Evaluating Green Infrastructure for Public and Private Investment: *Lessons from Lima, Peru*

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INVERSIÓN EN AGUA PARA LIMA

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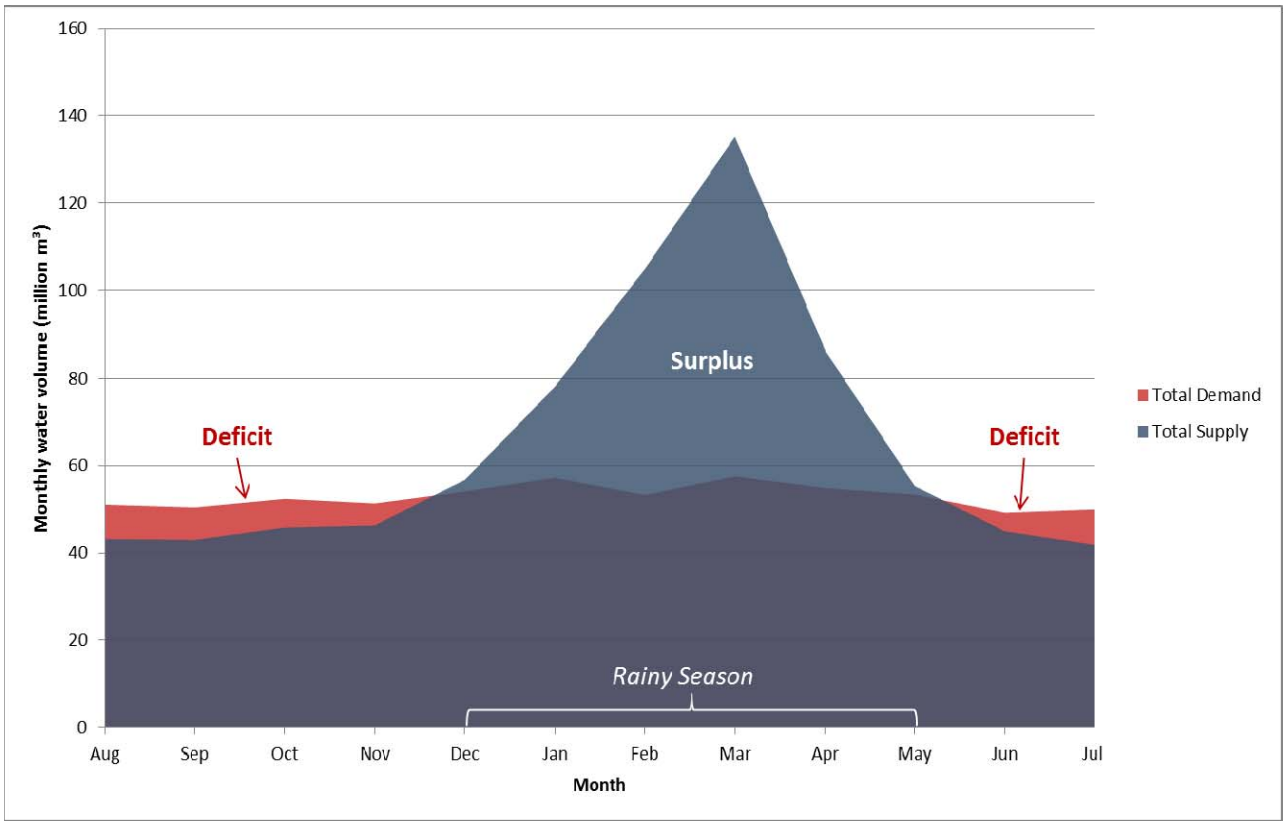
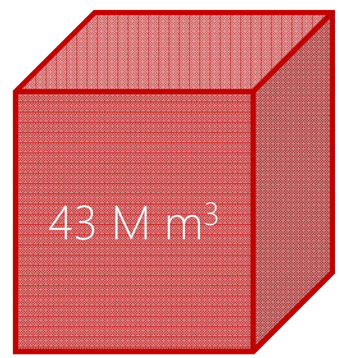
Lima, the second-largest desert city in the world, experiences a dry season deficit of over 40 million m^3 of water each year.



Average Water Supply and Demand, Rimac River Basin.
Source: Peru Ministry of Agriculture (2010)

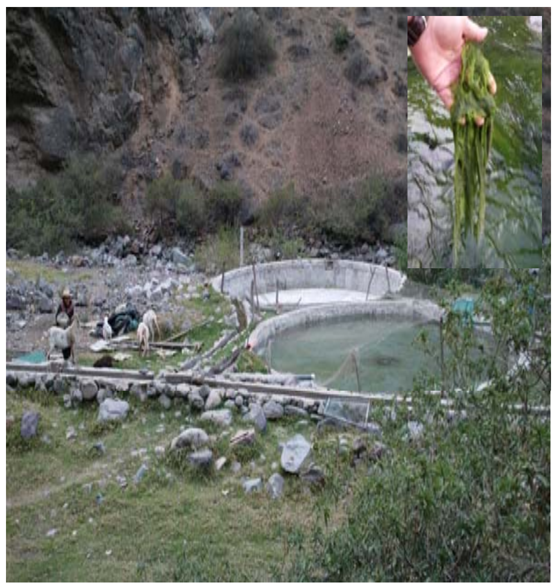


Dry season deficit

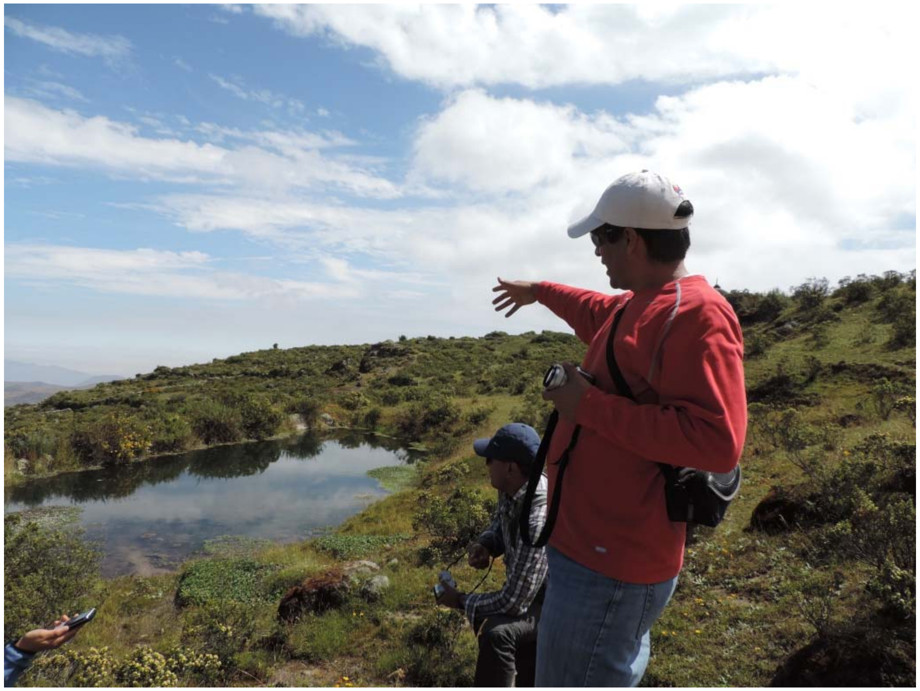
30-second Watershed Tour








Green infrastructure…the sponge to turn excess water in the wet season into crucial dry season flows.



Estimating benefits of “Green” Infrastructure/Practices in Upper Watershed Areas

- Livestock management interventions
- Restoration of wetland hydrology
- “Amuna” restoration

Innovation: assessment amidst uncertainty

GOAL

Order-of-magnitude estimates of cost-effectiveness and potential benefits

CHALLENGE

Significant data gaps; limited flow monitoring

Need

Effective Water Fund (Aquafondo) investments

Analysis relies on estimates of hydrological benefit of a typical project.

- Estimating cost-effectiveness

  Cost of average project/baseflow benefit of average project

- Estimating potential impact

  Baseflow benefit of average project * potential number of projects

Estimating benefits: livestock management interventions

Mass Balance

Mass Budget Equation

A watershed-scale water mass budget is represented by the following equation: [5]

$$Q = P - ET - c^*\Delta S - \Delta G - \Delta L \qquad (1)$$

Where:

P = precipitation
Q = streamflow
ET = evapotranspiration
S = soil moisture
G = groundwater
L = leakage

Assumptions:

1. ET remains the same before and after intervention
2. Change in groundwater is nominal before and after intervention
3. Leakage remains the same before and after intervention
4. All infiltration initially counted as soil moisture
5. The soil moisture coefficient, **c**, can be used to adjust for assumptions 1-4

The equation simplifies to:

$$Q = P - c^*\Delta S \qquad (5)$$

Estimating benefits: livestock management interventions

Calculate Runoff Reduction

↓

Calculate Soil Moisture Increase

↓

Calculate Increase in Baseflow Volume (m^3)

↓

Calculate Increase in Baseflow (m^3/s)

Estimating benefits: hydrological restoration of wetlands

Mass Balance

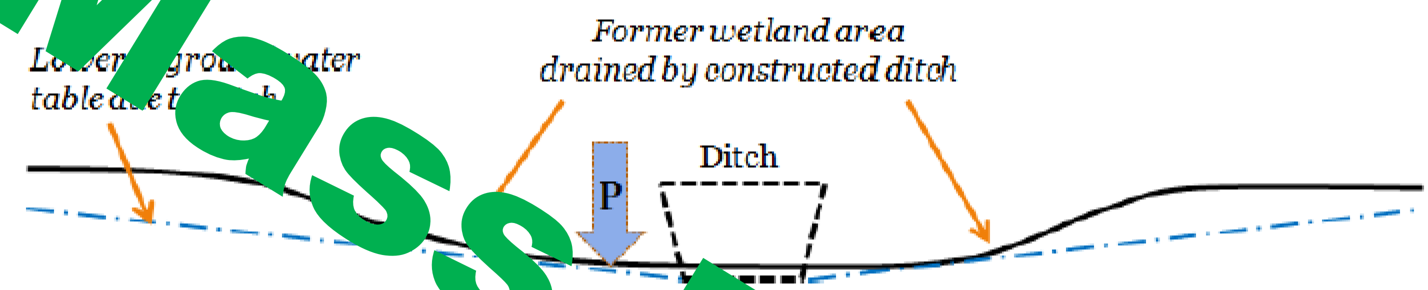


Figure 1a. Conceptual cross-sectional diagram illustrating a drained wetland via a constructed ditch which eliminates surface storage (that would otherwise be contributing to groundwater recharge), and a dewatering (lowering) of the local groundwater table. (P = precipitation)

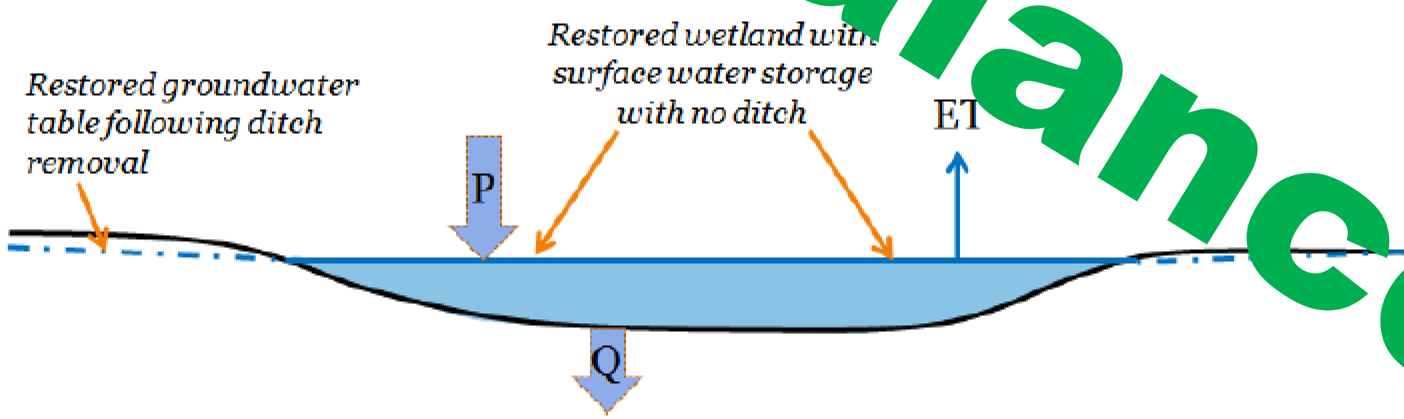


Figure 2b. Conceptual cross-sectional diagram of a wetland restored by removing the drainage ditch. This allows for surface storage, groundwater recharge and restored local groundwater levels. (P = precipitation; ET = evapotranspiration; Q = stream baseflow)

Estimating benefits: hydrological restoration of wetlands

Estimate amount of wet season precipitation that will be stored in restored wetland

↓

Calculate baseflow volume (m^3)

↓

Calculate increase in baseflow (m^3/s)

Estimating benefits:
Restoration of Amunas (ancient diversion channels)

Mass Balance

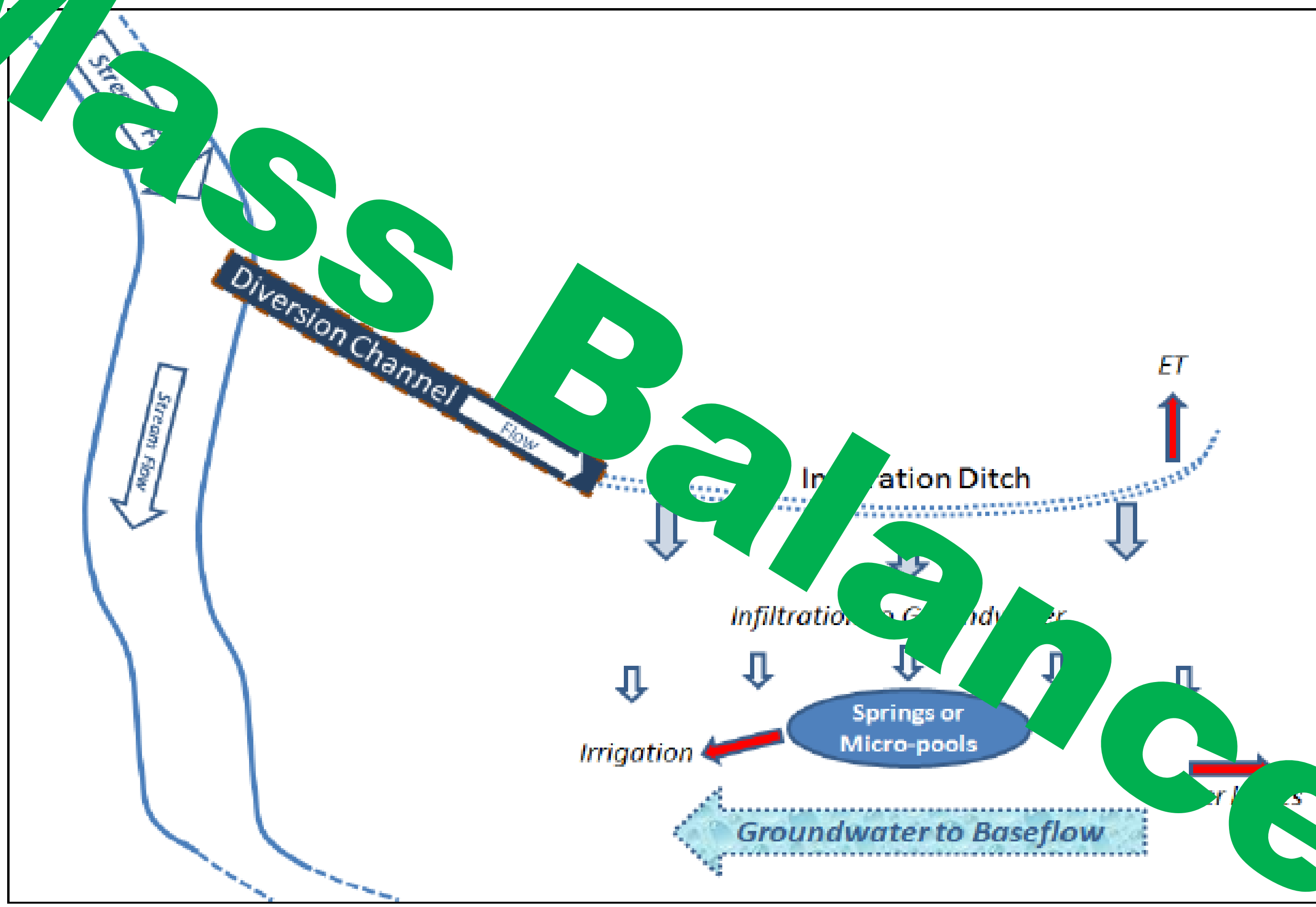


Figure 3. Conceptual schematic (plan view) of a diversion channel directing flow to an infiltration ditch increasing groundwater recharge and eventually, stream baseflow of the original stream during dry periods. (Transport pathways are italicized. Arrows indicate flow path; red infers a loss from baseflow contributions.)

Estimating benefits: Amuna restoration

Measure discharge from diversion channel

↓

Subtract out flow ‘lost’ to Ag use, ET, etc.

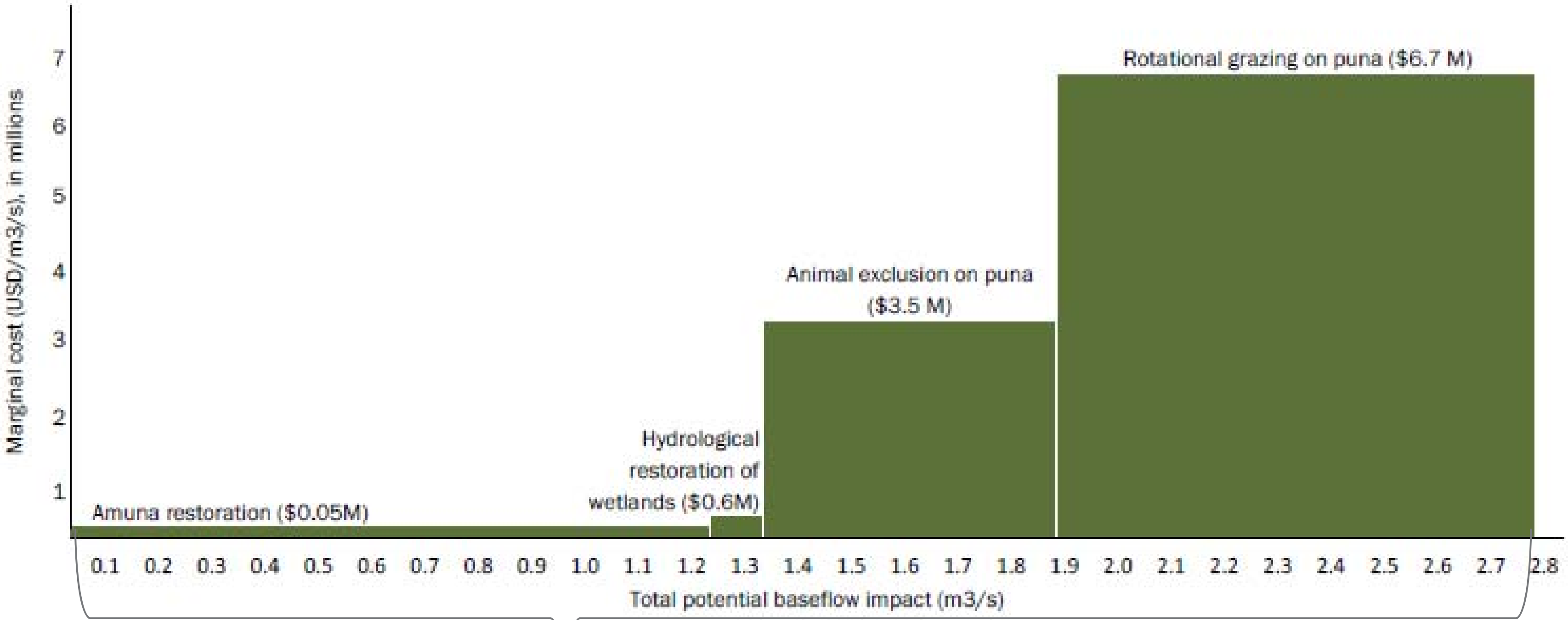
↓

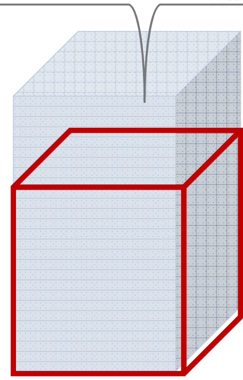
Calculate volume of infiltrated water (m^3)

↓

Calculate Increase in Baseflow (m^3/s)

This 'sponge effect' can substantially decrease water stress…

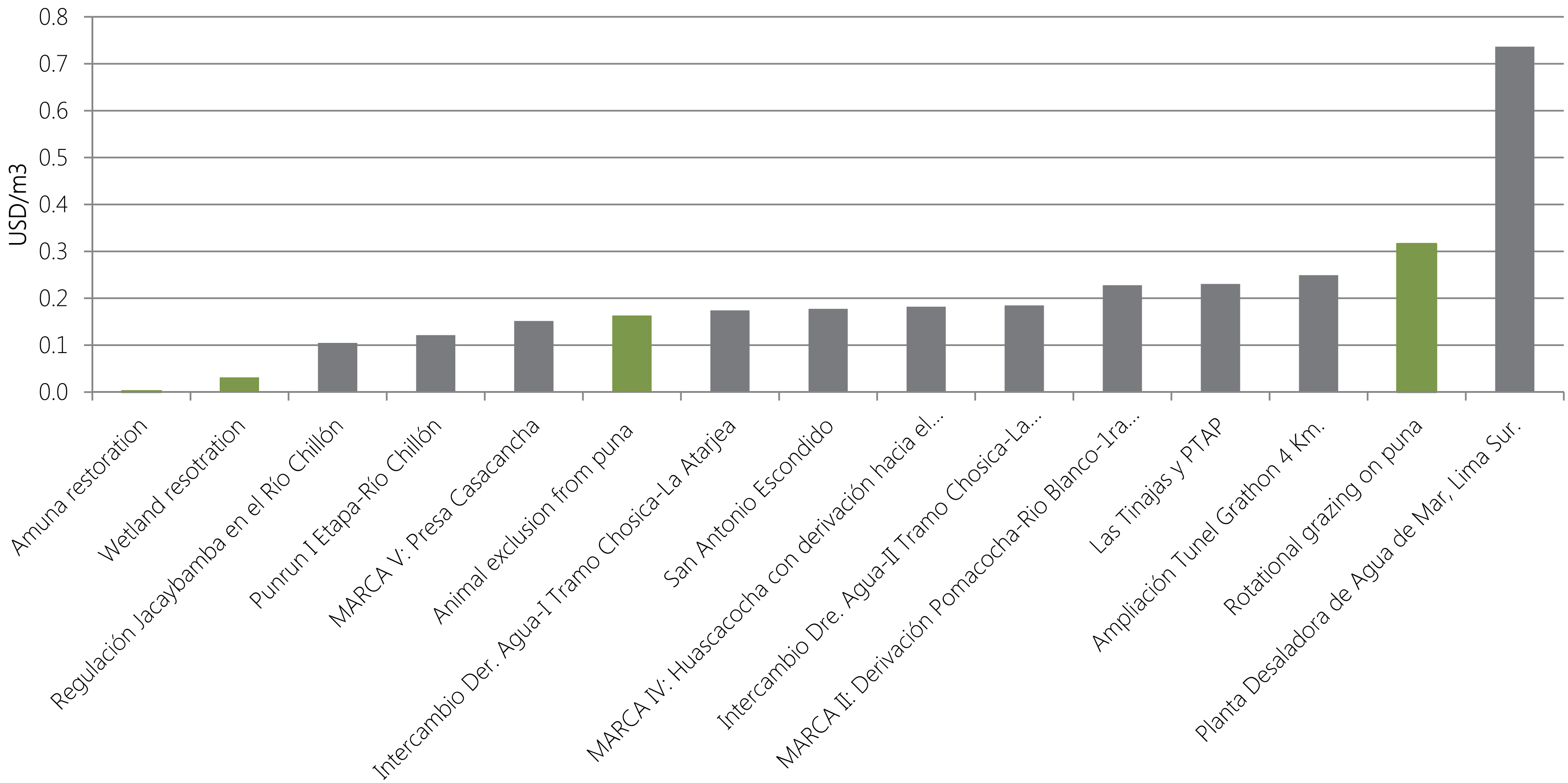




135% potential reduction of dry season deficit

Source: Forest Trends analysis

Competitive with gray infrastructure



Sources: Forest Trends analysis
Gray infrastructure costs: Nippon Koei (2011).

Approach can be credibly applied for a variety of purposes, advancing green investments while monitoring to improve estimates ‘catches up.’

- Justifying public investments by quantifying hydrological benefit for cost-benefit analyses

- Estimating impact of private sector voluntary compensation

- Prioritizing investments and estimating impacts of a water fund (in Lima, and in other cities)