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Water productivity analysis of sand dams irrigation farming in northern Ethiopia

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Abstract

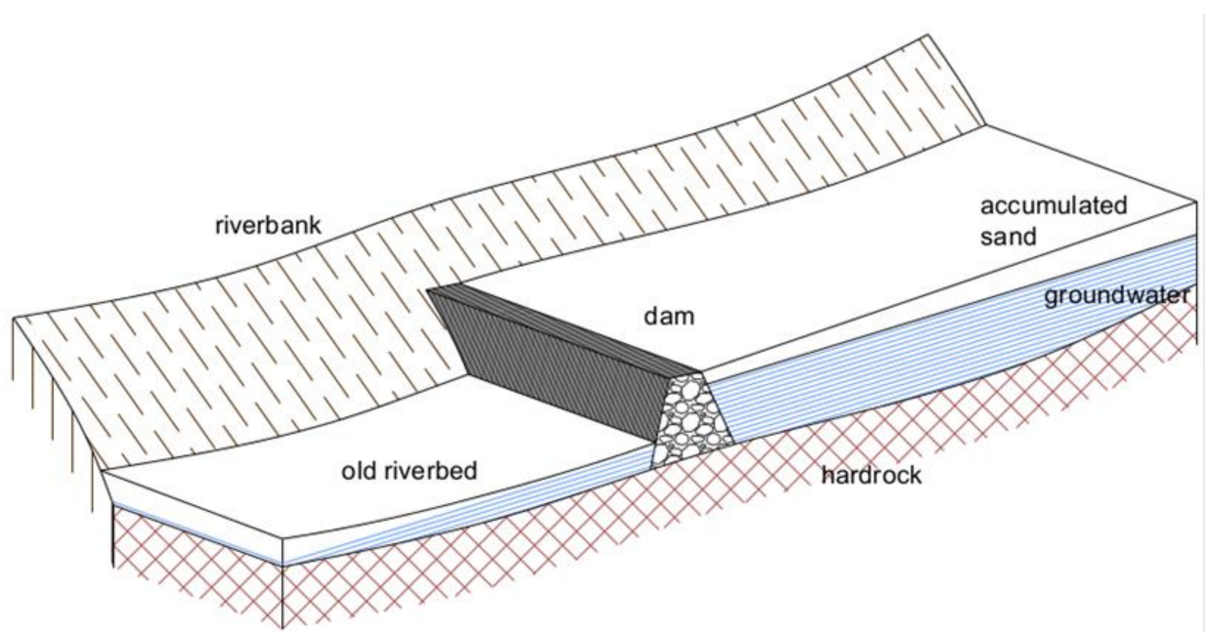
- Climate change and demography are expected to increase water scarcity in drylands. A large number of studies is calling to focus efforts to enhance **water productivity (WP)**, and one of the most promising option is represented by **water harvesting, the collection and storage of runoff water to be used for beneficial uses**.
- The research aims to deepen the knowledge about WP of water harvesting systems studying a **sand dam irrigation system in Tigray**, north Ethiopia. We analyzed a representative **maize plot** irrigated during the dry season of 2017 through a shallow well drilled in the sand dam aquifer, in terms of yield, **Crop Water Productivity (CWP), Crop Water Productivity based on Evapotranspiration (CWP(ET)) and Economic Water Productivity (EWP)**, through field data analysis and a **validated Aquacrop model.**

Study area (13.89° N 39.28° E)

- **May Gobo** Tabia (municipality), Hawzen Woreda (district), Tigray Region, Ethiopia
- Altitude of 1714 m a.s.l.
- Climate is **semi-arid** and is classified as BSk
- Mean annual temperature 17.4 °C
- Total rainfall is 611 mm
- Roughly half of it concentrated in the months of July and August

Sand dam and irrigated area

- Built in 2012
- A concrete wall built in the riverbed of **sandy ephemeral rivers**
- The sedimentation of the transported sand in the upstream of the wall in a few years creates an **artificial unconfined aquifer**, whose water is accessed by people through digging scoop holes or shallow wells
- Farmers were also provided with diesel pumps, fruit trees and improved seeds, to improve agriculture and livelihoods
- Furrow irrigation performed with very low efficiency
- Low soil fertility



General scheme of a sand dam. Source: Borst and de Haas (2006)

AI	considering actual irrigation method
NI	calculating the net irrigation requirements at constant field capacity
OI	generating an optimal irrigation schedule
NS	testing the OI irrigation schedule without soil fertility stress

$$CWP = \frac{grain\ yield\ in\ kg}{water\ applied\ to\ the\ field\ in\ m^3}$$

$$EWP = \frac{net\ return\ in\ birr}{water\ applied\ to\ the\ field\ in\ m^3}$$

$$CWP(ET) = \frac{grain\ yield\ in\ kg}{water\ evapotranspired\ \ in\ m^3}$$

May Gobo sand dam

Pictures allowed!!

Materials and methods

1. **Field data collection**
2. Simulation of AI conditions and **validation of Aquacrop** with collected data
3. **Simulation** of AI, NI, OI, NS
4. **Calculation and comparison** of maize Crop Water Productivity (CWP), Crop Water Productivity based on Evapotranspiration (CWP(ET)) and Economic Water Productivity (EWP)
5. EWP for the NS simulation was estimated considering a proportional increase in costs of fertilizers

Scoop hole in May Gobo

TABLE 1: result of Aquacrop model

	Yield (t/ha)	Water stress (%)	Soil fertility stress (%)	Evaporation (mm)	Transpiration (mm)	Net irrigation requirements (mm)	Gross irrigation requirements (m³)
AI	3.316	1%	60%	107.5	188.4	759	660
NI	3.332	0%	60%	148.9	190.5	341.5	297
OI	3.301	0%	60%	58.3	185.4	160.1	139
NS	8.491	0%	0%	40.9	245	160.1	139

	CWP (ET) (kg/m³)	CWP (kg/m³)	EWP (birr/m³)
AI	1.12	0.218	0.74
NI	0.98	0.488	
OI	1.35	1.033	3.94
NS	2.97	2.655	9.54

Field data results

CWP = 0.23 kg/m³
EWP = 0.77 birr/m³
***1 Birr = 0,031 E**

TABLE 2 AND BOX:
Water productivity calculation compared with field data results

CONCLUDING REMARKS

1. Technical suitability of materials and methos

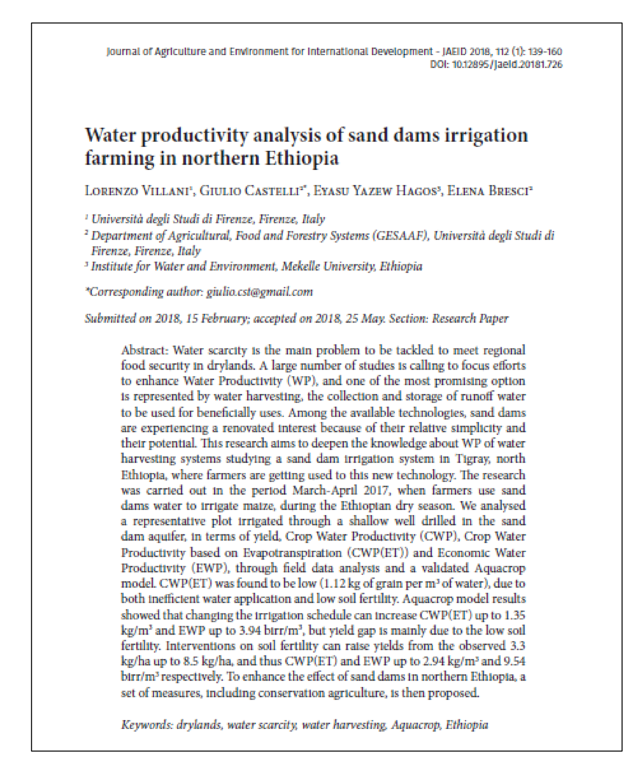
- AQUACROP model show **good accordance with field data**
- AI to NS simulation **in line with other studies** analyzing maize CWP and CWP(ET) both in good and bad conditions

2. Water Harvesting and irrigation planning

- Sand dams can be successfully used for irrigation purposes
- **Soil fertility is an essential co-constraint** that must be seriously tackled
- To increase WP, main solutions are to increase irrigation efficiency and soil fertility
- Farmers with **irrigation water** available tend to **misuse** it

3. Recommendations

- Sand dam planning is a crucial phase to avoid irreparable problems (residues invading fields)
- When planning interventions, important to have a **holistic approach**
- Farmers need time to adapt to **new technologies**: tillage method (Maresha plow) should be questioned in Ethiopia
- **Conservation agriculture** possible solution?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LINK to the paper

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