Assessing the effects of smallholder intensification through improved water management beyond “business as usual”: A multi-faceted lens on sustainability

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Small-scale irrigation in Sub-Saharan Africa

Emphasis in small-scale irrigation is mainly placed on water resource availability and access to water, but less attention is paid to environmental impacts of water appropriation and the on-farm management strategies to use water effectively and profitably. Furthermore, the relation to irrigation labor, and profits is less understood. This study uses a multi-disciplinary approach to explore and evaluate sustainable small-scale irrigation development (Fig.1).

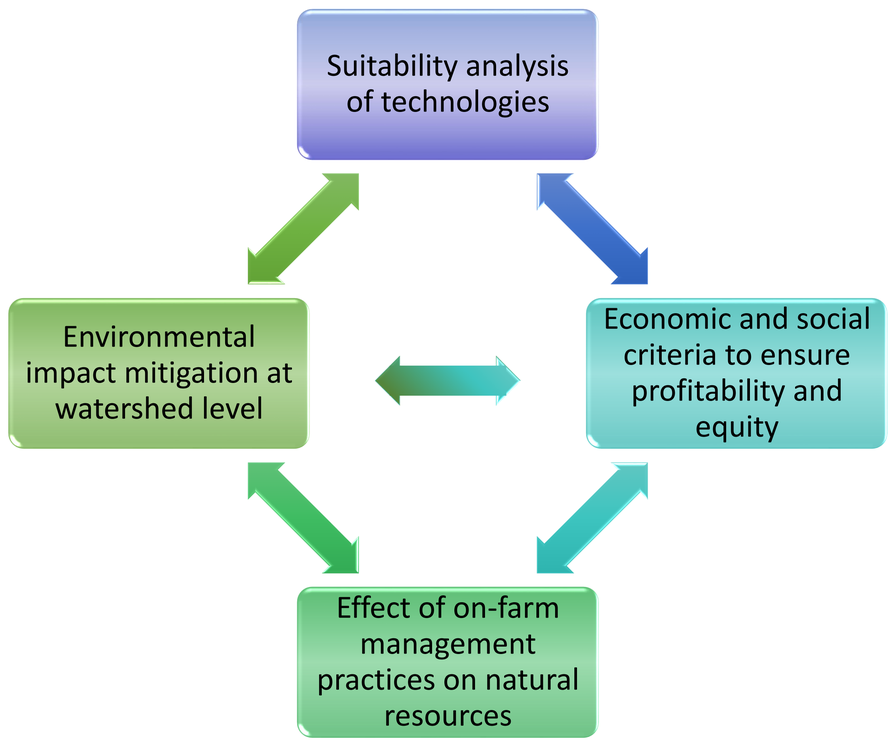

Fig. 1: Components of the sustainability framework for water lifting technologies considered in this study.

Suitability analysis of solar pumps

- Solar pumps are emerging as part of the climate-smart agricultural agenda given the reduction in greenhouse gass emissions and their multi-purpose use (Table 1). Using groundwater and surface water resources, suitability was assessed for two types of solar punps, i.e. lifting capacity from 0 m to 7 m and 7.1 m to 25 m.
- Taking into account water resources availability, market access, irradiation, land use and topography and simplified criteria on groundwater sustainability a suitable area of 68 10^3 km^2 was estimated (Fig. 2). Largest potential was found around Lake Tana and the Rift Valley.

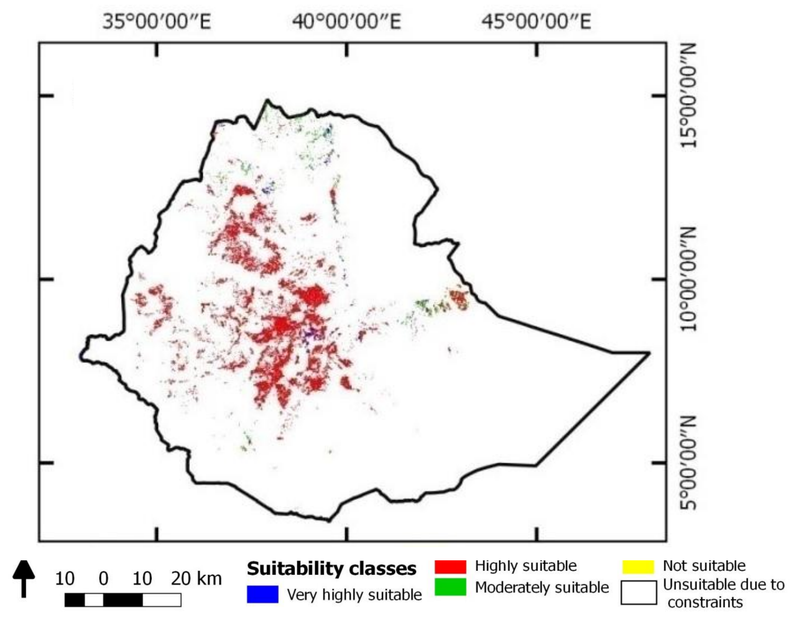

Fig. 2: Suitability map for solar based lifting in Ethiopia combining surface water resources and groundwater up to 25 m (Shale et al. in prep). Analysis included groundwater depth, aquifer productivity, groundwater storage, irradatiation, slope, rivers, surface water potential, roads and proximity to markets and towns

Economic profitability and social equity

- Biophysical and socio-economic data were combined from 35 households in 2015 and 2016 (Table 1)
- Water productivity was related to irrigation labor. Labor increased with increased application and more frequent irrigation scheduling.
- Yield and water productivity, labor saving, profit and multi-purpose use affected women and men farmers differently.

Table 1: Summary of the opportunities and challenges related to each of the water lifting technologies respectively towards the control. ++, + and – represent a high, medium and low effect (modified after Schmitter et al., 2016).

	Labour saving	Yield	Water productivity	Profit	Multi-purpose use
Control	0	0	0	0	0
Rope and washer	0	0	0/+	-/0	+
Solar	++	+	-/0/+	++	++
Motorized pump & drip	-/+	++	++	-/+	-

Effects of on-farm management on nutrient cycling

- Irrigation scheduling was done with 18 farmer divided in 3 groups: farmer practice (FP), soil moisture based using a TDR (TDR) and the FAO-cropwater requirement (CWR).
- Fertilizer application was not controled. Application of N (mainly urea) by farmers was higher compared to recommended local rates. On the other hand P (DAP) and K (only manure) were signficantly lower than the recommended rate.
- Removal of N, P and K from the field was highest for CWR /TDR which corresponded to the higher water productivity and yield obtained from irrigation scheduling (Fig. 3)

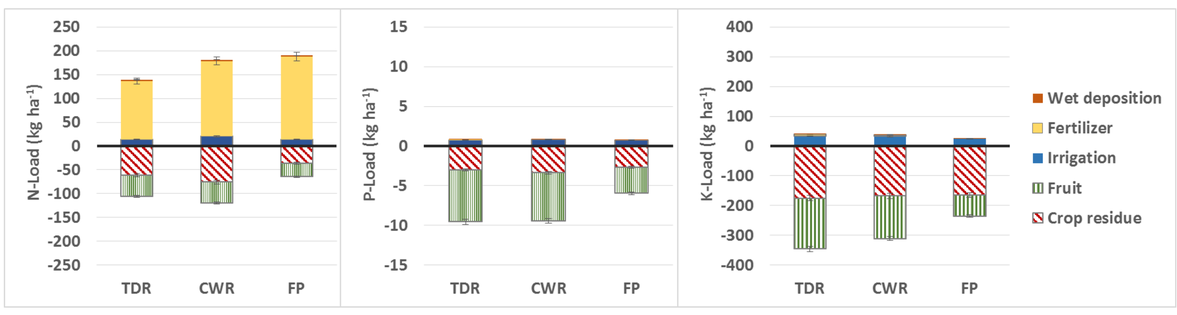

Fig. 3: Nitrogen (N), phosphorus (P) and potassium (K) load of inputs and outputs in function of the three different irrigation scheduling methods (FP, TDR and CWR) for irrigated tomato.

Conclusion and further work

Small scale irrigation is expanding quickly on the African continent. Some areas are still mainly using manual pumps, but farmers are rapidly adopting motorized pumps and investors show high interest in solar pumps given their *climate-smart* and multi-purpose use potential. This study showed that the suitability for solar driven water lifting has considerable potential in Ethiopia. Furthermore, results revealed that each technology has challenges and opportunities beyond water lifting that must be assessed. Benefits to women and men irrigators differ. Water and overall natural resource management need to be added to the *‘irrigation package’* to ensure equitable sustainabilty at farm and landscape scales. Currently, both water quantity aspects and potential impact of agrochemical fluxes needs better empirical knowledge to guide sustainable intensification through irrigation development.

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