Multi-method efficiency analysis of Rainwater Harvesting Systems in Corredor Seco region, Central America

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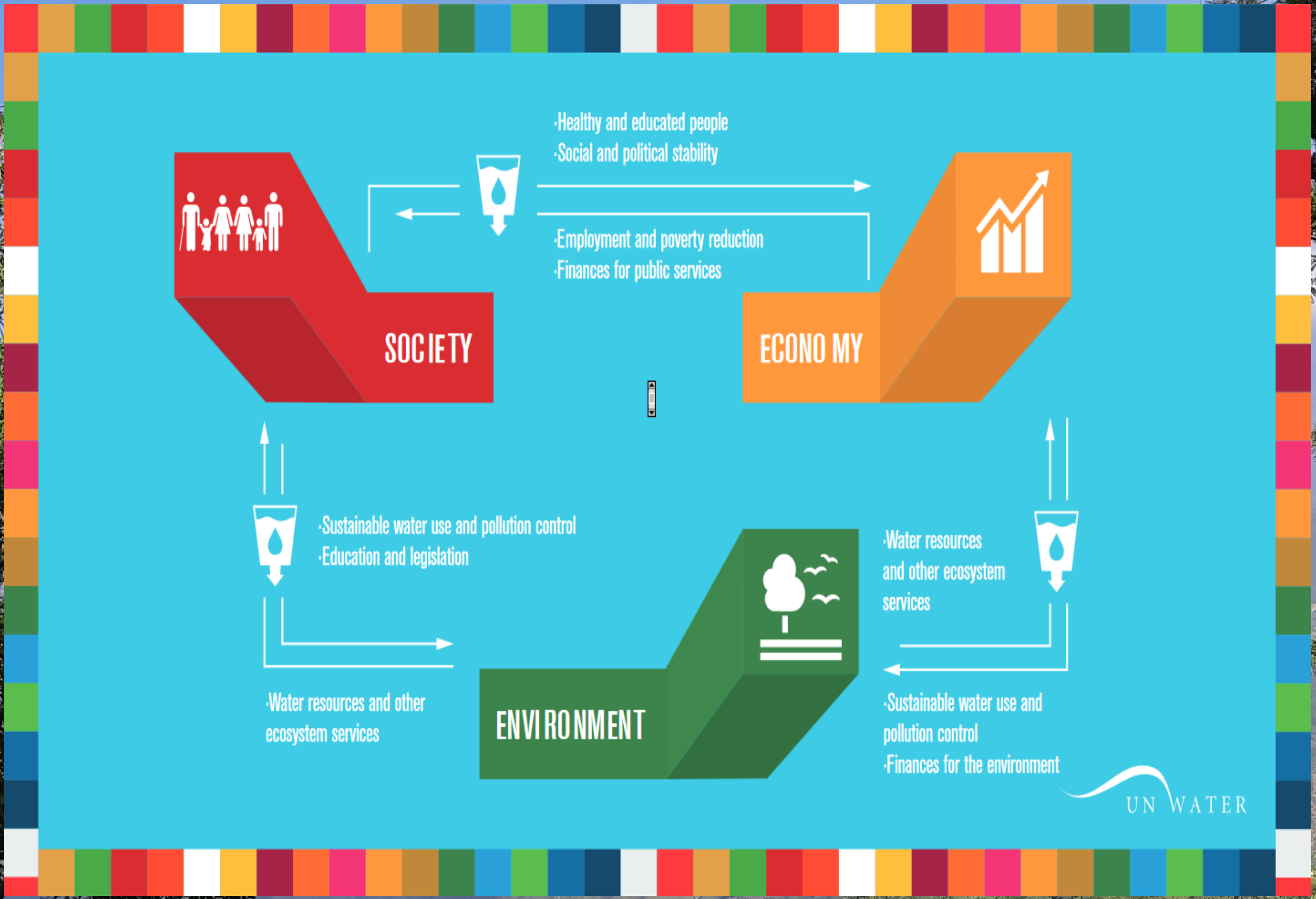
HS5.1.3
Water resources - assessment, management, and allocation - in (semi-)arid regions
Convener: Enrica Caporali | Co-conveners: Jan Friesen, Ralf Ludwig, Leonor Rodriguez-Sinobas
Displays | Chat Mon, 04 May, 14:00–15:45

WATER AND THE 3 DIMENSIONS OF SUSTAINABLE DEVELOPMENT



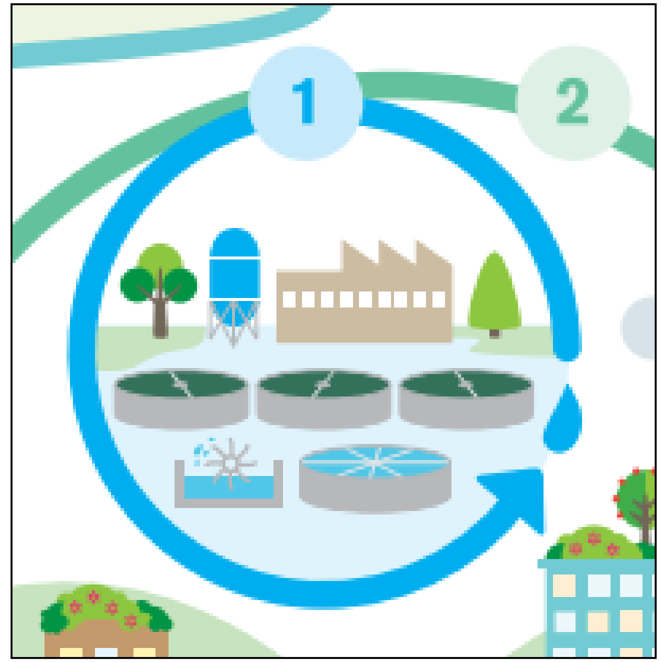
UN-Water, 2016

Highlights

- Efficiency of **Rooftop Water Harvesting systems (RWHS)** was calculated by **Probability Analysis (PA)** and **Water Balance (WB)**
- Results evidence that RWHS for **rural community in Guatemala** are designed for **high demand ratios**
- **Efficiency** may be maximized just **modulating the demand ratio**, thus preserving water harvested for food production.
- **Efficiency analysis** may be used to achieve **sustainable development goals**.

1 Regenerative Water Services

- Replenish Waterbodies and their Ecosystems
- Reduce the Amount of Water and Energy Used
- Reuse, Recover, Recycle
- Use a Systemic Approach Integrated with Other Services
- Increase the Modularity of Systems and Ensure Multiple Options



To fully realize the vision, **increased capacities and competencies** are needed, through sharing success stories from other cities, **learning to work differently with new tools**, pooling resources, and opening to other sectors' approaches and methods.

(IWA)

EFFICIENCY OF RAINWATER HARVESTING SYSTEMS AROUND THE WORLD

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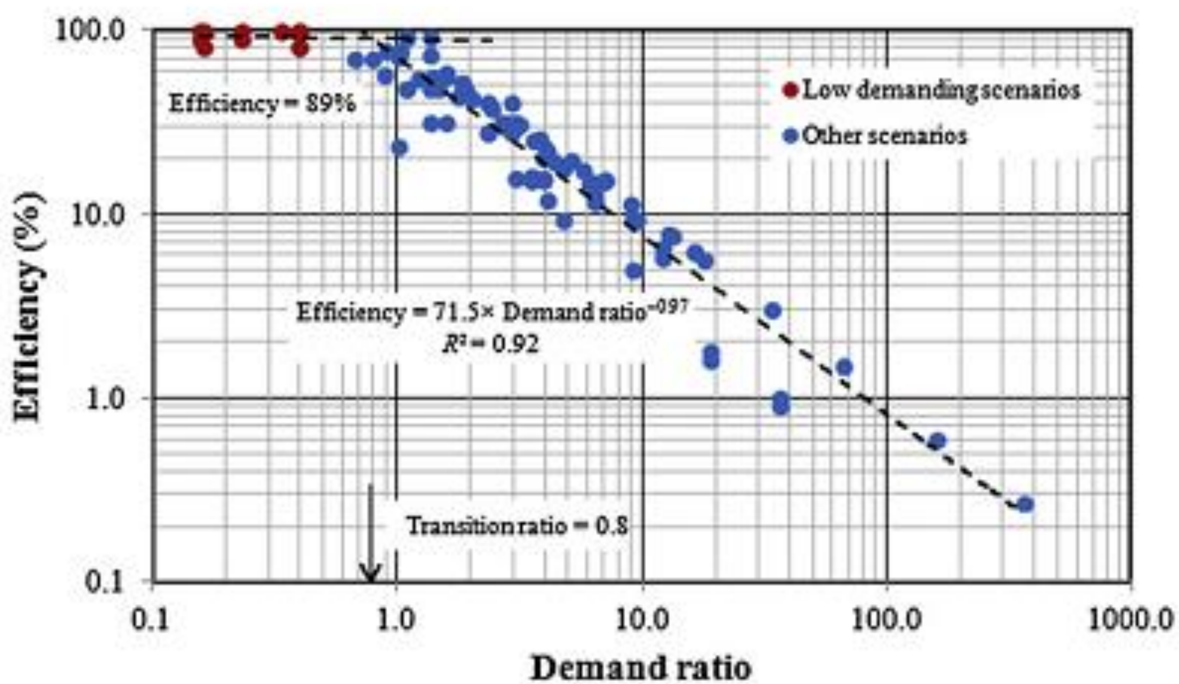
Rainwater harvesting systems for low demanding applications

Luís F. Sanches Fernandes [a,b], Daniela P.S. Terêncio [a], Fernando A.L. Pacheco [c,d,*]



Mani Tese project n. 2339 SOBERANOS – Right to Food for farmers of the Corredor Seco in Guatemala related to "Agroecology, nutritional education, creation of seed reserves, construction of water collection systems rainwater and water systems to irrigate vegetable gardens”

mani tese
UN IMPEGNO DI GIUSTIZIA

Agricultural System

- Rainfed cropping from **April to November – December**
- Dry period from **January to March**
- Need of additional water supply for **dry season cropping**

Data source

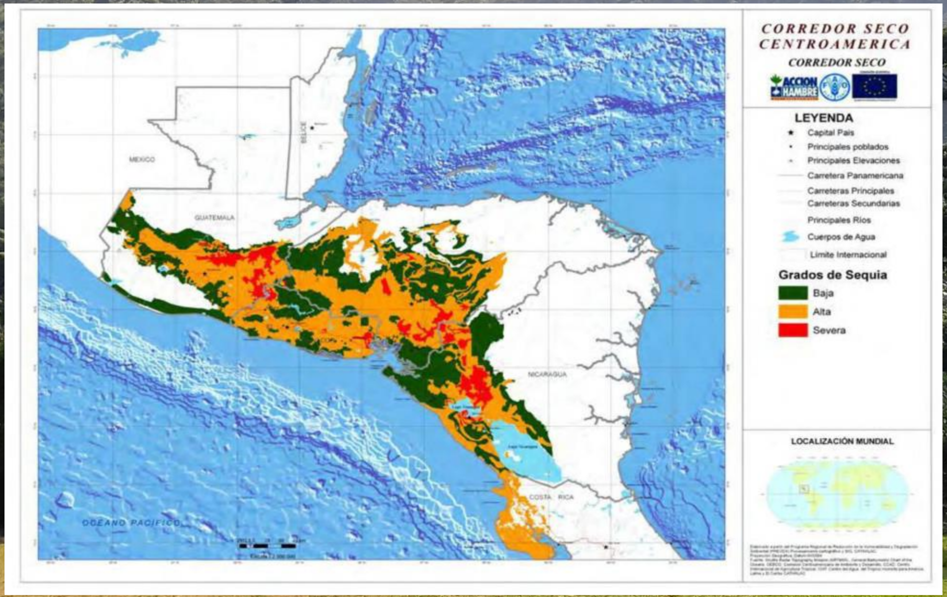
- 2017 – 2019 rainfall season (with 2018-2019 extreme dry year)
- **Daily** data from project rainfall stations
- Water use and tank data from in-field survey

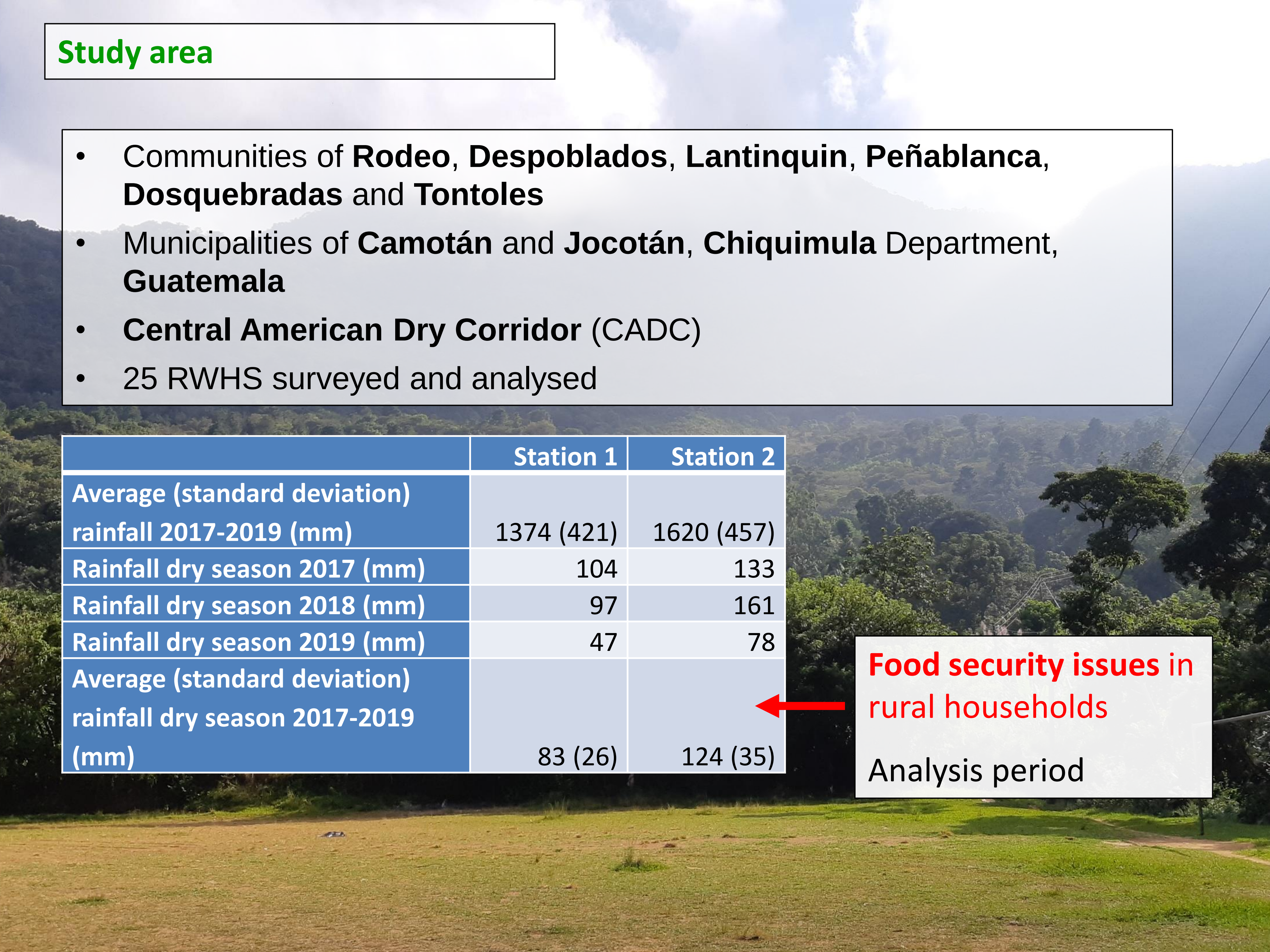
Objective

- Check **Rooftop water harvesting efficiency in extreme drough conditions** and improve the project approach

Study area

- Communities of **Rodeo**, **Despoblados**, **Lantinquin**, **Peñablanca**, **Dosquebradas** and **Tontoles**
- Municipalities of **Camotán** and **Jocotán**, **Chiquimula** Department, **Guatemala**
- **Central American Dry Corridor** (CADC)
- 25 RWHS surveyed and analysed





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	Station 1	Station 2
Average (standard deviation) rainfall 2017-2019 (mm)	1374 (421)	1620 (457)
Rainfall dry season 2017 (mm)	104	133
Rainfall dry season 2018 (mm)	97	161
Rainfall dry season 2019 (mm)	47	78
Average (standard deviation) rainfall dry season 2017-2019 (mm)	83 (26)	124 (35)

Food security issues in rural households

Analysis period

PROBABILITY ANALYSIS

Data were used for estimating:

- Daily average rainfall depth $\frac{1}{\zeta}$
- Average length $\frac{1}{\lambda}$ of the time τ between two rain events

Probability distribution of rainfall depth and inter-arrival time:

$$f_h = \zeta\, e^{-\zeta h}$$

$$f_t = \lambda\, e^{-\lambda t}$$

PROBABILITY ANALYSIS

Efficiency (E) = probability that the storage capacity is full when needed

Data were used for estimating:

- Daily average rainfall depth $\frac{1}{\zeta}$
- Average length $\frac{1}{\lambda}$ of the time τ between two rain events

Probability distribution of rainfall depth and inter-arrival time:

$$f_h = \zeta\, e^{-\zeta h}$$

$$f_t = \lambda\, e^{-\lambda t}$$

Statistical maximum and minimum efficiencies (Emax & Emin):

$$E_{max} = 1 - e^{-b}$$

$$E_{min} = \frac{b}{a+b}\left[1 + e^{-(a+b)}\right]$$

$$a = \frac{\zeta V_s}{\phi S} \quad b = \frac{\lambda V_s}{Q_0}$$

$V_s = storage\ capacity$

$\phi = runoff\ coefficient$

$S = catchment\ surface$

$Q_0 = water\ demand$

PROBABILITY ANALYSIS

Demand Ratio (DR) = ration between the overall volume needed to fulfill the demand and the collected volume

Data were used for estimating:

- Daily average rainfall depth $\frac{1}{\zeta}$
- Average length $\frac{1}{\lambda}$ of the time τ between two rain events

Probability distribution of rainfall depth and inter-arrival time:

$$f_h = \zeta\, e^{-\zeta h}$$

$$f_t = \lambda\, e^{-\lambda t}$$

Statistical maximum and minimum Demand Ratio (DRmax & DRmin):

$$a = \frac{\zeta V_s}{\phi S} \quad b = \frac{\lambda V_s}{Q_0}$$

$$DR_{max} = \frac{a+b}{ab}\frac{1}{1-e^{-(a+b)}}$$

$$DR_{min} = \frac{a}{b}\frac{1}{1-e^{-a}}$$

$V_s = storage\ capacity$

$\phi = runoff\ coefficient$

$S = catchment\ surface$

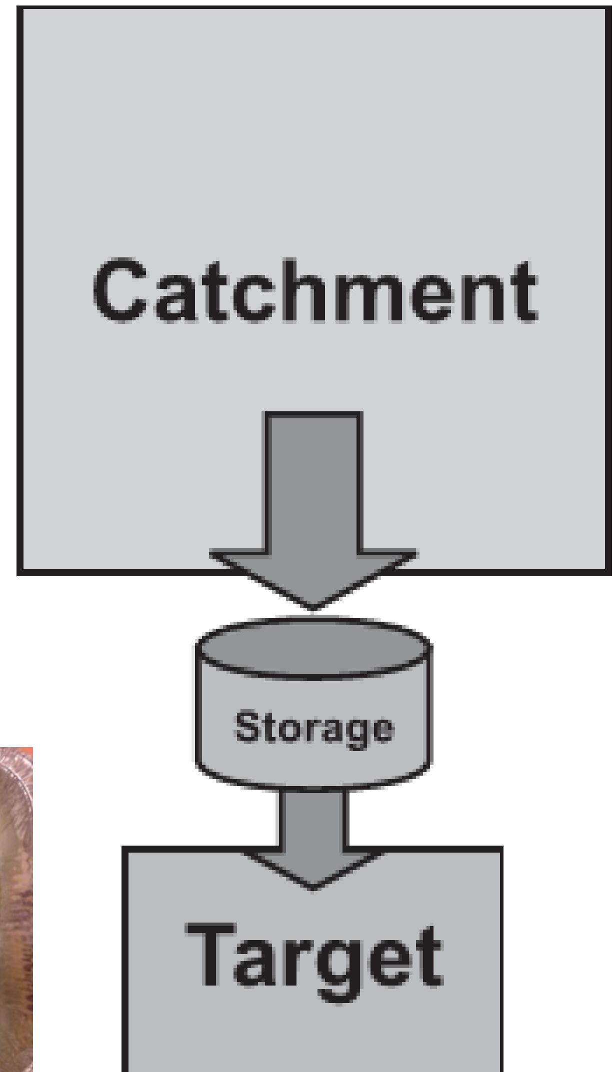
$Q_0 = water\ demand$

MASS BALANCE (Daily)

$$\frac{\Delta V}{\Delta t} = \begin{cases} I - Q & if\ h > 0\ and\ V \geq Q\Delta t \\ -Q & if\ h = 0\ and\ V \geq Q\Delta t \\ I & if\ \ V \leq Q\Delta t \end{cases}$$

$$I = h\, S\, \varphi$$

- h is daily rainfall
- S is the area of the rooftop
- φ is a runoff coefficient less than 1

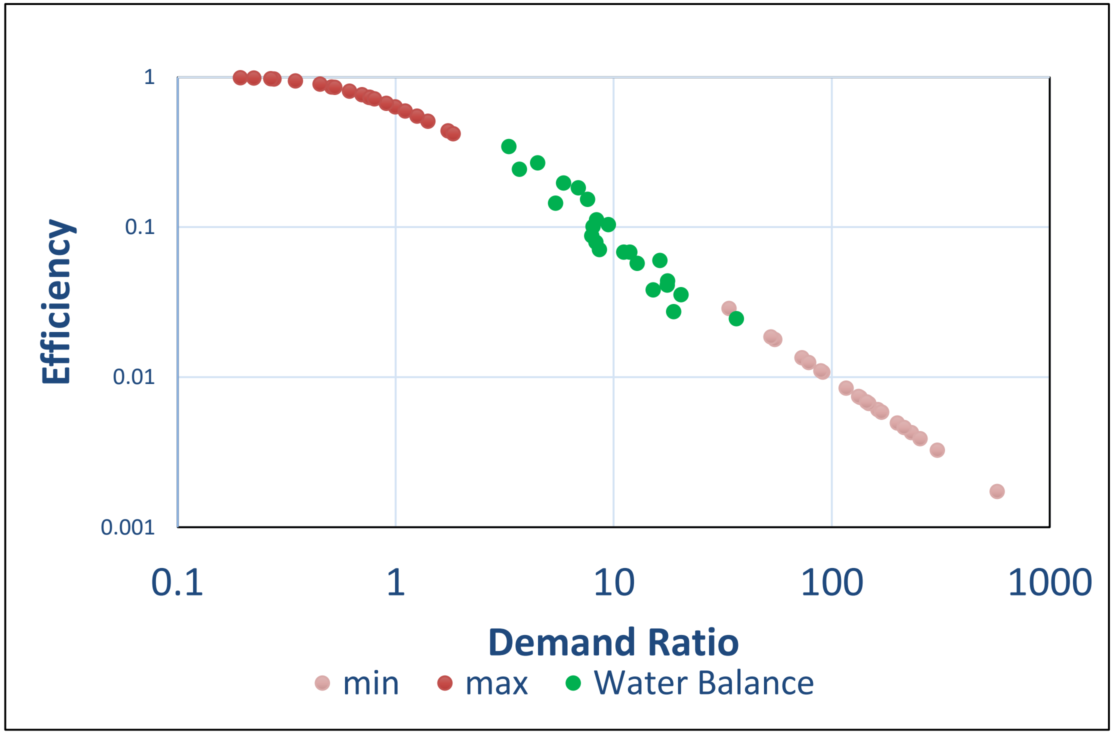


$$E = \frac{M}{T} = \frac{1 - \sum_{i=1}^{T} \delta_V(t)\Delta t}{T}$$

- $\delta_V(t) = 1$ if $V \geq Q\Delta t$,
- $\delta_V(t) = 0$ otherwise

$$DR = \frac{\sum_{i=1}^{T} \Delta V(t)}{QT}$$

RESULTS



Water Demand (Baseline Scenario)

- domestic water demand: 25 l/d/cap
- livestock water demand: 50 l/family
- cropped area,: 40 m2 [average size of a family vegetable garden (FAO, 1995; FAO-TCP, 2006).]
- ET, FAO CLIMWAT

RESULTS (DEMAND MANAGEMENT AND DESIGN OPTIMISATION)

Cropped area (m^2)	Tank Volume	Water Demand	Average Efficiency (Water balance)
40	**From survey**	**From survey**	**0.11**
20	From survey	From survey	0.2
20	5 m^3	From survey	0.42
40	5 m^3	From survey	0.26
40	From survey	Irrigation	0.12
20	From survey	Irrigation	0.28
20	5 m^3	Irrigation	0.54
20	**6 m^3**	**Irrigation**	**0.63**
15	***From survey***	***Irrigation***	***0.39***
12	***From survey***	***Irrigation***	***0.5***
40	6 m^3	Irrigation	0.3

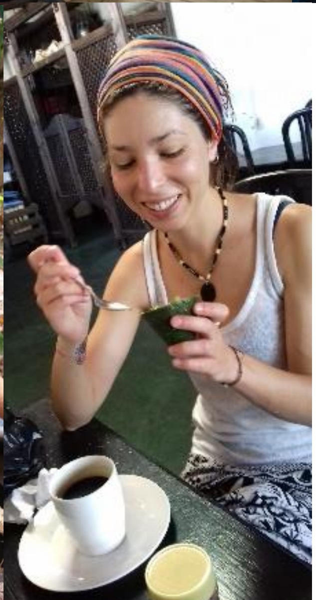
Extreme dry years (2017-2018-2019): Sufficient water for dropping vegetables in a reduced area.

CONCLUSIONS

- On a ***baseline scenario***, the tanks lay in the **high DR range**, with **E less that the maximum achievable** and depending on DR
- The **less conservative hypothesis for PA** overestimates E, provides an estimate of the maximum achievable E but cannot be used for the redefinition of a more suitable consumption schedule.
- Instead, **the most conservative hypothesis for** PA, underestimates E but identifies the trend of E(DR) in good agreement with the outcome of WB for a large number of RWHS.
- With reference to the case study considered here, **sensitivity analysis evidences how the allocation of resources may help to preserve water stored** for the most dry days, preserving water for food and increasing the tank E, in agreement with a more sustainable development policy.

Thanks from the full research group

including also: Elia Degli Innocenti, Beatrice Laurita, Tomas Etcheverry, Marlon Salazar, Alonzo Torres, Jose Angel Urzua, Giulia Donnici, Claudia Zaninelli



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