Code -between 2 and 15 m wide on each side- instead of the 30 m required. About 90% of the farmers pointed out the incompatibility between environmental legislation and the size and geometry of their farms. Amongst the respondents, 89% said that only punitive law enforcement would be able to force them to maintain all the APP (in-farm permanent protection areas). About 88% of the farms that adopted pasture base dairy-MIG, fenced off springs and remaining forests. The use of electric fences in MIG system minimizes animals contact with water, streams and forest areas. Finally, for 91% of the famers interviewed pasture carrying capacity and milk sales increased substantially when they switch from traditional semiconfinement to pasture based dairy.

### Conclusions

For the farmers pasture based dairy through management intensive grazing reduced environmental impact and improved the flow of ecosystem services. These environmental assets should be further measured and recorded.

### References

Alves JP. Graduate Coolllege, University of Vermont, 1–17.

Farley J 2010. Environmental Management 45, 26–38.

Freitas CA 2009. Agropecuária Catarinense 22, 1:22–31.

Meurer FJ, Schnitt AL, Farley J, Alvez JP, Oldra A and Francisco F 2009. Proc of Agroecology Latino American Meeting 1, 4422–4446.

Rizzoli AL and Schmitt AL 2007. Proc of Congresso Brasileiro de Sistemas 1, 56–67.

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# Assessment of water productivity and entry points for improvement in mixed crop-livestock systems of the Ethiopian highlands

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### Introduction

Crop-livestock systems are very important both in terms of area and contribution to people's livelihoods in the Ethiopian highlands. However, a common problem in these systems is low livestock and crop productivity, which is partly caused by water scarcity and environmental degradation. As water is a key and often limiting input for agriculture and environmental functioning, there is an urgent need to improve water productivity in order to sustain both people's livelihoods and a healthy environment. Water productivity, generally defined as the ratio of agricultural outputs to the volume of water depleted, measures the ability of agricultural systems to convert water into food. In the crop sector, crop water productivity (CWP) has been investigated for many years. By contrast, livestock water productivity (LWP) is a new concept (Peden *et al.*, 2009), for which reference points, standardized definitions and adequate methods for water partitioning are still in their infancy (Descheemaeker *et al.*, 2010). Also, a systems approach for analyzing water productivity in mixed systems is still to be developed, tested and adapted. This paper therefore examines how water productivity can be assessed in mixed crop-livestock systems, and identifies entry points for water productivity improvement with the wider aim to improve the sustainability of the systems.

### Materials and Methods

The study was carried out in two micro-watersheds, which are characteristic of water scarce (Lenche Dima) and water abundant (Kuhar Michael) conditions in the Ethiopian highlands. The determinants of water productivity were identified through farming system characterization, based on a household survey, key informant interviews and farmer group discussions. The biomass production of different feed types was measured. Water flows were determined based on measurements of climate, crop and soil variables and soil water balance modelling. The water flows were then partitioned into water flows for livestock and for crops, based on harvest indices and the percentage of the available feed that is consumed by the animals. The identification of entry points for improvement was based on the farming system analysis taking into account water resources, feed, livestock and crop management and production levels.

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## Results

A framework was proposed to bring together the data on water flows for the feed types and crops, livestock and crop outputs and the resulting physical and financial productivity variables for the whole system and its components. The major water productivity determinants in the farming systems included livestock herd size, preferential uses of animals, land degradation, water availability, and cropping intensity. The overall crop, livestock and system water productivity values are summarized in Table 1. Crop water productivity was influenced by irrigation, multiple cropping, and inputs from the livestock component, such as manure and draught power, pointing to the strong interactions between the two system components. One entry point for water productivity improvement was to reduce non-productive water flows through vegetation restoration and soil and water conservation efforts. Alleviating feed deficits, by improving feed quantity and quality, was essential as well. As animals tend to loose a lot of energy by walking to far away drinking points in the dry season, another key entry point was to provide all year drinking water in the homesteads through water harvesting. Finally, high animal mortality and morbidity pointed to the importance of improving veterinary services.

**Table 1** *Water productivity of mixed crop livestock systems at the household level in Kuhar Michael (n = 50) and Lenche Dima (n = 54)*

| | Kuhar Michael | | Lenche Dima | |
|---|---|---|---|---|
| Water productivity components(*) | Average | Standard deviation | Average | Standard deviation |
| CWP (US\$ $m^{-3}$) | 0.45 | 0.21 | 0.56 | 0.24 |
| LWP (US\$ $m^{-3}$) | 0.091 | 0.040 | 0.077 | 0.050 |
| SWP (US\$ $m^{-3}$) | 0.21 | 0.07 | 0.23 | 0.12 |

(*): CWP: crop water productivity, LWP: livestock water productivity, SWP: system water productivity.

## Conclusions

Mixed crop-livestock systems provide farmers with several assets that emerge both from the separate crop and livestock production components, and from the interactions between the two. This study presented a method and framework to quantify the contributions of different livestock products and services and unite them with crop benefits in a system's water productivity analysis. Water flow partitioning between the crop and livestock component of the system was a key feature of the methodology. The method and framework are applicable in other regions beyond the specific study area and proved to be useful in understanding system functioning and identifying entry points for improvement.

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## References

Descheemaeker K, Amede T and Haileslassie A 2010. Agricultural water management 97, 579–586.

Peden D, Taddesse G and Haileslassie A 2009. The Rangeland Journal 31, 187–193.



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