

Improving Livestock Water Productivity: Lessons from the Nile River Basin

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Many criticisms regarding livestock keeping in recent years stem from the perception in developed countries that animal production consumes too much water; especially in a world where farmers' access to water resources is decreasing. Research conducted over the past ten years confirms that excessive water use is common, especially for beef production in industrialised countries. However, understanding water use in small-scale livestock farming systems in many developing countries requires a different way of thinking. This article highlights key research findings from a project in the Nile River Basin (Awulachew *et al.*, 2012), along with their implications for agricultural water management in general and livestock keeping in particular. The results are drawn primarily from the Consultative Group on International Agricultural Research (CGIAR) Comprehensive Assessment of Water Management in Agriculture (2007) and the CGIAR Challenge Program on Water and Food.

Key research findings

- Rainfall is the ultimate agricultural water resource. Past research and development focused on management of *blue-water* resources, which include rivers, lakes and streams, particularly for irrigation. However, about 60% of global rainfall accumulates as soil water and evaporates or transpires directly to the atmosphere without passing through blue-water bodies. This is termed *green water* (Falkenmark and Rockstrom, 2006).
- The Nile River Basin receives $\approx 1,900$ billion m^3 of rainfall per year. About 4% (≈ 80 billion m^3) passes through the river and lakes of the Nile to reach Lake Nasser, Egypt. Of the Nile catchment area, 62% is used for livestock grazing and mixed crop-livestock systems, and it receives about 85% (≈ 1600 billion m^3) of total basin rainfall (Peden *et al.*, 2009). Evapotranspiration (ET) from green water in these agricultural areas is 63% (1200 billion m^3) of basin rainfall. Access to more rainfall and surface flow water and using it more productively and effectively for the benefit of people and nature offers the greatest opportunity for improved cropping and livestock production.
- Inappropriate management of both livestock grazing and mixed crop-livestock systems is a leading cause of land degradation or desertification in the Nile Basin. Loss of vegetative cover, biomass and production characterises land degradation and results in sub-optimally high evaporation (E) and low transpiration (T) rates. Because T is a primary driver of plant production, conversion of non-productive E to productive T is key to improving crop and livestock water productivity. Here, we focus on livestock water productivity (The Rangeland Journal, 2009), but simultaneous consideration of cultivation practices and conservation of natural biodiversity remains necessary.
- Although drinking water is crucial to animal production, the amount of water required to produce animal feed may be 100 times greater than that for direct animal intake. By focusing on water use for feed production and the impacts of livestock-keeping on hydrology, increasing livestock water

productivity (LWP) can help enhance beneficial goods and services derived from domestic animals while making more effective use of available water in rainfed agriculture.

Livestock water productivity

Within an agricultural system, rainfall is the primary source of water, but surface flow from upstream areas can be locally important. Depletion usually refers to the volume of water lost from an agro-ecosystem and includes transpiration, evaporation and downstream discharge. LWP is a scale-dependent concept. For example, water depleted from a small upstream watershed may be available to downstream users.

LWP is the ratio of the total value of goods and services derived from domestic animals to the amount of water depleted as a cost of livestock-keeping (Figure 1). Livestock provide multiple benefits and services such as meat, milk, hides, manure, farm power and a preferred means to accumulate wealth. To increase LWP, we must increase the benefits animals provide or reduce the amount of water depleted through livestock-keeping. To assess multiple benefits, we can monetise and use monetary equivalents such as US\$ per cubic metre of water depleted. While non-monetary cultural benefits remain important, they were not addressed in this research. There are four basic LWP-enhancing strategies:

1. Feed sourcing and management strategies require procurement of feeds with a low water cost of production (WCP). A prime example is using food-feed crops in mixed crop-livestock systems. Growing 1 dry weight kg of a crop such as teff, maize or sorghum typically requires 2-3 m³ of water. After harvest, crop residues used to sustain domestic animals constitutes feed that requires no additional water. Notwithstanding farmers' potential use of crop residues for fuel, home construction and soil nutrient replenishment, effective use of food-feed crops reduces the WCP of both crop and animal products. In some cases, such as dryland pastures, forage may have a relatively lower WCP because available water cannot sustain competitive demands from cultivation. Within water-scarce areas, importation of feed for livestock creates no additional local demand for water, although it likely will do so elsewhere.
2. Production-enhancing strategies help maximise benefits derived from animal production per unit volume of water depleted. Water used to produce feed for sick and dying animals results in little or no benefit to producers. Thus veterinary care, provision of appropriate nutrients and creation of a stress-free environment helps increase LWP, as can enhancing market opportunities for animal products.
3. Water-conserving strategies help increase LWP by shifting evaporation to transpiration. For example, overgrazing depletes vegetative cover, resulting in high evaporation and low transpiration in rangelands. Better pasture management through seasonally varying and sustainable stocking rates and rehabilitation of degraded areas fosters higher transpiration rates by encouraging infiltration of rainwater, replenishing soil fertility and maintaining a critical mass of live plant biomass that can respond to the onset of rains. In addition, well-managed vegetative buffer strips around the edges of lakes, rivers and ponds limit degradation of water quality through sedimentation and contamination with pathogens. A 3-metre wide vegetative buffer can filter out

>90% of sediments and zoonotic pathogens, helping to maintain down-slope water quality. In many countries, these buffer zones are protected by law, although enforcement is rare.

4. Strategically allocating spatial and temporal distributions of livestock, drinking water and feed resources will allow for sustainability in animal production. Under free-grazing systems, the LWP is low, because the cattle concentrate around drinking water supplies which results in overgrazing near water sources while undergrazing occurs elsewhere.

Rather than technical fixes, these strategies involve having access to and adopting an appropriate mix of technology, training and education, community participation, investment, marketing opportunities and

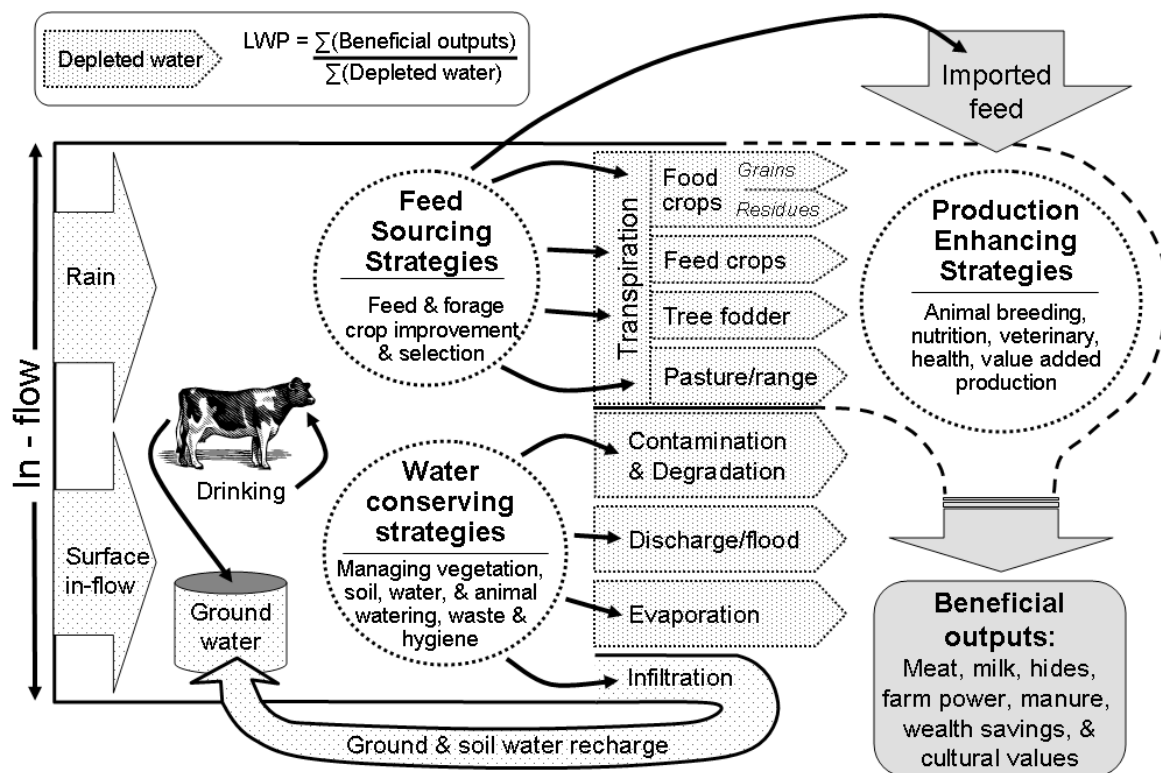


Figure 1. LWP depends on water accounting principles and helps identify opportunities for more effective water use.
Source: Peden *et al.* (2012)

coherent governance. This is especially true where livestock, land, water and market development depend on access to common-property natural resources managed through local institutions and various levels and branches of government. These strategies need integration with development priorities related to improving cultivation practices, adapting to climate change and promoting agricultural markets.

Integrating irrigation development with livestock keeping is important. Africa-wide, the highest livestock densities are associated with large-scale irrigation (Peden *et al.*, 2006). Large-scale irrigation, such as in Gezira (Sudan), often generates abundant crop residues and nutritional supplements that can sustain

meat and dairy production and thus farm income. Yet planners often fail to provide access to safe and sustainable watering sites, veterinary services and corrals. In small-scale irrigation, water harvesting can also help to increase LWP and farm income (see case 1 below). Ironically, much investment in African irrigation aims to reduce poverty. When successful, many farmers use the extra income to acquire livestock as a means to grow and secure wealth.

Rather than using a fixed set of recommendations, there is need to gain a better understanding of the local situation. An assessment of agricultural water use is necessary to identify appropriate intervention options, as shown in the two case studies which follow.

Case 1: *Smallholder Ethiopian farming in Ethiopia* (Figure 2). In the Awash River Basin, a group of farmers with mean annual income of about US\$300 were trapped in poverty. A few local cows and subsistence cultivation sustained them. Sasakawa-Global 2000 and ILRI provided training and loans of about US\$1100 per household. This credit enabled construction of underground water tanks and establishment of supplemental irrigation of cash crops such as garlic and onions. Irrigation water was collected from household water catchments of about 2500 m². The farmers also replaced local with hybrid cows that combined benefits of indigenous and Friesian breeds. Daily milk production rose from about one to almost 20 litres. Farmers converted milk into butter and procured feed resources. The stored water eliminated the need for children to trek long distances daily to the river to water their animals and enabled them to attend school. Farmers also introduced “cut-and-carry” feeding and use of crop residues. Within three years, family income rose more than 300%. Marketing of vegetables and milk represented 40% and 60% of their increased income, respectively. Loans were repaid over a three-year period during which net farm income also rose. Marketing of dairy products and cash crops along with improved productivity of crops and milk generated increased beneficial income combined with decreasing non-productive water depletion (run-off) resulted in higher agricultural water productivity.



Figure 2. Water harvesting (top left) for supplemental irrigation for cash crops combined with cut-and-carry feeding (top right) of improved dairy cows (bottom left) and conversion of milk to butter (bottom right).

Case 2: Rehabilitating degraded rangelands in Uganda (Figure 3). In Nakasongola District, Uganda, overgrazing and excessive charcoal production led to severe loss of vegetation and the feed and ecosystem services it provides, greatly increasing termite damage. Resultant land degradation forced herders to abandon their land and migrate to new areas. Uncontrolled animal access to drinking water led to bacterial contamination and loss of riparian buffer vegetation. Soil carried by runoff from upstream areas filled ponds or valley tanks with sediment, reducing water storage capacity. With loss of available drinking water, herders were forced to trek long distances to Nile riparian areas for drinking and grazing in the dry season. Stress associated with forced migration led to high rates of animal morbidity and mortality. Researchers from Makerere University and ILRI collaborated with livestock keepers to rehabilitate pastures and improve valley tank management. By restoring grass production, herders transformed excessive evaporation into transpiration, thereby increasing forage production and LWP. By providing vegetative buffers and separate drinking troughs, valley tanks retain greater storage capacity and water quality.



Figure 3. Overgrazing in Ugandan rangelands led to loss of forage (top left) and contaminated and sediment filled valley tanks (top right). Rehabilitating pastures (bottom left) and improving water management (bottom right) increased LWP, enabling more productive and sustainable animal production.

Conclusion

LWP takes an interdisciplinary agro-ecosystems approach to achieve more effective, sustainable and productive use of agricultural water for animal production. It calls for better feed sourcing and management, adoption of best-bet animal production technology, and improved water conservation. Increasing LWP requires appropriate technology within the context of multi-stakeholder participation and enabling financial and governance systems. In African rainfed agriculture, the greatest opportunity for increasing LWP lies in capturing non-productive evaporation and converting it into productive transpiration, a strategy that can increase water availability and access without increasing competition for already scarce blue-water resources.

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References:

Awulachew, S.B., Smakhtin, V., Molden, D. and Peden, D. 2012. *The Nile River Basin: Water, Agriculture, Governance and Livelihoods*. Routledge, UK.

Comprehensive Assessment of Water Management in Agriculture (CA). 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Earthscan, London, UK and International Water Management Institute, Colombo, Sri Lanka.

<http://www.iwmi.cgiar.org/Assessment/>

Falkenmark, M. and Rockstrom, J. 2006. The new blue and green water paradigm: breaking new ground for water resources planning and management. *Journal of Water Resources Planning and Management* 132(3), 129–132.

Peden, D., Freeman, A., Astatke, A., Notenbaert, A., Ayalneh, W., Baltenweck, I. *et al.* 2006. *Investment options for integrated water-livestock crop production in sub-Saharan Africa*. Working paper 1.

International Livestock Research Institute, Nairobi, Kenya.

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.168.3964&rep=rep1&type=pdf>

Peden, D., Alemayehu, M., Amede, T., Awulachew, S.B., Faki, H., Hailelassie, A. *et al.* 2009. Nile basin livestock water productivity. CPWF Project Report Series, PN37. CPWF, Colombo, Sri Lanka.

http://cgspace.cgiar.org/bitstream/handle/10568/3927/PN37_ILRI_Project%20Report_Nov09_final.pdf?sequence=1

Peden, D., Amede, T., Hailelassie, A., Faki, H., Mpairwe, D., van Breugel P. et al. 2012. Livestock and water in the Nile River Basin. In The Nile River Basin: Water, Agriculture, Governance and Livelihoods. Awulachew, S.B., Smakhtin, V., Molden, D. and Peden, D.(eds), Routledge, Abingdon, UK.

The Rangeland Journal, 2009. Special issue: Livestock Water Productivity. *The Rangeland Journal* 31 (2).