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Multiple uses of small reservoirs in crop-livestock agro-ecosystems of Volta basin: Implications for livestock management

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ABSTRACT

Small reservoirs (SR) are structures that capture and store run-off from upstream catchment area for multiple uses including irrigation, fishing, livestock watering, domestic purpose and groundwater recharge. Though livestock watering is one of the major uses of small reservoirs in the Volta River basin of West Africa, there is limited information on how livestock management practices co-exist with other use of SRs. This study was carried out in a typical Sudano-Sahelian zone within the Volta basin in Burkina Faso, covering five reservoirs to 1) document multiple uses of the reservoirs with a focus on their utilization for livestock production. 2) identify proximate and long-term causes of livestock-related conflicts with regard to multiple uses of the water infrastructure and 3) explore strategies to manage the SR equitably for various uses. Adult males and boys accounted for at least 60% of the users of small reservoirs in our study. Livestock watering was done mainly by adult males. In addition to provision of water for livestock, small reservoirs also contributed to feed resources for animals by providing green forage (pasture grown on residual moisture) in the dry season which accounted for at least 5% of the total dry matter diet of cattle and small ruminant in late dry season. None of the 5 small reservoirs we studied was used for irrigated fodder production. Increased competitions over the use of small reservoirs, damage to irrigated crops by the animals, and increased number of livestock using the small reservoirs were ranked as the most important causes of conflict in the communities. Peaceful co-habitation of the use of the small reservoirs for irrigated vegetable production and livestock watering are essential for reduction of the incidence of conflict.

1. Introduction

Small reservoirs, or dams, are fundamental water management infrastructure in agricultural production systems, whether in temperate or tropical agro-ecosystems. In particular in semiarid subtropics and tropics, storage of water are essential to ensure resilience in crop livestock production, and hence, income. For example, in Australia, 2 million farm with an approximate volume of 8 million ML of water (Australia Government, http://lwa.gov.au/node/2640; last accessed Feb 2018) in addition to water withdrawal from large reservoirs and natural water ways supports the crop, horticulture and livestock production sector to generate 3% of annual GDP, or 36.1 billion USD (World Bank, 2018). In the United Kingdom, there is increasing interest in small farm water storage development to secure production and productivity. An indication of this is the growth of +4% in storage volume for so-called winter spray abstraction licenses (Weatherhead et al., 2014). In Brazil, hundreds of small reservoirs were built in the Preto River Basin, a sub-basin of the São Francisco river basin, contributing to the improvement of irrigated agriculture and livestock watering in the region (Rodrigues et al., 2012). Similarly, in Zimbabwe, southern African region, over 7000 small reservoirs, which constitute the bulk of small water bodies in the country, have been constructed in the past decades, supplying water for mostly for livestock watering, domestic purposes, and irrigation (Senzanje et al., 2008). There is a renewed recognition in several countries in Sub Saharan Africa to develop small scale distributed water infrastructure, such as the 'One dam, one village' in Ghana (e.g., http://www.atlfmonline.com/home/24-ghana/6742-sona-2018-one-village-one-dam-starts-full-operation-this-year.html) and similarly in Kenya (e.g., https://www.nation.co.ke/news/Water-storage-top-priority-as-the-rains-start/1056-3886706-awewfuz/).

Whereas there has been a long and heated debate on the pros and cons of large infrastructural water storage (e.g., Moore et al., 2010), there is much less solicited evidence on the pros and cons around small

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scale distributed water infrastructure. Given the emerging challenges with increasing need to have resilient water management in many of the world's food baskets (e.g. Rockström et al., 2014), there is a need to better understand the role of manmade distributed built small scale water infrastructure in agricultural landscapes. This is particularly important in agro ecological environments with sparse natural water infrastructure of water bodies such as parts of sub- Saharan Africa (e.g., Vörösmarty et al., 2005) and with having limited economic access to explore tentative potential groundwater resources of groundwater storage (Altchenko and Villolt, 2015). There is a specific interest pertinent to explore the use and benefits of SR for crop and livestock production systems in the West Africa Sudano-Sahelian zone of West Africa which is characterized by short (4–5 months) rainfall duration and high intra-annual rainfall variability. Here, a key adaptation strategy to climate variability by millions of poor people is crop-livestock based livelihoods (Douxchamps et al., 2015) which is highly dependent on water availability. Indeed numerous opportunities exist to increase returns on investment in agricultural water through integrated water-crop-livestock management (Peden et al., 2005). In this context, small reservoirs (dams) with a typical dam height of less than 10 m, capture and store runoff from upstream water networks and catchment with varying sizes (Boelee et al., 2009; Venot et al., 2012) for multiple uses. Some reservoirs have larger dimensions but the maximum storage capacity is not a criterion for effective use, as many reservoirs, though shallow are vastly spread out on the agricultural landscape. Small reservoirs are used for irrigation during dry spells, fishing, livestock watering, domestic use and groundwater recharge (Douxchamps et al., 2014). They were largely constructed in the West African context in Mali, Burkina Faso, and Ghana in response to the Sahelian droughts of the 1970s and 1980s (Morris and Barron, 2014). The study country of interest in this paper is Burkina Faso, as it currently has the highest densities of small reservoirs in West Africa (Leemhuis et al., 2009; Sally et al., 2011). Although the number of small reservoirs has increased over the years, natural processes and human induced activities often affect them, threatening their sustainable use. More than one thousand small reservoirs across Burkina Faso are under low to high impact of anthropogenic influences including soil erodibility, rainfall and population impact (Forkuor et al., 2015). Expected increased rainfall variability will likely put more demand on these small reservoirs as they provide multiple and essential benefits to livelihoods during lengthy dry season. Small reservoirs were initially used as a source of agricultural water for livestock (Opoku-Ankomah et al., 2006), but the development of irrigated agriculture around these reservoirs soon followed (Venot and Cecchi, 2011). The increasing use of small reservoirs in this context for off-season production of vegetables and crops at the expense of livestock watering is creating conflict (Sally et al., 2011).

Previous studies on small reservoirs in the Volta River Basin have neglected the importance of livestock management practices, particularly utilization by livestock, although livestock watering was the primary purpose of their establishment. Most of the studies focused on understanding the hydrological processes, water balance, irrigation performance of small reservoirs and local water management practices (Sally et al., 2011; Fowe et al., 2015). Results from hydrological monitoring of small reservoirs in the Volta River Basin indicated that their irrigation potential has been underutilized (Fowe et al., 2015; Poussin et al., 2015). Studies have also been conducted on the governance of small reservoirs in the Volta River Basin, which looked at the strengths and weaknesses of the local institutions, such as the local water management committee, called Comités Locaux de l'Eau (CLE), in Burkina Faso (Sally et al., 2011). It is commonly observed that the local water management committees have not been able to satisfactorily address questions regarding access to, and allocation of water, though they are crucial for the satisfactory functioning of the reservoirs (Petit and Baron, 2009; Sally et al., 2011; Venot and Cecchi, 2011).

There is limited information, if any, on how livestock management practices affect uses of small reservoirs in the Volta River basin. For example, cases of conflict have been blamed on the livestock use of small reservoirs (Sally et al., 2011), but there is hardly any studies on the evolution, and proximate and long-term causes of these conflicts. Besides, livestock affect the use of small reservoirs through water contamination, which poses health risks to communities that use the small reservoirs for domestic purposes (Poda, 2007). It is important to address the management of the livestock around the small reservoirs to reduce health hazards associated with livestock watering. In addition, due to the rapid increase in the use of the small reservoirs for vegetable production, vegetable fields around reservoirs often block the passage of livestock that come in search of water (de Fraiturea et al., 2014). The issues raised above necessitate that adequate attention is given to livestock management practices around small reservoirs.

The aim of this study is to document the multiple uses of small reservoirs in the study sites with an emphasis on access to, and use by, livestock, and the potential conflicts that arise over the use of small reservoirs. Specifically, the objectives of this study are to: (i) document the multiple uses of small reservoirs with a focus on how livestock management practices affect this use; and (ii) identify the causes of livestock-related conflicts with regard to multiple uses of small reservoirs and (iii) strategies to manage them. The underlying hypothesis for this study is that adequate consideration of livestock management practices in planning for the multiple uses of small reservoirs in the Volta River basin of Burkina Faso reduces the incidence of conflict and improves the livelihoods of the various users and ultimately the human and societal benefits obtained by improved water productivity. Specific research questions addressed were: (i) how do livestock management practices impact multiple uses of small reservoirs, and what is the implication of the number of livestock owned by households for the use of small reservoirs? and (ii) what are the proximate and long-term causes of conflict over the use of small reservoirs in the study sites?

2. Materials and methods

2.1. Description of the study sites

The study was conducted in communities using five small reservoirs in Yatenga Province of Burkina Faso: Bagyalgo, Soumyalga, Goinre, Ninighi and Thiou in the commune rurale (local government area) of Namissiguima, Oula, Ouahigouya, Koumbri and Thiou, respectively. Landsat data acquired in 2014 were analyzed to map the geographical location and surface area of the selected small reservoirs. Reservoir volume was estimated from the surface area as recommended in the literature (Liebe et al., 2005; Annor et al., 2009).For each of the reservoirs, the upstream contributing river network and watershed were delineated within an ArcGIS environment using NASA's Digital Elevation Data (DEM). The location of the five small reservoirs where the study was conducted is presented in Fig. 1. Yatenga province is situated between the Sudano-Sahelian and the Sahelian climate zones. The climate is characterized by an extended dry season from November to May. The average annual rainfall in the province for the period 1963–2003 was reported as 617 mm, with the ranges from 358 mm to the North of the province to 836 mm to the South (Douxchamps et al., 2015).

2.2. Livestock management practices

Most households in the study areas engage in both crop and livestock production (Douxchamps et al., 2015). The level of integration of crop production and livestock husbandry varies depending on the socioeconomic conditions of the households and opportunities for off-farm activities, such as artisan mining which is common in these areas. Livestock production is mainly extensive involving cattle, sheep, goats and poultry, although there are households that practice sedentary livestock production systems which often involve lactating cows and animal fattening. Under a sedentary system, animals are confined