Lower Volta Optimization: objective functions

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1 Irrigation

Minimization of the difference between annual demand and the sum of the actual water diverted daily at the irrigation intake point over a year.

$$O_I : min \qquad f(y) = \frac{V_I - \sum_i^{365} x_i}{V_I}$$

subject to the constraint:

$$0 \leq x_i \leq Q_i$$

where:

V_I	annual irrigation demand (supply target)
$i \in I = \{1, \ldots, 365\}$	days in a year
x_i	diverted water on day i
Q_i	flow at diversion point on day i

2 Hydropower

2.1 Annual Hydropower

a) Maximization of hydropower generated annually (GWh/year)

$$O_{H,A} : max \quad f(y) = \sum_{i}^{365} HP_i$$

$$HP_i = \eta g \rho_w h_f q^t \ . \ 10^{-9}$$

OR

b) Minimization of deviation from target annual power of 4415 GWh

$$O_{H,A} : min \quad f(y) = |\sum_{i}^{365} HP_i - 4415|^2$$

both (a) and (b) subject to the constraint on minimum daily firm power requirement of 6 GWh/day:

$$HP_i \geq 6$$

where:

$i \in I = \{1, \ldots, 365\}$	days in a year
η	turbine efficiency
g	acceleration due to gravity (9.81 m/s ^{2})
ρ_w	water density (1000 kg/m ^{3})
h_f	net hydraulic head (m)
q^t	turbine flow (m ^{3})

2.2 Daily firm power

Maximization of daily hydropower at 90 per cent reliability over the hydrological ensemble (Ξ)

$$O_{H,D} : max \quad f(y) = mean\Xi[HP_{90,i} : P(HP_{t,i} = HP_{90,i}) = 0.90]$$

(=10th percentile of daily total energy production over simulation period)

3 Flooding

Minimization of inundated area for monthly flow releases (Q_m) above $2300 (m^3/s)$.

$$O_F : min \qquad f(y) = Area_{inundated}$$

Condition 1, $Q_m \leq 2300$

$$Area_{inundated} = 0$$

Condition 2, $2300 \leq Q_m \leq 3000$

$$Area_{inundated} = 0.2229 Q_m - 512.57$$

Condition 3, $3000 \leq Q_m \leq 10000$

$$Area_{inundated} = (2 * 10^{-6}) Q_m^2 - 0.0098 Q_m + 173.9$$

Condition 4, $Q_m \geq 10000$

$$Area_{inundated} = (3 * 10^{-5}) Q_m^2 - 0.593 Q_m + 3202.6$$

4 Clam BBN e-flows