)**
- Cldmd14*2.143197 + BAdmd7*3.680095 + Mldmd12*3.101996 + Sadmd9*4.511994 + Wadmd8*2.396997 **<=32420.4 (DMD)**
- Clb14*2.056343 + Mlb12*2.976286 + Sab9*4.329143 **<= 10474.63 (B)**
- Clbcs12*1.918091 + Babcs7*3.293564 + Mlbcs12*2.776184 + Sabcs9*4.038086 **<= 6090830 (BCS)**

LP FORMULATION : CONSTRAINTS

For Labor Availability (h day-1)

- SsSA8*2.7+ SaSA9*3.9 + SISA10*2.5 **<= 160 (SAMA)**
- Ssfl8*0 + Mafl9*0 **<= 160 (FL)**
- Cldmd14*0 + BAdmd7*0 + Mldmd12*0 + Sadmd9*0 + Wadmd8*0 **<= 160 (DMD)**
- Clb14*0 + Mlb12*0 + Sab9*0 **<= 160 (B)**
- Clbcs12*0 + Babcs7*0 + Mlbcs12*0 + Sabcs9*0 **<= 160 (BCS)**

For Tractor Availability (h day-1)

- SsSA8*0.7+ SaSA9*0.7+ SISA10*1 **<= 16 (SAMA)**
- Ssfl8*0 + Mafl9*0 **<= 16 (FL)**
- Cldmd14*0 + BAdmd7*0 + Mldmd12*0 + Sadmd9*0 + Wadmd8*0 **<= 16 (DMD)**
- Clb14*0 + Mlb12*0 + Sab9*0 **<= 16 (B)**
- Clbcs12*0 + Babcs7*0 + Mlbcs12*0 + Sabcs9*0 **<= 16 (BCS)**

LP FORMULATION

For Sprayer (h day-1)

- SsSA8*0.7+ SaSA9*1.3 + SISA10*0.5 **<= 32** **(SAMA)**
- Ssfl8*0 + Mafl9*0 **<= 32** **(FL)**
- Cldmd14*0 + BAdmd7*0 + Mldmd12*0 + Sadmd9*0 + Wadmd8*0 **<= 32** **(DMD)**
- Clb14*0 + Mlb12*0 + Sab9*0 **<= 32** **(B)**
- Clbcs12*0 + Babcs7*0 + Mlbcs12*0 + Sabcs9*0 **<= 32** **(BCS)**

For Harvester (h day-1)

- SsSA8*1+ SaSA9*1 + SISA10*1 **<= 16** **(SAMA)**
- Ssfl8*0 + Mafl9*0 **<= 16** **(FL)**
- Cldmd14*0 + BAdmd7*0 + Mldmd12*0 + Sadmd9*0 + Wadmd8*0 **<= 16 (DMD)**
- Clb14*0 + Mlb12*0 + Sab9*0 **<= 16** **(B)**
- Clbcs12*0 + Babcs7*0 + Mlbcs12*0 + Sabcs9*0 **<= 16** **(BCS)**

LP FORMULATION

Land Constraint

- SsSA8 + SaSA9 + SlSA10 **<=2099.6 (ha) (SAMA)**
- Ssfl8 + Mafl9 <= **1070 (ha) (FL)**
- Cldmd14 + BAdmd7 + Mldmd12 + Sadmd9 + Wadmd8 **<=8212 (ha) (DMD)**
- Clb14 + Mlb12 + Sab9 **<= 4922 (ha) (B)**
- Clbcs12 + Babcs7 + Mlbcs12 + Sabcs9 **<= 765091 (ha) (BCS)**

Standard constraint

- SsSA8, SaSA9, SlSA10 **>=0 (SAMA)**
- Ssfl8, Mafl9 **>=0 (fl)**
- Cldmd14, BAdmd7, Mldmd12, Sadmd9, Wadmd8 **>=0 (DMD)**
- Clb14, Mlb12, Sab9 **>=0 (B)**
- Clbcs12, Babcs7, Mlbcs12, Sabcs9 **>=0 (BCS)**

SOLUTION - R- CODE (SAMA)

```
# Load the lpSolve library
library(lpSolve)
# Define the coefficients of the objective function
c.obj <- c(6984.75, 6400.57, 5333.81) - c(259.52, 382.26, 242.15)
length(c.obj)
# Define the matrix of coefficients for the constraints
A <- matrix(c(2.7,3.9,2.5,0.7,0.7,1,0.7,1.3,0.5,1,1,1,4.43,4.43,4.43,1,1,1),
            ncol = length(c.obj), byrow = TRUE)
A

# Define the right-hand side values for the constraints
b <- c(160, 16, 32, 16, 14772.95, 2099.6)

# Set the direction of the inequalities (<=)
const.dir <- rep("<=", nrow(A))

# Function to solve the linear programming problem and print results
solve_lp <- function(c.obj, A, b) {
  lp_solution <- lp(direction = "max", objective.in = c.obj, const.mat = A, const.dir = const.dir, const.rhs = b)
  cat("Status:", lp_solution$status, "\n")
  cat("Optimal Value:", lp_solution$objval, "\n")
  cat("Optimal Solution:", lp_solution$solution, "\n")
}

# Solve the original problem
cat("Original Problem:\n")
solve_lp(c.obj, A, b)

# Sensitivity Analysis - Increase the coefficient of the first decision variable
cat("\nSensitivity Analysis - Increase Coefficient of SsSA8:\n")
c.obj_sensitivity <- c.obj
c.obj_sensitivity[1] <- c.obj_sensitivity[1] + 67850  # Increase the coefficient of SsSA8 by 100
solve_lp(c.obj_sensitivity, A, b)
c.obj_sensitivity

# Sensitivity Analysis - Increase the right-hand side value of the first constraint
cat("\nSensitivity Analysis - Increase RHS of Labor Availability Constraint:\n")
b_sensitivity <- b
b_sensitivity[4] <- b_sensitivity[4] + 1  # Increase the RHS of the first constraint by 10
solve_lp(c.obj, A, b_sensitivity)
b_sensitivity
```

INPUT MATRIX FOR SAMA

```
      [,1] [,2] [,3]
[1,] 2.70 3.90 2.50
[2,] 0.70 0.70 1.00
[3,] 0.70 1.30 0.50
[4,] 1.00 1.00 1.00
[5,] 4.43 4.43 4.43
[6,] 1.00 1.00 1.00
```

OPTIMIZED OUTPUT FOR SAMA

```
Optimal Value: 107603.7
Optimal Solution: 16 0 0
```

Optimal Profitability: 107603.7 R$

RESULT OF SAMA FORMULATION

The optimal profitability that we are getting of SAMA Farm from our analysis is 107603.7 R$. And our optimal solution is (16 0 0), which means that if we grow soybean of short cycle type in the optimal area obtained of 16 hectares then we will be making a profit of 107603.7 R$

SENSITIVITY ANALYSIS (SAMA)

```
# Solve the original problem
cat("Original Problem:\n")
solve_lp(c.obj, A, b)

# Sensitivity Analysis - Increase the coefficient of the first decision variable
cat("\nSensitivity Analysis - Increase Coefficient of SsSA8:\n")
c.obj_sensitivity <- c.obj
c.obj_sensitivity[1] <- c.obj_sensitivity[1] + 57850  # Increase the coefficient of SsSA8 by 100
solve_lp(c.obj_sensitivity, A, b)

# Sensitivity Analysis - Increase the right-hand side value of the first constraint
cat("\nSensitivity Analysis - Increase RHS of Labor Availability Constraint:\n")
b_sensitivity <- b
b_sensitivity[5] <- b_sensitivity[5] + 1  # Increase the RHS of the first constraint by 10
solve_lp(c.obj, A, b_sensitivity)
```

SENSITIVITY ANALYSIS (SAMA)

```r
# Load the lpSolve library
library(lpSolve)
# Define the coefficients of the objective function
c.obj <- c(6984.75, 6400.57, 5333.81) - c(259.52, 382.26, 242.15)
length(c.obj)
# Define the matrix of coefficients for the constraints
A <- matrix(c(2.7,3.9,2.5,0.7,0.7,1,0.7,1.3,0.5,1,1,1,4.43,4.43,4.43,1,1,1),
            ncol = length(c.obj), byrow = TRUE)
A

# Define the right-hand side values for the constraints
b <- c(160, 16, 32, 16, 14772.95, 2099.6)

# Set the direction of the inequalities (<=)
const.dir <- rep("<=", nrow(A))

# Function to solve the linear programming problem and print results
solve_lp <- function(c.obj, A, b) {
  lp_solution <- lp(direction = "max", objective.in = c.obj, const.mat = A, const.dir = const.dir, const.rhs = b)
  cat("Status:", lp_solution$status, "\n")
  cat("Optimal Value:", lp_solution$objval, "\n")
  cat("Optimal Solution:", lp_solution$solution, "\n")
}

# Solve the original problem
cat("Original Problem:\n")
solve_lp(c.obj, A, b)

# Sensitivity Analysis - Increase the coefficient of the first decision variable
cat("\nSensitivity Analysis - Increase Coefficient of SsSA8:\n")
c.obj_sensitivity <- c.obj
c.obj_sensitivity[1] <- c.obj_sensitivity[1] + 67850  # Increase the coefficient of SsSA8 by 100
solve_lp(c.obj_sensitivity, A, b)
c.obj_sensitivity

# Sensitivity Analysis - Increase the right-hand side value of the first constraint
cat("\nSensitivity Analysis - Increase RHS of Labor Availability Constraint:\n")
b_sensitivity <- b
b_sensitivity[4] <- b_sensitivity[4] + 1  # Increase the RHS of the first constraint by 10
solve_lp(c.obj, A, b_sensitivity)
b_sensitivity
```

BEFORE SENSITIVITY ANALYSIS

```
> solve_lp(c.obj, A, b)
Status: 0
Optimal Value: 107603.7
Optimal Solution: 16 0 0
```

AFTER SENSITIVITY ANALYSIS

```
> solve_lp(c.obj, A, b_sensitivity)
Status: 0
Optimal Value: 114328.9
Optimal Solution: 17 0 0
```

CONCLUSIONS OF SENSITIVITY ANALYSIS

Outputs:

```
> b_sensitivity[4] <- b_sensitivity[4] + 1  # Increase the RHS of the first constraint by 1
> solve_lp(c.obj, A, b_sensitivity)
Status: 0
Optimal Value: 114328.9
Optimal Solution: 17 0 0
```

Here, after changing the value of each RHS constant(b) by 1 unit, we get to see the following:

- Changing b_sensitivity[1], b_sensitivity[2], b_sensitivity[3], b_sensitivity[5] by 1 unit doesn't change the value of the optimal value and solution. Therefore, in these cases, shadow prices = 0
- But changing the value of b_sensitivity[4] by 1 unit changes the optimal value and solution. In this case, the shadow price =114328.9 - 107603.7= **6,725.2 R$**. Therefore, the sprayer constraint is more sensitive.
- As for the range, we have calculated the range of coefficient 1 (C1) to be [6984.7485, 6984.754]

CONCLUSION

The study of Western Bahia, Brazil shows approach towards optimised agricultural activity in their dryland areas. To make better decisions about planting, irrigation and fertilisation, the model was created whose objective was to result in maximisation of revenue, minimising the cost and ultimately which led to the maximisation of profits given limited availability of water.