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*Augustine. A. Ayantunde, Mawa Karambiri, Viviane Yameogo and Olufunke O. Cofie*

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## Project

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## Collaborators

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# Contents

# Summary

Small reservoirs are structures that capture and store runoff at catchment level. The surface area of majority of these reservoirs ranges from 3 to 30 ha. In Burkina Faso, a small reservoir is defined by the height of the dam, which should be below 10 m. They have multiple uses: irrigation during dry spells, fishing, livestock watering, domestic use and groundwater recharge through increased infiltration. Although one of the major uses of small reservoirs in the Volta River Basin is for livestock watering, there is limited information, if any, on how livestock management practices affect this use. This study was conducted in communities using five small reservoirs (Bagyalgo, Soumyalga, Goinre, Ninighi and Thiou) in Yatenga Province of Burkina Faso in the Volta River Basin. The aim of the study was to document the multiple uses of small reservoirs in the study sites with an emphasis on access to, and use by, livestock, and conflicts that arise over the use of these 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 proximate and long-term causes of livestock-related conflicts with regard to multiple uses of small reservoirs and strategies to manage them. The results of this study have confirmed the commonly reported trend of the increasing use of the small reservoirs for vegetable production, even though most of the small reservoirs were initially constructed for livestock watering. The competition for use of these small reservoirs for vegetable production and livestock watering is the main challenge to the management of these reservoirs in the study sites. Adult males and boys accounted for at least 60% of the users of small reservoirs in this study. Livestock watering was carried out mainly by adult males and boys, whereas the use of small reservoirs for domestic purposes was dominated by adult females and girls. In addition to the provision of water for livestock, small reservoirs also contributed to supplying feed resources for livestock by providing green forage in the dry season, which accounted for at least 5% of the total dry matter feed. None of the five small reservoirs in the study were used for fodder production. Increased competition over the use of small reservoirs, damage caused by livestock to irrigated crops and vegetables, and an increased number of livestock using the small reservoirs were ranked as the most important causes of conflict. However, most cases of conflict over the use of the small reservoirs were resolved at the community level. Peaceful coexistence in the use of the small reservoirs for vegetable production and livestock watering is essential for reducing the incidence of conflict, and this will require engagement of key stakeholders such as vegetable growers' associations and livestock keepers' associations.

## INTRODUCTION

Small reservoirs usually have a dam height of less than 10 m, and capture and store runoff from catchments with an area ranging from 3 to 30 ha (Boelee et al. 2009). However, there are some reservoirs of larger dimensions. The maximum storage capacity or volume of the small reservoir is not a criterion, as most reservoirs are vast but very shallow with important seasonal variations. They are used for irrigation during dry spells, fishing, livestock watering, domestic use and groundwater recharge (Douxchamps et al. 2014). Small reservoirs were largely constructed in Burkina Faso in response to the Sahelian droughts of the 1970s and 1980s, and the country now has one of the highest densities of small reservoirs in West Africa (Leemhuis et al. 2009; Sally et al. 2011). They were initially used as a source of 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). To reduce this conflict and facilitate the equitable use of these small reservoirs, it is essential to include livestock management practices in the planning and management of their usage.

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). Studies have shown that the volumes of a large number of small reservoirs in the Volta River Basin ranged from 104 to 107 $m^3$ (Fowe et al. 2015). They play a considerable role in developing and maintaining livelihood activities in rural areas, and in providing irrigation water for agriculture and supplying water for both livestock and domestic use (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).

In the Volta River Basin, one of the major uses of small reservoirs is for livestock watering. However, there is limited information, if any, on how livestock management practices affect this use. 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 Fraiture 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 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 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. Specific research questions addressed were: (i) how do livestock management practices benefit multiple uses of small reservoirs, and what is the implication of the number of livestock owned by households for the use of these reservoirs? and (ii) what are the proximate and long-term causes of conflict over the use of small reservoirs in the study sites?

## METHODOLOGY

### 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. The location of the five small reservoirs where the study was conducted is presented in Figure 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).

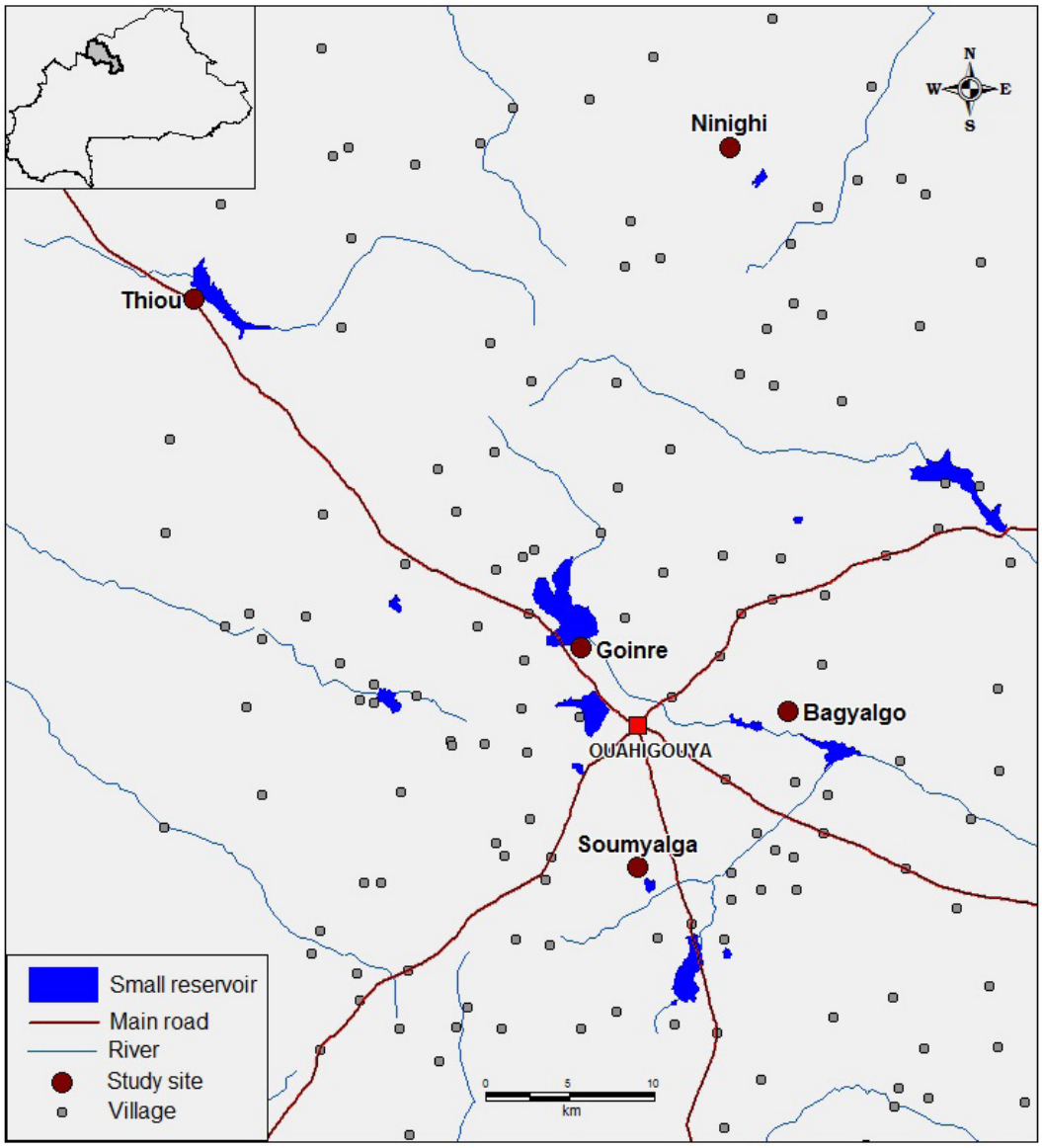
### Livestock Management Practices

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 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 within an enclosure or tethered, and feed and water are brought to them. In the study sites, there are few households that practice transhumance, but there is the strong presence of transhumant pastoralists from the drier zone of Burkina Faso and Mali who come in search of crop residues (to graze) and water during the dry season. Over the years, some of the transhumant herders have settled in the study areas to grow crops and raise their animals. In the individual interviews that were conducted, we asked questions on livestock ownership and feeding strategies adopted by the respondents using the small reservoirs.

### Surveys on the Multiple Uses of Small Reservoirs

Focus group discussions (FGDs) and individual surveys were conducted to document the multiple uses of small reservoirs in the White Volta sub-basin in Yatenga Province of Burkina Faso. The study focused on five small reservoirs in Bagyalgo, Soumyalga, Goinre, Ninighi and Thiou in the *commune rurale* (local government area) of Namissiguima, Oula, Ouahigouya, Koumbri and Thiou,

FIGURE 1. Map showing the five small reservoirs where the study was conducted in Yatenga Province of Burkina Faso.




respectively. These small reservoirs were representative of the reservoirs in Yatenga Province in terms of size and multiple uses. Two FGDs were conducted in communities around each small reservoir in December 2014 and included key water users, such as crop farmers, vegetable producers and animal herders. Details of the FGDs are presented in Table 1. In addition, 50 members of the communities around each small reservoir were interviewed, except for Ninighi where 49 individuals were interviewed. In total, 249 people were interviewed, including 57 women. A breakdown of the individuals interviewed in communities around each small reservoir is presented in Table 2. Several issues related to small reservoirs were addressed, including past and current state of these reservoirs, uses and users, stakeholder analysis with regards to use and maintenance, perception on use and governance, livestock management practices, and causes of conflicts due to use and strategies for resolution.

TABLE 1. Participants of the FGDs in five small reservoirs in Yatenga Province of Burkina Faso.

| Variable | | Small reservoir | | | | |
|---|---|---|---|---|---|---|
| | | Bagyalgo | Soumyalga | Goinre | Ninighi | Thiou |
| Communities where FGDs were held | | Bagyalgo, Bapore | Bourbo, Soumyalga | Goinre, Yissighin | Koumbri, Ninighi | Hamdallaye, Thiou |
| Average number of participants | | | | | | |
| - | Male | 10 | 8 | 10 | 10 | 11 |
| - | Female | 3 | 5 | 4 | 3 | 3 |
| - | Total | 13 | 13 | 14 | 13 | 14 |

TABLE 2. Number of individuals interviewed in communities around five small reservoirs in Yatenga Province of Burkina Faso.

| Variable | | Small reservoir | | | | |
|---|---|---|---|---|---|---|
| | | Bagyalgo | Soumyalga | Goinre | Ninighi | Thiou |
| Communities of the respondent | | Bagyalgo, Bapore, Poidougo, Watinoma | Bourbo, Soumyalga | Goinre | Koumbri, Mena, Ninighi | Hamdallaye, Thiou |
| Number interviewed | | | | | | |
| - | Male | 37 | 40 | 42 | 28 | 45 |
| - | Female | 13 | 10 | 8 | 21 | 5 |
| - | Total | 50 | 50 | 50 | 49 | 50 |

### Data Analysis

Analysis of the data collected from the individual interviews was carried out using the Statistical Analysis System (SAS) (Statistical Analysis System Institute 1987). The MEANS and FREQUENCY procedures in SAS were used for summary statistics, and the General Linear Model (GLM) procedures were used for variance and regression analyses of data on household herd size and normalized ranking of different uses of small reservoirs.

## RESULTS AND DISCUSSION

The main results from the study are presented in this section.

### General Features of the Small Reservoirs in the Study Areas

According to feedback received from the FGDs, the five small reservoirs considered in this study were established during three periods – 1960s, 1980s and 2003 (Table 3). The small reservoirs that were established during the 1980s were in response to the severe droughts of the 1970s and 1980s. Two of the small reservoirs in Goinre and Thiou were large and retained water for at least 9 months of the year due to their relatively large dimension compared to the other reservoirs. In the 1980s, the small reservoirs were established by the national government with external funding.

The most recent small reservoir in Bagyalgo was more or less a big dugout without a cemented wall. The major uses of these small reservoirs were similar and mainly for vegetable production, livestock watering, crop irrigation, domestic use, brick making and fishing. There are water users' associations (WUAs), including CLE, which are responsible for the management of the small reservoirs, specifically decision making on access to the small reservoirs and period, granting access to transhumant herders, resolution of conflicts, and collection of fees from those outside of the areas for using the small reservoirs.

TABLE 3. Key features of the five small reservoirs in the study sites based on feedback received from the FGDs.

| Variable | Small reservoir | | | | |
|---|---|---|---|---|---|
| | Bagyalgo | Soumyalga | Goinre | Ninighi | Thiou |
| Date of establishment | 2003 | 1983 | 1966 | 1988 | 1980 |
| Type of small reservoir | Big dugout without a cemented wall | Big dugout with a cemented wall | Well developed, small dam with irrigation facilities | Big dugout with a cemented wall | Well developed, small dam with irrigation facilities |
| Communities using it | Bagyalgo, Bapore, Poidougo, Watinoma | Soumyalga, Bourbo | Goinre, Yissighin | Ninighi, Mena, Koumbri | Hamdallaye, Thiou |
| Surface area (ha) | 61.28 | 32.18 | 925.65 | 35.63 | 378.61 |
| Estimated population of the communities using the small reservoir | 4,400 | 4,900 | 4,000 | 11,400 | 8,950 |
| Number of months when water is available | 6 months | 7 months | 9 months | 8 months | 9 months |
| Major uses | Vegetable production, livestock watering, domestic use, brick making | Vegetable production, livestock watering, fishing, domestic use | Vegetable production, crop irrigation, livestock watering, fishing, domestic use, road construction | Vegetable production, crop irrigation, livestock watering, fishing, domestic use, brick making, mining | Vegetable production, crop irrigation, livestock watering, fishing, domestic use, brick making, mining |
| Presence of WUAs | WUAs | CLE, vegetable growers' associations | CLE, vegetable growers' associations | CLE, vegetable growers' associations | CLE, vegetable growers' associations |
| Major problems facing the small reservoir | Sedimentation, increased competition, conflicts, water contamination | Sedimentation, increased competition, water contamination | Sedimentation, increased competition, conflicts, weak governance | Sedimentation, increased competition, water contamination | Sedimentation, increased competition, conflicts, weak governance |

### Age, Occupation and Household Size of the Respondents

The average age of the male and female individuals interviewed ranged from 43 to 56 and 37 to 51 years, respectively (Table 4). Women respondents were generally younger than the males, which is the normal trend in many rural communities in sub-Saharan Africa, as women tend to get married much earlier than men. All the respondents have resided in their communities for at least 20 years. The household size ranged from about 10 to 18. At least 40% of the household members in all the communities using the five small reservoirs were below the age of 15 years, which agrees with the trend in many rural communities in West Africa. The productive members of the family, those aged between 16 and 60 years, accounted for about 40% of the household. The proportion of males to females was similar in all the communities, but the proportion of females tended to be slightly higher than that of males (INSD 2015).

The occupation of at least 70% of the respondents in the study sites was crop-livestock farming while about 20% were crop farmers (Figure 2). Most of the respondents were from the Mossi ethnic group, though there was a significant presence of those from the Peulh ethnic group in Thiou where there are settled pastoralists (Figure 3).

At least one-third of the respondents had no form of education, except in Thiou (Figure 4). Many of the respondents had Koranic education, while some had primary education. Less than 10% of the respondents had secondary school education.

FIGURE 2. Primary occupation of the respondents in the study sites.

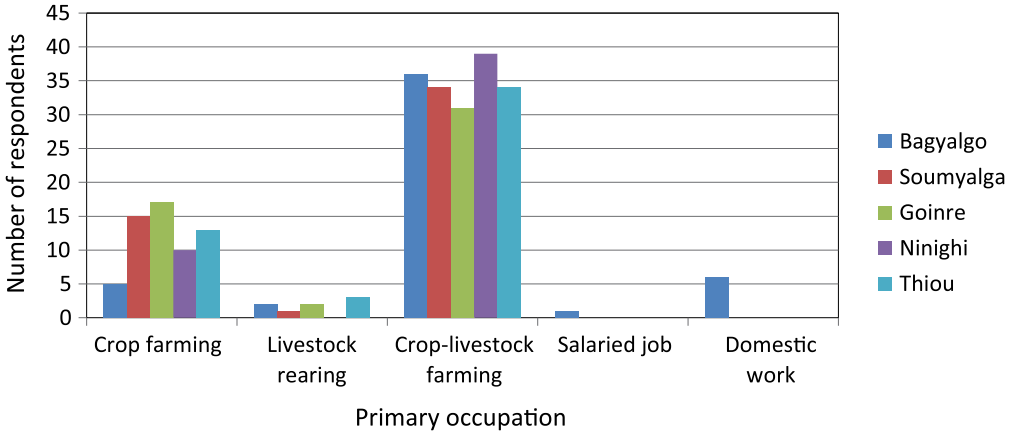



FIGURE 3. Ethnic group of the respondents.

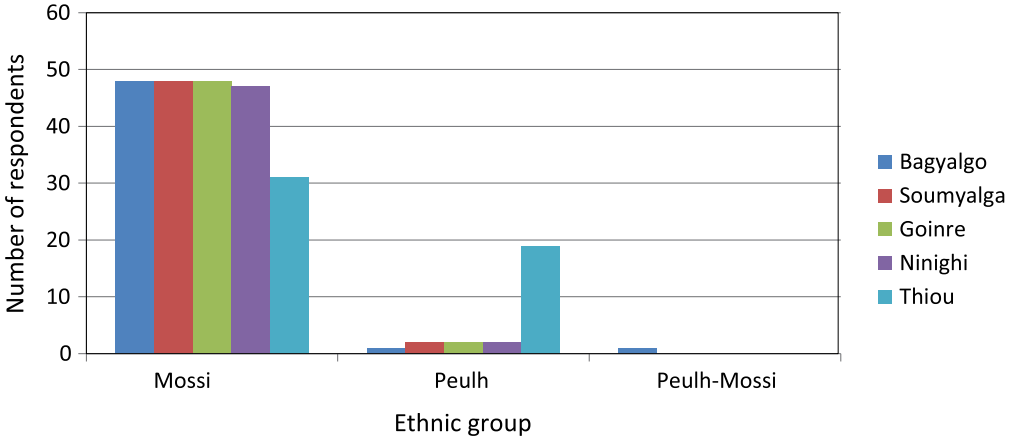
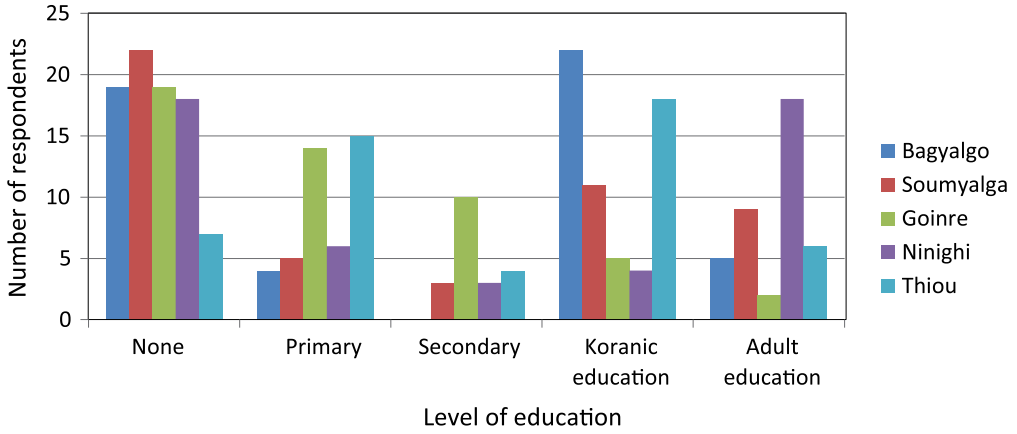


TABLE 4. Age and household composition of the users of small reservoirs interviewed in the study sites according to gender of the respondents (means ± standard error).

| Variable | Small reservoir | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bagyalgo | | Soumyalga | | Goinre | | Ninighi | | Thiou | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| Age (years) | 55.6±1.7[a] | 51.1±3.8[a] | 43.5±1.9[b] | 37.3±3.7[b] | 48.6±1.9[a] | 45.5±3.7[a, b] | 52.6±2.[4a] | 42.9±2.[2b] | 43.8±1.[9b] | 42.3±2.[9b] |
| Years residing in the community | 53.5±2.5[a] | 49.7±4.5[a] | 43.2±1.7[b] | 31.8±5.7[b] | 36.2±2.0[b] | 26.4±4.[4b] | 50.9±2.[3a] | 32.7±3.[3b] | 40.4±2.[6b] | 29.0±3.[1b] |
| Household composition | | | | | | | | | | |
| Male < 5 years | 1.0±0.2 | 2.1±0.4 | 1.2±0.2 | 1.3±0.4 | 1.2±0.2 | 1.1±0.3 | 1.1±0.3 | 1.9±0.3 | 1.6±0.2 | 1.8±0.7 |
| Female < 5 years | 1.8±0.3 | 1.8±0.6 | 1.2±0.2 | 1.6±0.3 | 1.3±0.2 | 1.1±0.3 | 1.1±0.5 | 2.3±0.4 | 1.7±0.2 | 2.3±0.7 |
| Male 6-15 years | 2.1±0.3 | 2.1±0.4 | 1.9±0.3 | 1.5±0.6 | 2.3±0.3 | 1.5±0.5 | 2.2±0.7 | 2.6±0.8 | 2.6±0.3 | 2.7±0.8 |
| Female 6-15 years | 2.1±0.3 | 2.0±0.4 | 2.0±0.3 | 2.0±0.5 | 1.9±0.3 | 0.9±0.3 | 3.5±0.9 | 2.1±0.9 | 1.9±0.2 | 2.7±0.6 |
| Male 16-60 years | 3.1±0.4 | 2.7±0.4 | 2.5±0.3 | 1.9±0.2 | 2.3±0.2 | 2.6±0.6 | 3.6±0.6 | 3.5±0.4 | 2.7±0.2 | 2.0±0.8 |
| Female 16-60 years | 3.3±0.5 | 2.9±0.5 | 2.3±0.2 | 2.4±0.6 | 2.2±0.2 | 2.6±0.4 | 4.4±1.4 | 4.8±0.7 | 2.5±0.3 | 3.0±1.4 |
| Male > 60 years | 0.4±0.1 | 0.3±0.1 | 0.4±0.1 | 0.4±0.2 | 0.4±0.1 | 0.4±0.2 | 0.7±0.1 | 0.5±0.2 | 0.4±0.1 | 0 |
| Female > 60 years | 0.4±0.1 | 0.5±0.3 | 0.6±0.1 | 0.6±0.2 | 0.6±0.1 | 0.4±0.2 | 0.5±0.2 | 0.7±0.3 | 0.7±0.1 | 0.2±0.1 |
| Total household size | 14.2±1.6[a] | 14.4±1.5[a] | 12.2±1.0[a, b] | 11.7±1.2[a, b] | 12.3±0.9[a, b] | 10.6±1.5[b] | 17.1±3.7[a] | 18.4±2.6[a] | 14.2±1.1[a] | 14.8±2.3[a] |

*Note:* [a, b] Values denote significant difference ($p < 0.05$) between means within the same row.

FIGURE 4. Level of education of the respondents.




**Livestock and Land Assets of the Respondents, and Implications for the Use of Small Reservoirs**

The livestock and land assets of the households, based on interviews conducted in the study sites, are presented in Tables 5 and 6, respectively, according to gender of the respondents. According to male respondents, the average household cattle herd size was reported to be at least 3 Tropical Livestock Units (TLU) (an animal of 250 kg live weight). Female respondents reported a cattle herd size between 1.40 and 2.90 TLU per household. The lower herd size reported by female respondents is a reflection of the lower number of cattle owned by women in general. The total herd size ranged from 2.9 TLU in Goinre to 7.4 TLU in Thiou (Table 5). The highest herd size in Thiou could be attributed to the significant population of settled pastoralists in the community who, by tradition, often possess a large herd size. Females tended to own more small ruminants (sheep and goats) than males, as reflected in the slightly higher number reported by female respondents, except in Goinre, Ninighi and Thiou. The number of livestock owned by the household has implications for the use of small reservoirs, as they depend mainly on these sources for livestock watering.

The area of land cultivated varied markedly with the crops and the communities as presented in Table 6. According to male respondents, the area under millet was the highest in Ninighi (5.2±0.9 ha per household). The area of land under sesame was generally the lowest in all the study sites. Female respondents reported a higher area of land under cowpea and groundnut in all the communities (except Goinre), which is a reflection of the common trend in Burkina Faso where women generally cultivated more of these two crops than men. The area under vegetables was less than 1 ha per household, which ranged from 0.3 ha to 0.9 ha, according to both male and female respondents. Off-season vegetable production depends mainly on the small reservoirs. The area of land cultivated tended to be positively correlated with the household size (Figure 5).

Results of the regression analysis of the household herd size for different animal species on the independent variables for the combined data of all the respondents showed that being of Peulh ethnic group had significant effect on the herd size (Table 7) compared to being of the Mossi ethnic group. The Peulh are pastoralists and they generally own more livestock than the Mossi ethnic group who are traditionally farmers. Household size also had a significant effect on the herd size, with the tendency for large households to have more livestock.

Results of the contribution of different feed resources to livestock diet across different seasons (wet, early dry and late dry) showed that natural pastures are the main source of feed for ruminants (cattle, sheep and goats) in the wet season, while crop residues (cereal straw, legume residues) become increasingly important as a feed source as the season progresses from wet to dry (Figures 6[a] to 6[e]).

TABLE 5. Herd size (TLU) of households interviewed in the study sites according to gender of the respondents (means ± standard error).

| Variable | Small reservoir | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bagyalgo | | Soumyalga | | Goinre | | Ninighi | | Thiou | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| Cattle | 3.4±0.8$^{a}$ | 2.3±0.7$^{a, b}$ | 3.2±0.9$^{a}$ | 1.6±0.6$^{b}$ | 3.5±0.2$^{a}$ | 1.4±0.7$^{b}$ | 3.9±0.9$^{a}$ | 2.9±0.8$^{a, b}$ | 5.2±1.1$^{c}$ | 1.9±0.7$^{a}$ |
| Sheep | 0.3±0.1$^{a}$ | 0.7±0.2$^{b}$ | 0.7±0.1$^{b}$ | 0.8±0.3$^{b}$ | 0.9±0.1$^{b}$ | 0.4±0.2$^{a}$ | 0.9±0.2$^{b}$ | 0.9±0.2$^{b}$ | 0.9±0.2$^{b}$ | 0.8±0.4$^{b}$ |
| Goats | 0.42±0.1$^{a}$ | 0.6±0.2$^{a}$ | 0.9±0.1$^{a, b}$ | 1.0±0.3$^{b}$ | 0.5±0.1$^{a}$ | 0.4±0.2$^{a}$ | 0.7±0.2$^{a}$ | 0.7±0.3$^{a}$ | 0.6±0.2$^{a}$ | 0.7±0.5$^{a}$ |
| Donkeys | 0.3±0.1$^{a}$ | 0.4±0.1$^{a, b}$ | 0.5±0.1$^{a, b}$ | 0.3±0.1$^{a}$ | 0.3±0.1$^{a}$ | 0.4±0.1$^{a, b}$ | 0.6±0.1$^{b}$ | 0.6±0.1$^{b}$ | 0.5±0.1$^{b}$ | 0.5±0.1$^{b}$ |
| Poultry | 0.1±0.0$^{a}$ | 0.2±0.0$^{a}$ | 0.2±0.0$^{a}$ | 0.2±0.1$^{a}$ | 0.2±0.1$^{a}$ | 0.3±0.1$^{a}$ | 0.2±0.1$^{a}$ | 0.1±0.1$^{a}$ | 0.2±0.0$^{a}$ | 0.2±0.1$^{a}$ |
| Total | 5.5±0.8$^{a}$ | 4.3±1.0$^{a}$ | 5.4±1.1$^{a}$ | 3.8±1.1$^{a}$ | 5.4±1.0$^{a}$ | 2.9±1.0$^{a}$ | 6.3±1.2$^{a, b}$ | 5.3±1.1$^{a}$ | 7.4±1.3$^{b}$ | 4.0±1.1$^{a}$ |

*Notes:* The t-test showed that the cattle herd size reported by male respondents was higher than that reported by female respondents in all the study sites.

$^{a, b, c}$ Values denote significant difference ($p < 0.05$) between means within the same row.

TABLE 6. Area of land (ha) cultivated by the households for different crops in the study sites according to gender of the respondents (means ± standard error).

| Variable | Small reservoir | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bagyalgo | | Soumyalga | | Goinre | | Ninighi | | Thiou | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| Maize | 0.6±0.1$^{a}$ | 0.2±0.1$^{b}$ | 0.7±0.1$^{a}$ | 0.5±0.2$^{a}$ | 0.8±0.1$^{a}$ | 0.6±0.2$^{a}$ | 0.2±0.1$^{b}$ | 0.3±0.1$^{b}$ | 0.4±0.1$^{a, b}$ | 0.4±0.1$^{a, b}$ |
| Rice | 0.5±0.1$^{a}$ | 0.3±0.1$^{a}$ | 0.4±0.1$^{a}$ | 0.1±0.0$^{b}$ | 0.3±0.1$^{a}$ | 0.5±0.2$^{a}$ | 0.1±0.1$^{b}$ | 0.2±0.1$^{b}$ | 0.4±0.1$^{a}$ | 0.4±0.1$^{a}$ |
| Sorghum | 0.8±0.1$^{a}$ | 0.6±0.2$^{a, b}$ | 1.1±0.1$^{a}$ | 1.0±0.2$^{a}$ | 1.2±0.2$^{a}$ | 0.9±0.2$^{a}$ | 1.2±0.4$^{a}$ | 1.2±0.4$^{a}$ | 0.8±0.1$^{a}$ | 0.3±0.1$^{b}$ |
| Millet | 0.5±0.1$^{a}$ | 0.6±0.1$^{a}$ | 0.9±0.1$^{a, c}$ | 0.9±0.1$^{a, c}$ | 0.7±0.1$^{a}$ | 0.6±0.1$^{a}$ | 5.2±0.9$^{b}$ | 3.5±0.9$^{b}$ | 1.3±0.1$^{c}$ | 1.1±0.3$^{c}$ |
| Cowpea | 0.2±0.1$^{a}$ | 0.3±0.1$^{a}$ | 0.5±0.1$^{b}$ | 0.6±0.1$^{b}$ | 0.4±0.1$^{a, b}$ | 0.4±0.1$^{a, b}$ | 0.6±0.1$^{b}$ | 0.8±0.2$^{b}$ | 0.3±0.1$^{a, b}$ | 0.7±0.2$^{b}$ |
| Groundnut | 0.3±0.1$^{a}$ | 0.9±0.1$^{a, b}$ | 0.5±0.1$^{a}$ | 0.6±0.1$^{a}$ | 0.9±0.2$^{a, b}$ | 0.6±0.1$^{a}$ | 1.2±0.2$^{b}$ | 1.9±0.5$^{b}$ | 0.5±0.1$^{a}$ | 0.6±0.1$^{a}$ |
| Vegetables | 0.9±0.1$^{a}$ | 0.7±0.1$^{a}$ | 0.5±0.1$^{b}$ | 0.3±0.03$^{b}$ | 0.8±0.1$^{a}$ | 0.4±0.1$^{a, b}$ | 0.5±0.2$^{a, b}$ | 0.5±0.1$^{a, b}$ | 0.6±0.1$^{a, b}$ | 0.4±0.1$^{b}$ |
| Sesame | 0.1±0.1$^{a}$ | 0.1±0.1$^{a}$ | 0.1±0.1$^{a}$ | 0.1±0.1$^{a}$ | 0.1±0.0$^{a}$ | 0 | 0.2±0.1$^{a}$ | 0.2±0.1$^{a}$ | 0.1±0.1$^{a}$ | 0.2±0.1$^{a}$ |
| Total | 3.9±0.3$^{a}$ | 3.7±0.3$^{a}$ | 4.6±0.3$^{a}$ | 4.0±0.4$^{a}$ | 5.1±0.6$^{a}$ | 4.0±0.7$^{a}$ | 9.4±1.1$^{b}$ | 8.5±1.8$^{b}$ | 4.2±0.4$^{a}$ | 4.1±0.4$^{a}$ |

*Notes:* The t-test showed that the area under groundnut is significantly higher as reported by female respondents than male respondents in Bagyalgo. Male respondents reported a higher area under vegetables than female respondents in Goinre.

$^{a, b, c}$ Values denote significant difference ($p < 0.05$) between means within the same row.

A similar trend was observed for browse shrubs/trees. For cattle and small ruminants (sheep and goats), natural pastures accounted for at least 75% of the total dry matter diet in the wet season. The contribution of natural pastures as a feed source for cattle and small ruminants decreased significantly as the season progressed from wet to late dry. However, even in the late dry season, natural pastures still accounted for at least 5% of the total diet of both cattle and small ruminants, which can be explained by the availability of green forage around the small reservoirs. This was confirmed by the respondents who observed that their animals spent a significant time grazing around the small reservoirs in the dry season. Results of feed assessments in sites in Burkina Faso and Niger, where there is no small reservoir, showed that the contribution of natural pastures to ruminant diet was virtually zero in the late dry season (Amole and Ayantunde 2016). There was no fodder production in all the small reservoirs where we conducted our study, which further confirms that the contribution of small reservoirs to feed resources for animals is through the provision of green forage in the dry season.

FIGURE 5. Relationship between the area of land cultivated and household size in communities around the five small reservoirs in the study sites.

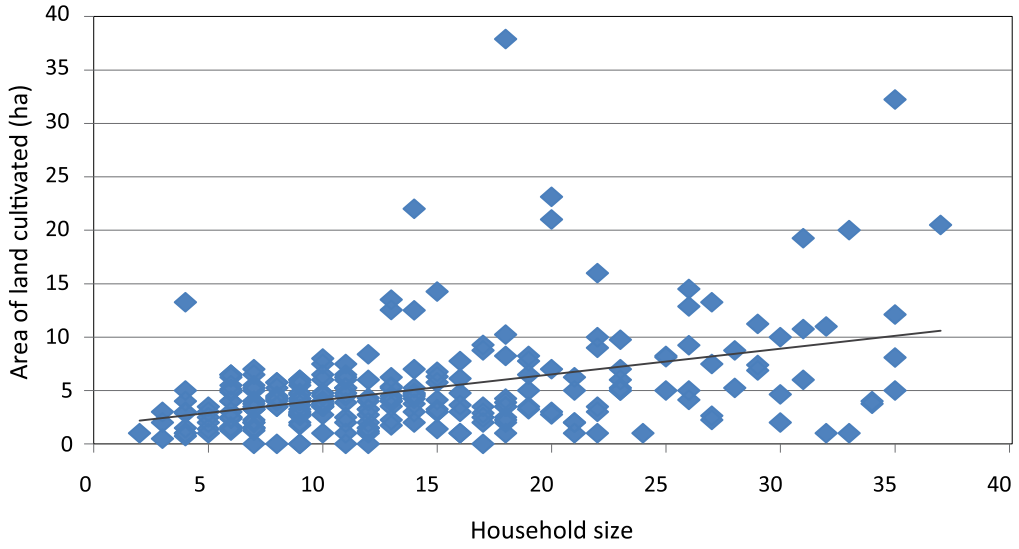



TABLE 7. Results of the regression analysis of the household herd size for different animal species on the independent variables for the combined data of the five small reservoirs studied in the Volta River Basin.

| Independent variable | Cattle | Sheep | Goats | Poultry | Total herd |
|---|---|---|---|---|---|
| Age | 0.004 | -0.008* | -0.002 | -0.002** | -0.009 |
| Female | -0.588 | 0.009 | 0.088 | -0.065** | -0.520 |
| Peulh | 10.571*** | 0.909*** | 0.990*** | 0.032 | 12.523** |
| No education | 0.893 | -0.150 | 0.010 | -0.022 | 0.665 |
| Koranic education | -0.386 | -0.346** | -0.150 | -0.044 | -0.988 |
| Adult education | -0.267 | -0.093 | 0.239 | -0.042 | -0.143 |
| Household size | 0.089*** | 0.023*** | 0.016*** | 0.007 | 0.145*** |
| Constant | 0.640 | 0.864*** | 0.365* | 0.189*** | 2.395** |
| $R^2$ | 0.421 | 0.166 | 0.173 | 0.154 | 0.421 |

*Notes:* *** Significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Values are regression coefficients for each independent variable.

FIGURE 6(a). Contribution of different feed sources to the total dry matter diet of cattle and small ruminants in the wet (June to October), early dry (November to January) and late dry (February to May) seasons in Bagyalgo.

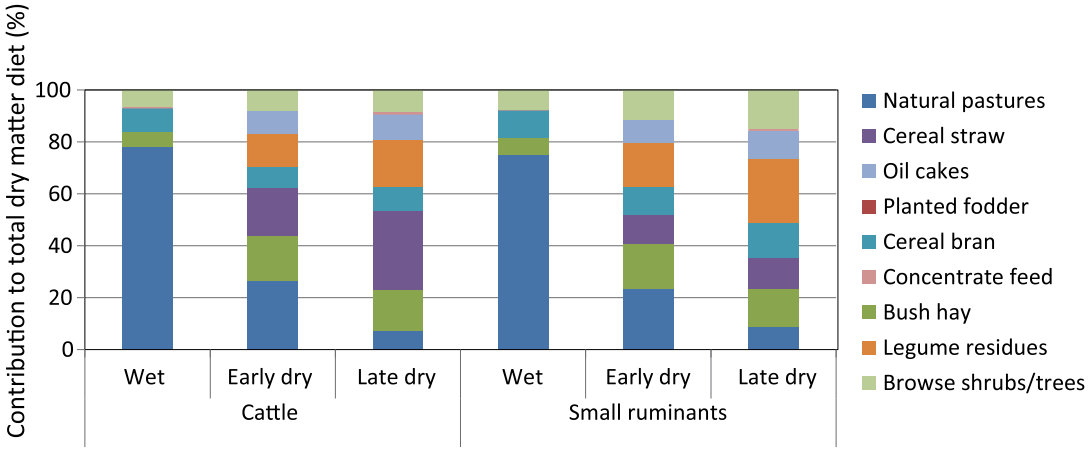



FIGURE 6(b). Contribution of different feed sources to the total dry matter diet of cattle and small ruminants in the wet (June to October), early dry (November to January) and late dry (February to May) seasons in Soumyalga.

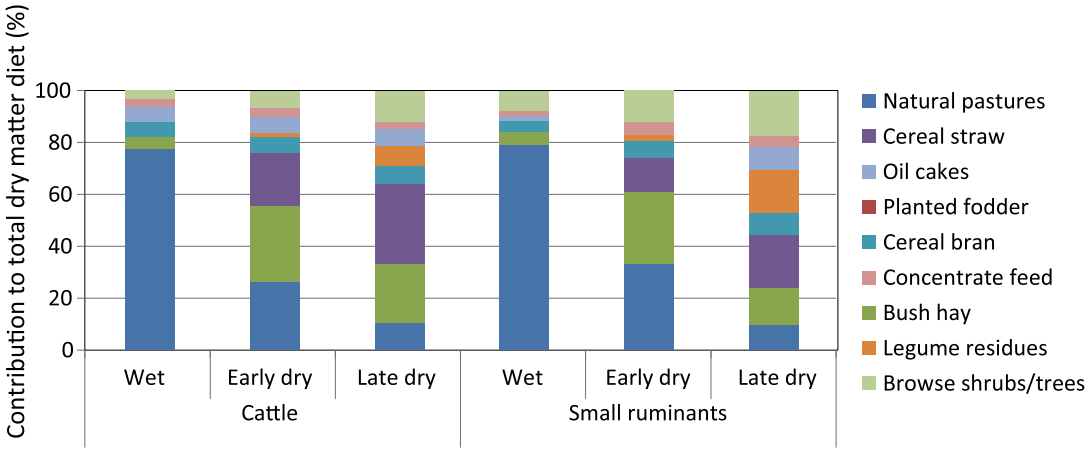



FIGURE 6(c). Contribution of different feed sources to the total dry matter diet of cattle and small ruminants in the wet (June to October), early dry (November to January) and late dry (February to May) seasons in Goinre.

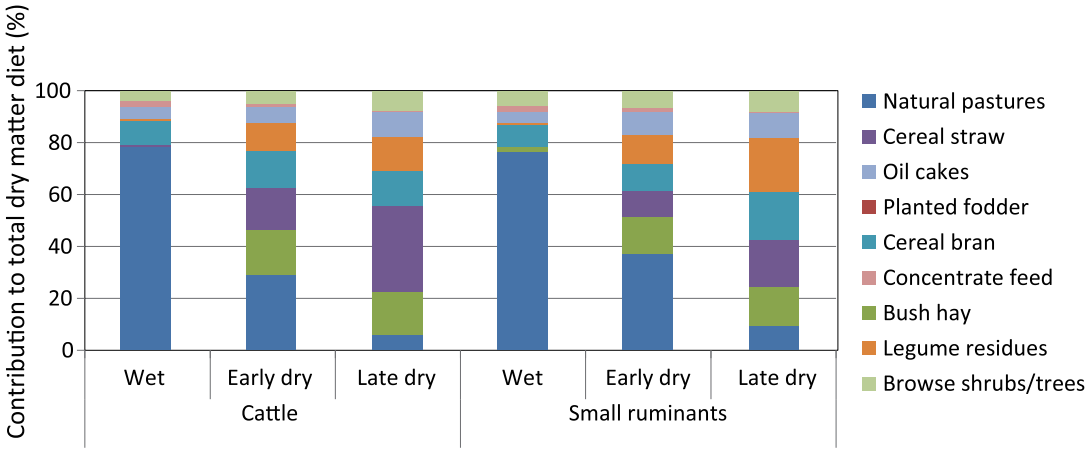


FIGURE 6(d). Contribution of different feed sources to the total dry matter diet of cattle and small ruminants in the wet (June to October), early dry (November to January) and late dry (February to May) seasons in Ninighi.

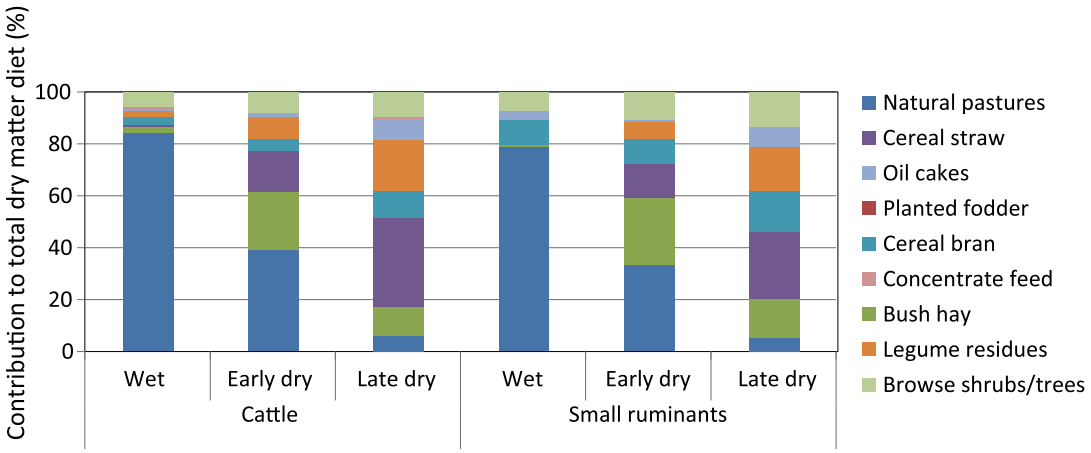
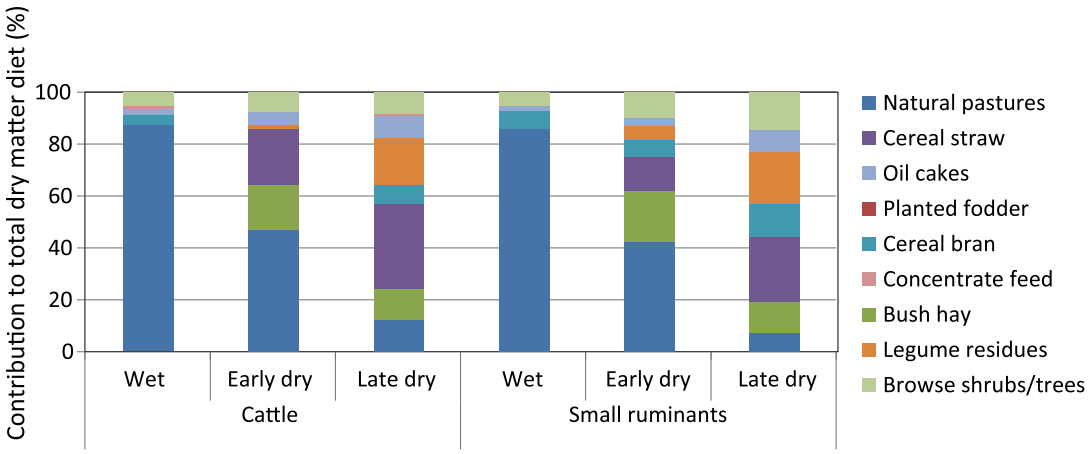



FIGURE 6(e). Contribution of different feed sources to the total dry matter diet of cattle and small ruminants in the wet (June to October), early dry (November to January) and late dry (February to May) seasons in Thiou.




## Multiple Uses of Small Reservoirs in the Study Areas

The results of the normalized ranking of different uses of small reservoirs in the study areas showed that the first priority was to use the reservoirs for vegetable production, which was then closely followed by livestock watering (Table 8). In the dry season, using the reservoirs for livestock watering may also entail grazing by some animals around the small reservoirs. These results confirm the commonly reported trend of the increasing use of the small reservoirs for vegetable production, even though most of the small reservoirs were initially constructed for livestock watering. According to the respondents, the competition for use of these small reservoirs for vegetable production and livestock watering is the main challenge to the management of these reservoirs in the study sites.

Finding mechanisms for accommodating the use of the small reservoirs for vegetable production and livestock watering are critical to their sustainable use. Other uses of small reservoirs in the study areas were for crop irrigation, domestic use (e.g., washing clothes and dishes), brick making and fishing. Results of the normalized ranking for the use of the small reservoirs for crop irrigation (e.g., maize, rice and cowpea) seemed to be specific to the location.

TABLE 8. Mean normalized ranking[†] (0 to 1) of different uses of small reservoirs according to gender of the respondents in the study sites (means ± standard error).

| Variable | Small reservoir | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bagyalgo | | Soumyalga | | Goinre | | Ninighi | | Thiou | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| Crop irrigation | 0.19±0.02[a] | 0.24±0.06[a] | 0.24±0.03[a] | 0.25±0.08[a] | 0.60±0.04[b] | 0.44±0.09[a, b] | 0.24±0.03[a] | 0.22±0.03[a] | 0.45±0.04[a, b] | 0.54±0.17[a, b] |
| Vegetable production | 0.95±0.02[a] | 0.95±0.02[a] | 0.94±0.03[a] | 0.98±0.02[a] | 0.95±0.02[a] | 1 ± 0[a] | 0.98±0.01[a] | 1 ± 0[a] | 0.90±0.03[a] | 0.95±0.04[a] |
| Livestock watering | 0.86±0.01[a] | 0.94±0.03[a] | 0.83±0.02[a] | 0.62±0.10[b] | 0.73±0.03[a, b] | 0.60±0.11[b] | 0.83±0.02[a] | 0.82±0.02[a] | 0.88±0.02[a] | 0.83±0.07[a] |
| Domestic use | 0.63±0.04[a] | 0.74±0.04[a] | 0.42±0.04[a, b] | 0.23±0.04[b] | 0.46±0.02[a, b] | 0.29±0.05[b] | 0.44±0.04[a, b] | 0.38±0.04[b] | 0.26±0.02[b] | 0.33±0.07[b] |
| Brick making | 0.25±0.03[a] | 0.19±0.03[a] | 0.27±0.03[a] | 0.27±0.07[a] | 0.32±0.02[a] | 0.25±0.06[a] | 0.54±0.04[b] | 0.47±0.05[b] | 0.36±0.03[a, b] | 0.21±0.04[b] |
| Fishing | 0.17±0.01[a] | 0.17±0.01[a] | 0.17±0.01[a] | 0.17±0.02[a] | 0.23±0.02[a] | 0.17±0.01[a] | 0.21±0.01[a] | 0.23±0.02[a] | 0.24±0.02[a] | 0.25±0.05[a] |

*Notes:* [†] Normalized ranking = 1 – ([raw rank – 1] / total number of items).

[a, b] Values denote significant difference ($p < 0.05$) between means within the same row.

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Crop irrigation was given a higher priority in Goinre and Thiou than in other areas (Table 8), probably because these reservoirs are well-developed, small dams with irrigation facilities. Results of the regression analysis of the normalized ranking of different uses of small reservoirs in the study sites showed that ethnic group, household size and total area of land cultivated had a significant effect on the ranking given by the respondents (Table 9). Respondents from the Peulh ethnic group generally gave a low ranking to the use of small reservoirs for vegetable production, domestic use and brick making, and a high ranking for livestock watering. Essentially, the results suggest that Peulh communities ranked the use of small reservoirs for livestock watering as being more important than all the other uses. Household size seemed to be positively correlated with a high ranking for the use of small reservoirs for vegetable production, livestock watering and domestic use. The results of regression analysis further showed that there was a positive relationship between ranking of the use of the small reservoirs for vegetable production and total land area cultivated (Table 9). This suggests that higher the land area cultivated lower the priority attached to the use of the small reservoirs for domestic use, as more water is needed for irrigation. Gender had a significant effect on the ranking of the use of small reservoirs for crop irrigation, as women tended to give this a lower priority.

In agreement with the results of the normalized ranking of the uses of the small reservoirs, the respondents reported that the small reservoirs were either moderately or always used for vegetable production and livestock watering in all the five small reservoirs studied (Figures 7[a] to 7[e]). The small reservoirs were reported to be rarely used for fishing and brick making, although the results were different in Ninighi, where brick making seemed to be one of the major uses of the small reservoir. Small reservoirs seemed to be mainly used for domestic purposes in the dry season, when the open wells used for domestic chores sometimes dried up.

Results of the monthly distribution in the use of the five small reservoirs (Figures 8[a] to 8[e]) in our study showed that they are used year round for livestock watering, which increases as the season progresses from wet (June to October) to dry (November to May). The use of the small reservoirs for livestock watering was reported to be limited in the late dry season (April and May), when the small reservoirs dried up completely. The small reservoirs were also used for vegetable production and brick making, but other uses seemed to be seasonal. For example, fishing was

TABLE 9. Results of the regression analysis of the normalized ranking of different uses of small reservoirs on the independent variables for the combined data of the five small reservoirs studied in the Volta River Basin.

| Independent variable | Crop irrigation | Vegetable production | Livestock watering | Domestic use | Brick making | Fishing |
|---|---|---|---|---|---|---|
| Age | -0.002 | -0.001 | 0.001 | 0.003** | 0.001 | -0.001 |
| Gender (female) | -0.074* | 0.011 | -0.037 | -0.044 | -0.018 | 0.005 |
| Ethnic group (Peulh) | 0.072 | -0.197*** | 0.100** | -0.236*** | -0.106** | 0.017 |
| No education | -0.071 | 0.005 | 0.049* | 0.059 | -0.032 | 0.062*** |
| Household size | -0.001 | 0.002** | 0.002** | 0.003** | 0.003** | 0.001 |
| Total area of land cultivated | -0.001 | 0.004** | -0.003 | -0.011*** | -0.019** | -0.001 |
| Herd size | -0.004 | -0.007*** | 0.003 | -0.002 | -0.002 | 0.003 |
| Constant | 0.554*** | 0.988*** | 0.737*** | 0.313*** | 0.276*** | 0.252 |
| $R^2$ | 0.102 | 0.441 | 0.131 | 0.170 | 0.216 | 0.134 |

*Notes:* *** Significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Values are regression coefficients for each independent variable.

carried out mainly in the wet season when the water level of the small reservoirs was high. The use of small reservoirs for crop irrigation was seasonal, except in Goinre where it was carried out year round due to the availability of water for most of the year.

FIGURE 7(a). Frequency of use of the small reservoir in Bagyalgo.

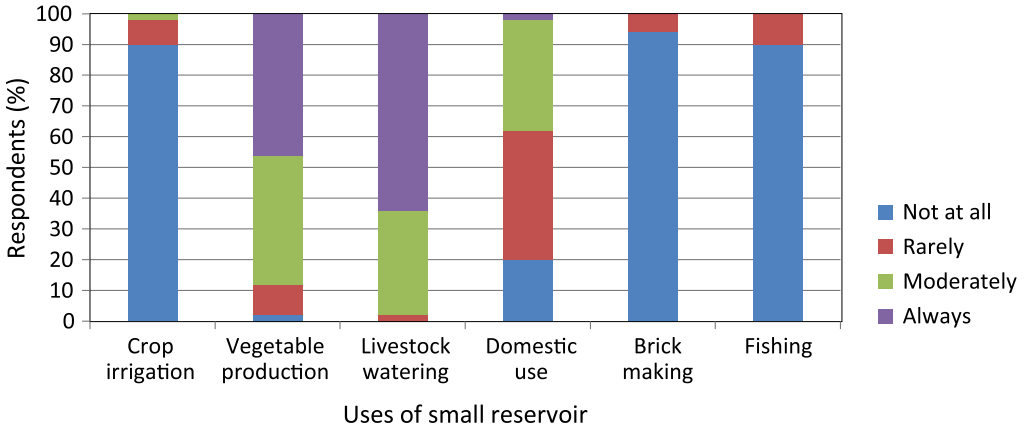



FIGURE 7(b). Frequency of use of the small reservoir in Soumyalga.

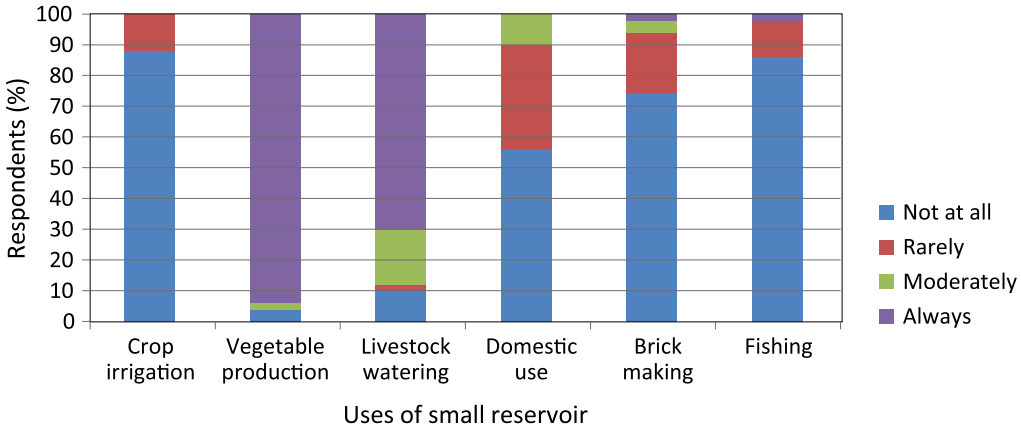



FIGURE 7(c). Frequency of use of the small reservoir in Goinre.

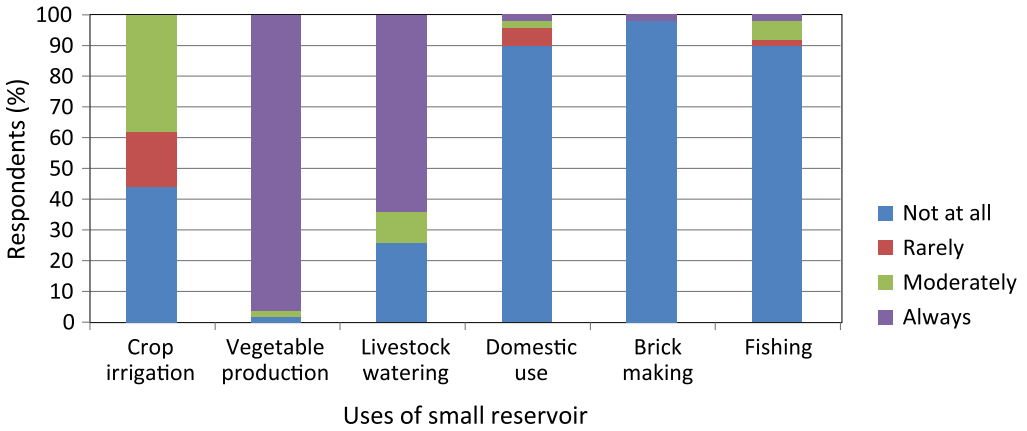


FIGURE 7(d). Frequency of use of the small reservoir in Ninighi.

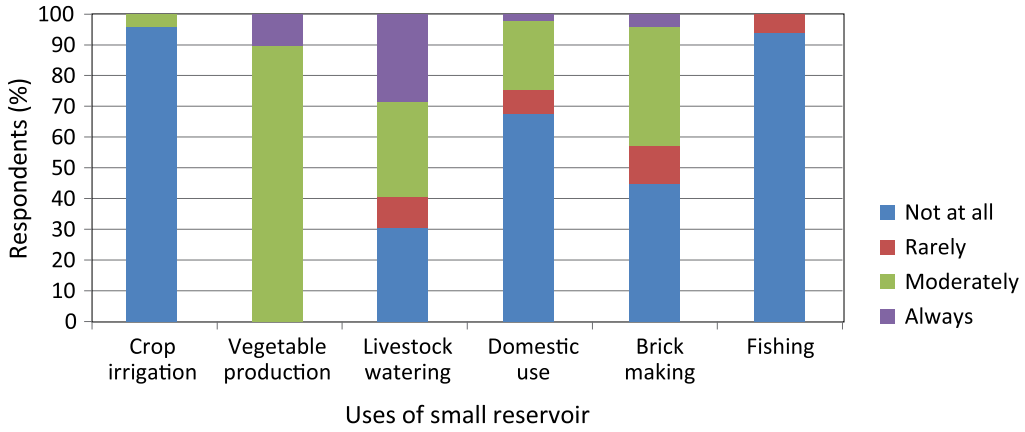



FIGURE 7(e). Frequency of use of the small reservoir in Thiou.

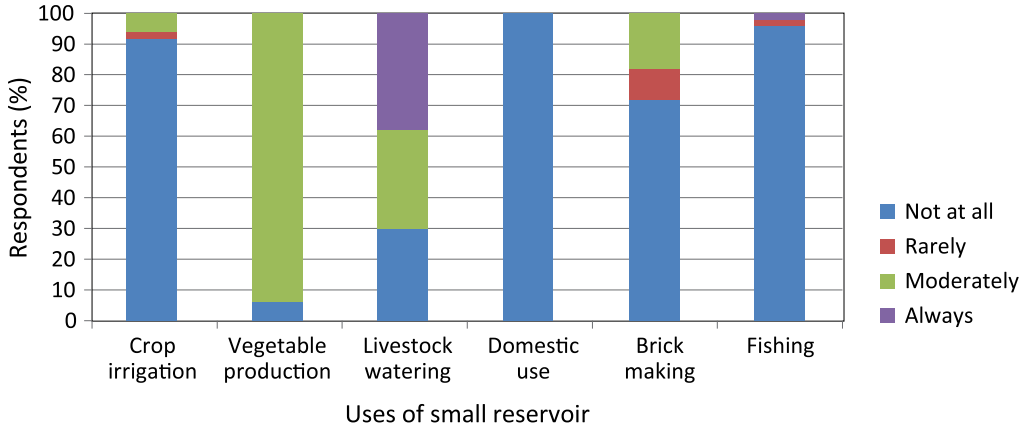



FIGURE 8(a). Monthly distribution in the use of the small reservoir in Bagyalgo.

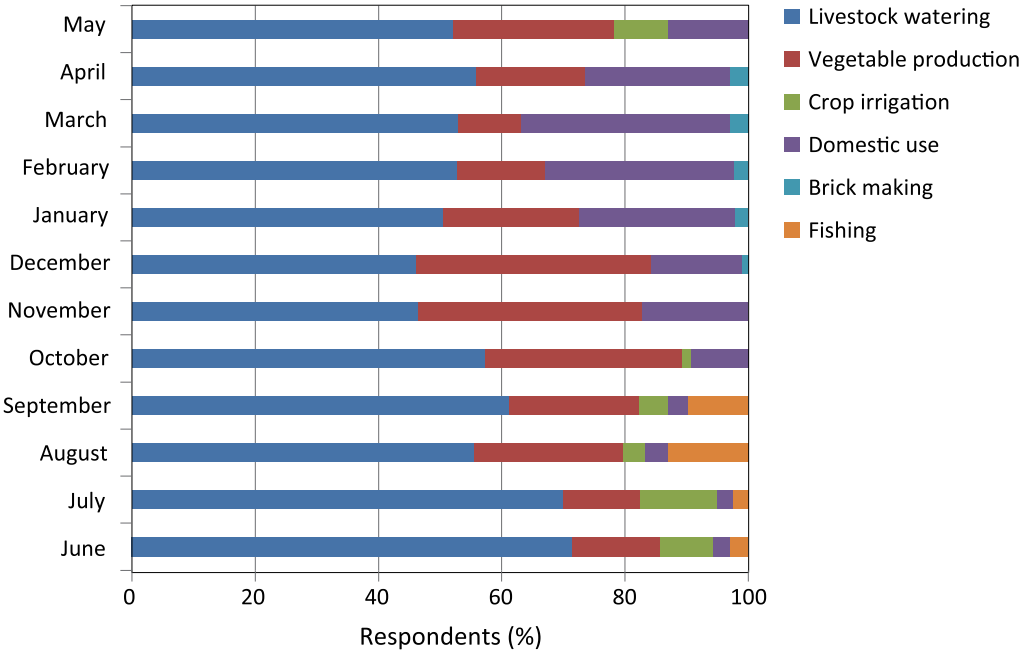


FIGURE 8(b). Monthly distribution in the use of the small reservoir in Soumyalga.

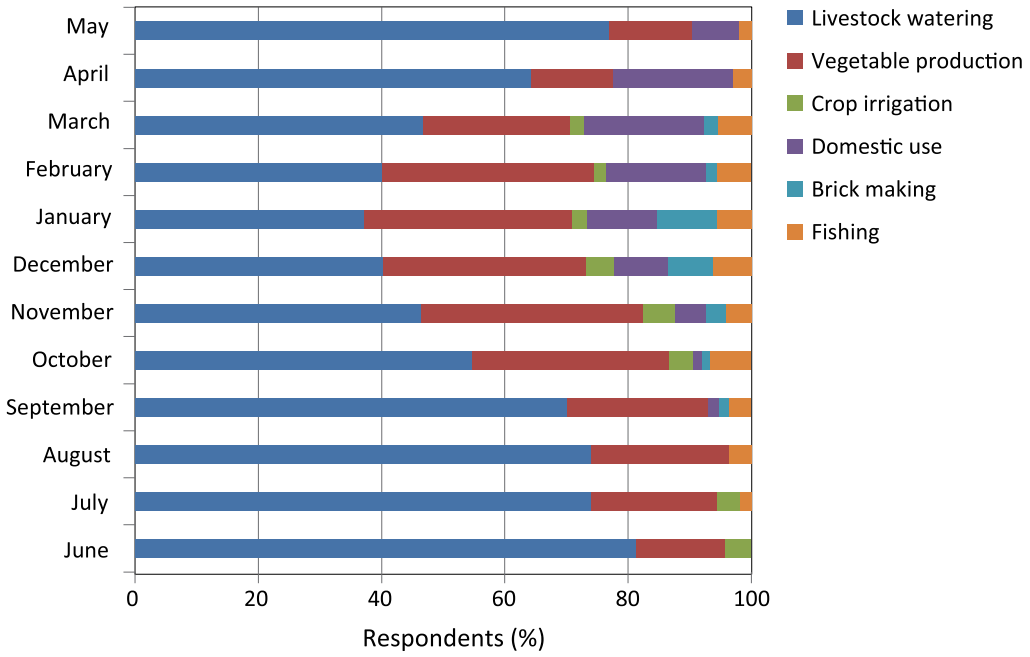



FIGURE 8(c). Monthly distribution in the use of the small reservoir in Goinre.

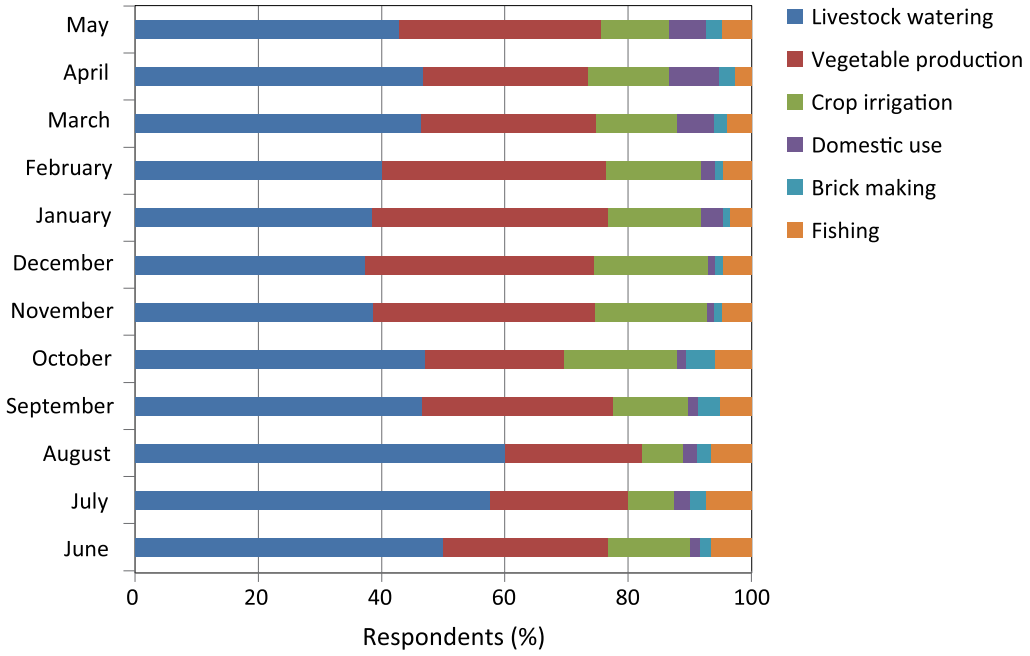


FIGURE 8(d). Monthly distribution in the use of the small reservoir in Ninighi.

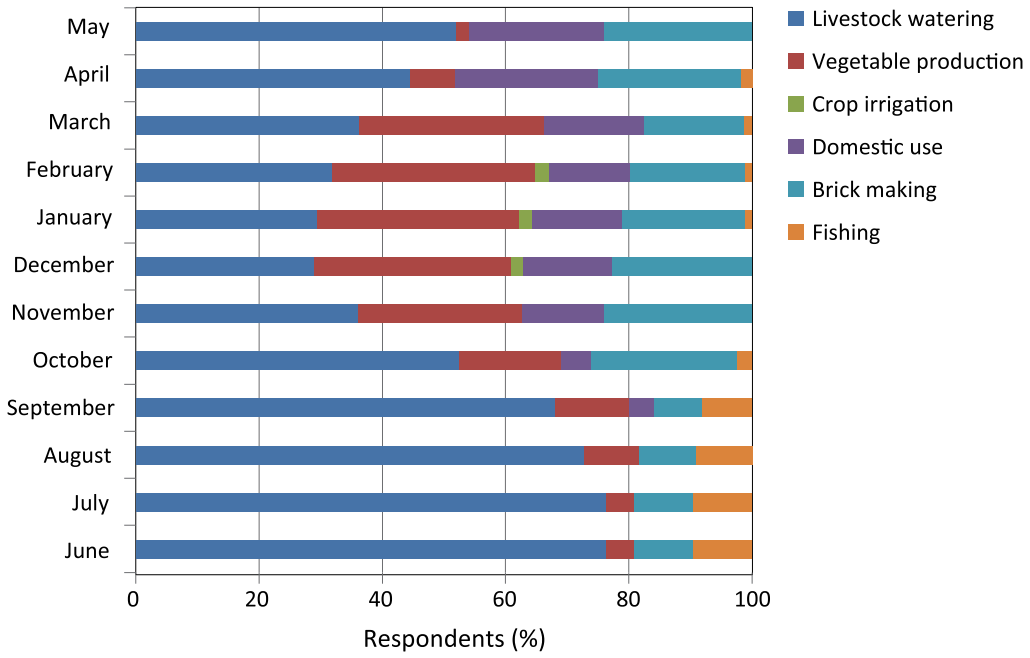
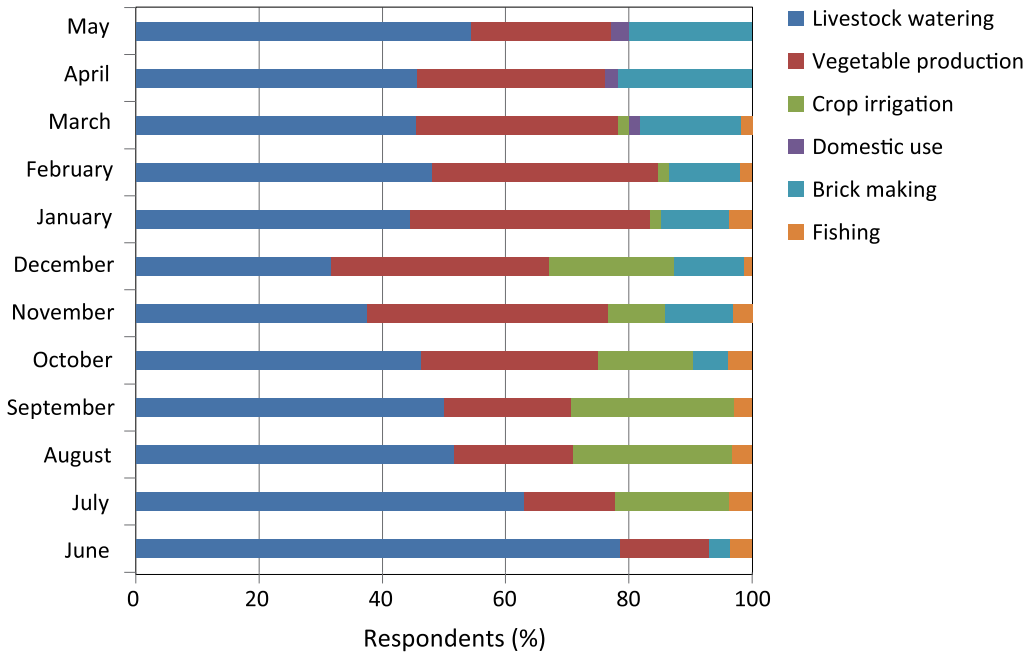



FIGURE 8(e). Monthly distribution in the use of the small reservoir in Thiou.



Results of the distribution of labor in using the small reservoirs showed that males accounted for at least 60% of the users (Figure 9[a] to 9[e]). Livestock watering was carried out mainly by adult males and boys, whereas the use of small reservoirs for domestic purposes was dominated by adult females and girls. Brick making and fishing were solely carried out by adult males and boys. According to the respondents, hired labor was sometimes used for all the activities, except for fishing. The results further showed that males (adult males and boys) dominated the use of small reservoirs for crop irrigation. The diversity of the users of the small reservoirs should be considered in the governance structure of the reservoirs.

FIGURE 9(a). Distribution of labor in the use of the small reservoir in Bagyalgo.

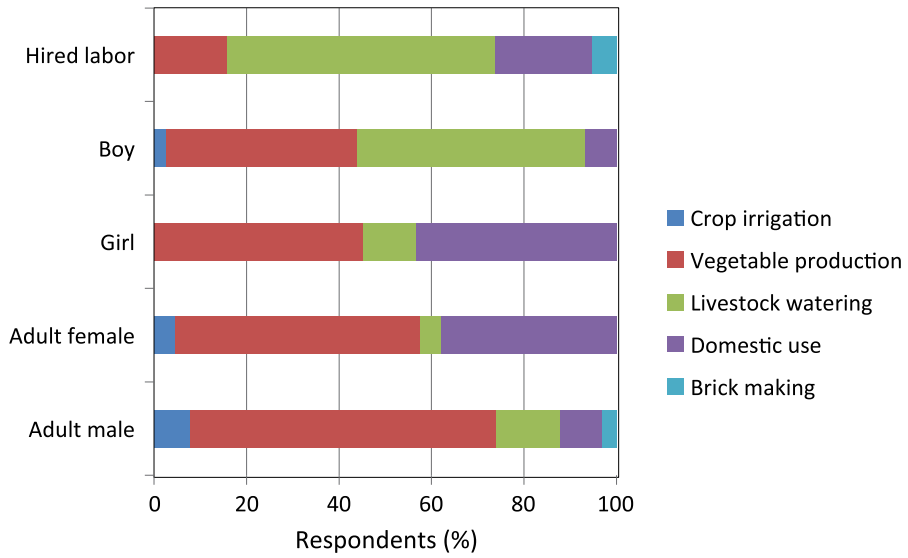



FIGURE 9(b). Distribution of labor in the use of the small reservoir in Soumyalga.

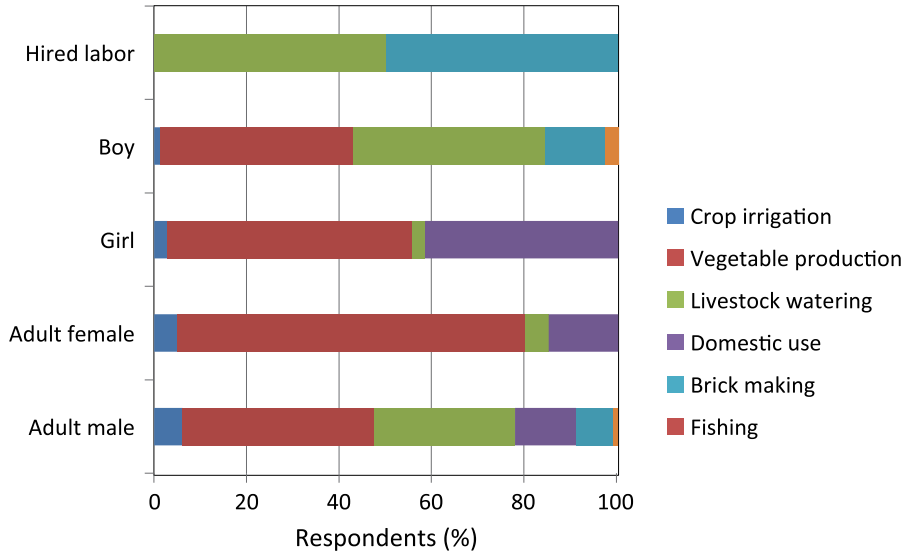


FIGURE 9(c). Distribution of labor in the use of the small reservoir in Goinre.

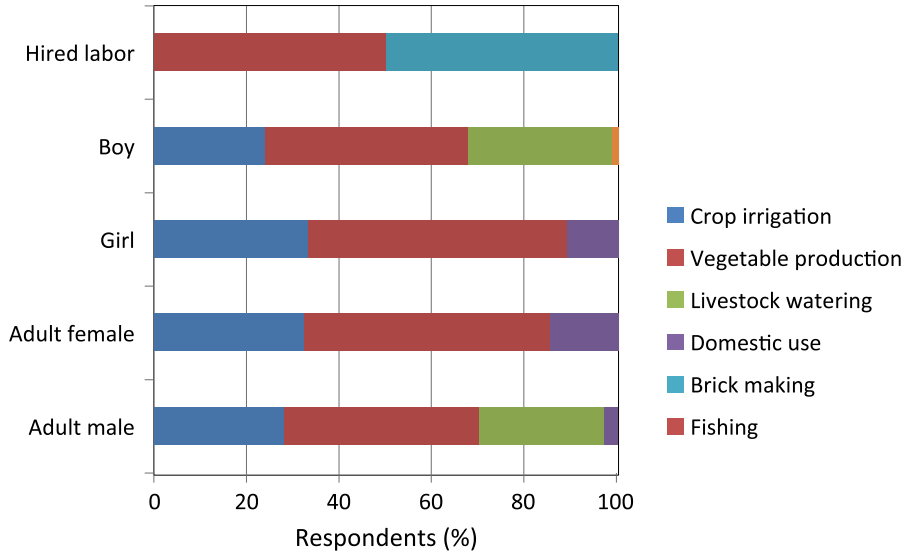



FIGURE 9(d). Distribution of labor in the use of the small reservoir in Ninighi.

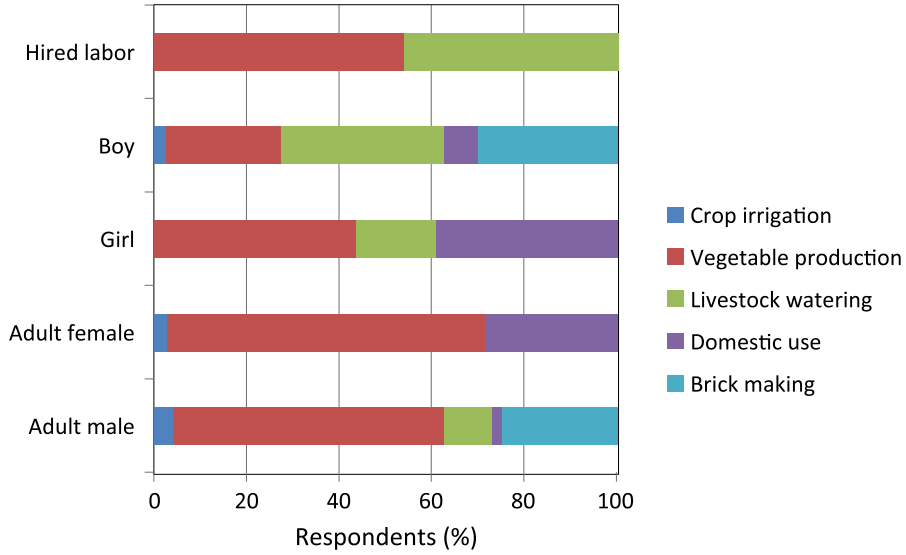
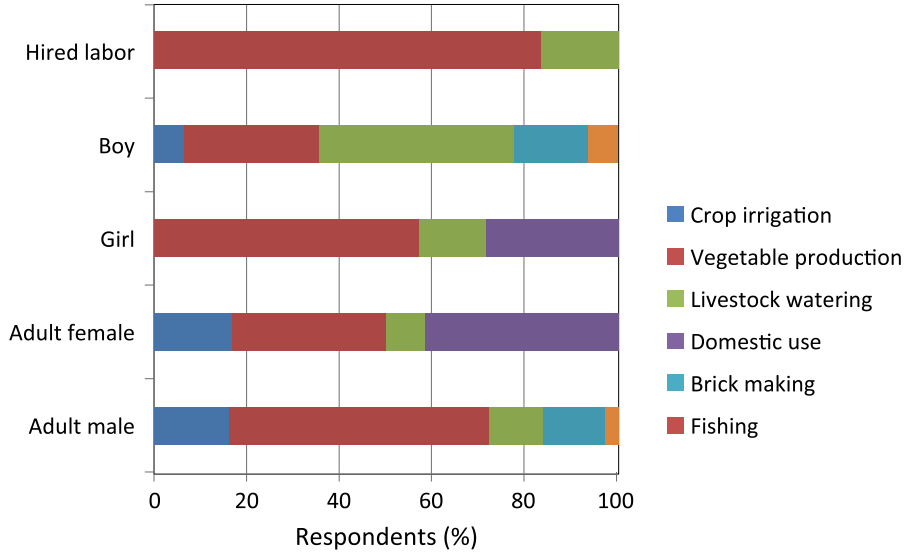


FIGURE 9(e). Distribution of labor in the use of the small reservoir in Thiou.




**Conflict over the Use of the Small Reservoirs**

According to the respondents using the five small reservoirs in the study, conflict is inevitable due to the reservoirs being used for multiple purposes (Table 10). In response to a series of statements on conflict due to the use of the small reservoirs and natural resources in general, the respondents in three (Bagyalgo, Goinre and Thiou) of the five small reservoirs agreed that incidence of dispute and associated conflict has increased over the past 20 years, while those in two reservoirs (Soumyalga and Ninighi) disagreed. This suggests that the incidence of conflict over the use of small reservoirs may be specific to location depending on the interplay of many factors, such as diversity of users and social relations, local institutions governing natural resource use (Turner et al. 2012), community leadership and demographic pressure. According to the results, respondents from Bagyalgo, Ninighi and Thiou strongly agreed, while those from Soumyalga and Goinre agreed that the incidence of conflict is often high between the vegetable/crop growers and the herders who are not resident in the areas (largely transhumant herders). According to the respondents, the transhumant herders who use the small reservoirs for livestock watering tend not to respect the rules, and this can sometimes result in the animals causing damage to vegetables and crops. To underline the importance of local leadership in resolving conflict, the respondents agreed that most cases of conflict related to the use of the small reservoirs are resolved at community level (Table 10). These results agree with the observation by Turner et al. (2012) that whether or not a conflict of interest leads to a socially-degenerative conflict and to violence or inhibiting production decisions depends on the capacity of local communities to manage conflicts and having the ability to not allow them to escalate. The respondents also agreed that women play an important role as mediator in conflict resolution. According to the respondents, though women may not be vocal in public mediation, they are very effective in behind-the-scene persuasive discussions with individual disputants encouraging them to accept peaceful resolution of the conflict.

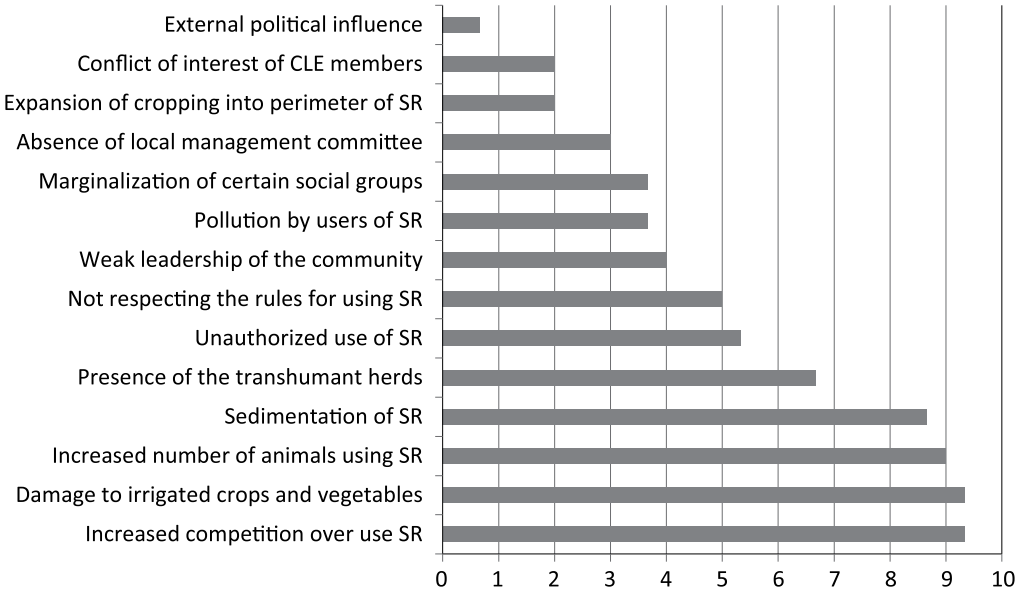
TABLE 10. Perception of the respondents on conflict over the use of the five small reservoirs in this study. The results are a modal score where 0 = Strongly disagree, 1 = Disagree, 2 = Neither agree nor disagree, 3 = Agree, and 4 = Strongly agree.

| Statement | Bagyalgo (n=50) | Soumyalga (n=50) | Goinre (n=50) | Ninighi (n=50) | Thiou (n=49) |
|---|---|---|---|---|---|
| 1. The incidence of conflict over the use of small reservoirs has increased in the past 20 years | 4 (n=34) | 1 (n=38) | 4 (n=34) | 1 (n=28) | 4 (n=28) |
| 2. Conflict is inevitable due to the small reservoirs being used for multiple purposes | 4 (n=28) | 3 (n=32) | 3 (n=29) | 4 (n=36) | 4 (n=33) |
| 3. It is becoming increasingly difficult to resolve conflicts over the use of small reservoirs | 4 (n=30) | 1 (n=32) | 1 (n=33) | 0 (n=28) | 0 (n=31) |
| 4. Incidence of conflict is often high between the farmers and the herders who are not resident in the areas | 4 (n=39) | 3 (n=37) | 3 (n=28) | 4 (n=28) | 4 (n=32) |
| 5. Good social relations among different groups in a community reduce conflict significantly | 4 (n=29) | 3 (n=39) | 3 (n=43) | 4 (n=35) | 4 (n=47) |
| 6. Conflict over natural resource use is normal in every community where social relations involve cooperation and competition | 3 (n=28) | 3 (n=34) | 3 (n=35) | 3 (n=32) | 3 (n=35) |
| 7. Conflict over natural resource use in a community can sometimes be influenced by external politics at local or national level | 4 (n=35) | 1 (n=35) | 1 (n=35) | 0 (n=27) | 1 (n=27) |
| 8. Most cases of dispute/conflict over the use of small reservoirs are resolved at community level | 4 (n=37) | 3 (n=39) | 3 (n=38) | 4 (n=45) | 4 (n=44) |
| 9. Women often play an important role as mediator in conflict resolution | 4 (n=27) | 3 (n=35) | 3 (n=36) | 4 (n=46) | 4 (n=28) |
| 10. Not all cases of dispute/conflict can be resolved peacefully | 0 (n=29) | 1 (n=37) | 1 (n=34) | 0 (n=35) | 0 (n=32) |

Using a scale of 0 (none) to 10 (very important) to rank the cause of conflict due to the use of the small reservoirs, increased competition over the use of the reservoirs, damage caused by animals to irrigated crops and vegetables, and an increased number of livestock using the reservoirs were ranked as the most important causes (Figure 10). Increased number of livestock is related to increased competition over the use of the small reservoirs. Sedimentation of the small reservoirs was also mentioned as an important cause of conflict. This is more of a long-term cause as sedimentation reduces available water over time for different uses. Besides, vegetable production and irrigated crops often expand to the area of the small reservoir due to sedimentation, and this may block the passage of animals that come to look for water. This has resulted in conflict, as animals, particularly those coming from outside the areas, trampled or even ate the vegetables and irrigated crops. There were few cases of dispute reported by the respondents which were related to weak local institutions. The weak local institutions may be manifested through weak leadership of the community, marginalization of certain social groups, not respecting the rules of access to the small reservoir and conflict of interest of CLE members.

In view of the important role played by the local institutions and leadership in conflict management, there is a need to strengthen local WUAs to better manage the small reservoirs. Besides, leadership of the local WUAs should be representative of the different categories of users of small reservoirs, such as young people (boys and girls) and livestock keepers, particularly the transhumant herders who are among the major users. Peaceful coexistence in the use of the small reservoirs for vegetable production and livestock watering is essential to reduce the incidence of conflict, and this will require the engagement of key stakeholders, such as vegetable growers' associations and livestock keepers' associations.

FIGURE 10. Causes of conflict over the use of small reservoirs in the study sites (n=249) on a scale of 0 (none) to 10 (very important).




*Note:* SR – Small reservoir.

## CONCLUSIONS

Small reservoirs are used for different purposes in the Volta River Basin: vegetable production, livestock watering, crop irrigation and domestic use. However, the small reservoirs are mainly used for vegetable production and livestock watering. This 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. The main findings from this study are given below:

1. The results of this study have confirmed the commonly reported trend of the increasing use of the small reservoirs for vegetable production, even though most of the small reservoirs were initially constructed for livestock watering. The competition for use of these small reservoirs for vegetable production and livestock watering is the main challenge to the management of the small reservoirs in the study sites.
2. Despite the growing trend in the use of the small reservoirs for vegetable production, the use for livestock watering is still very important and cannot be ignored. It is, therefore, critical to give adequate consideration to livestock management practices in the use of the small reservoirs to avoid conflict.
3. At least 40% of the household members in all the communities using the five small reservoirs in the study were less than 16 years old. Therefore, it may be necessary to include youth in the local WUAs that oversee the management of the small reservoirs.
4. Adult males and boys accounted for at least 60% of the users of small reservoirs in this study. Livestock watering was carried out mainly by adult males and boys, whereas the use of small reservoirs for domestic purposes was dominated by adult females and girls. Brick making and fishing were carried out solely by adult males and boys.
5. Results of the monthly distribution of the use of the five small reservoirs showed that they are used year round for livestock watering and vegetable production, whereas other uses were seasonal.
6. Increased competition over the use of small reservoirs, damage caused by livestock to irrigated crops and vegetables, and the increased number of livestock using the small reservoirs were ranked as the most important causes of conflict. However, it should be emphasized that most disputes were resolved locally without accelerated conflict, and with both men and women involved through different mechanisms in the process of solving the dispute.
7. Peaceful coexistence in the use of the small reservoirs for vegetable production and livestock watering is essential for reducing the incidence of dispute/conflict. Given the changing use and users of small reservoirs, an evolving representation for management and resolution is needed, which will include both vegetable producers and livestock keepers, as well as youth and women.

## REFERENCES


Amole, T.A.; Ayantunde, A.A. 2016. Assessment of existing and potential feed resources for improving livestock productivity in Niger. *International Journal of Agricultural Research* 11(2): 40-55.

Boelee, E.; Cecchi, P.; Kone, A. 2009. *Health impacts of small reservoirs in Burkina Faso*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 40p. (IWMI Working Paper 136).

de Fraiture, C.; Kouali, G.N.; Sally, H.; Kabre, P. 2014. Pirates or pioneers? Unplanned irrigation around small reservoirs in Burkina Faso. *Agricultural Water Management* 131: 212-220.

Douxchamps, S.; Ayantunde, A.; Barron, J. 2014. Taking stock of forty years of agricultural water management interventions in smallholder systems of Burkina Faso. *Water Resources and Rural Development* 3: 1-13.

Douxchamps, S.; Ayantunde, A.; Panyan, E.K.; Ouattara, K.; Kaboré, A.; Karbo, N.; Sawadogo, B. 2015. Agricultural water management and livelihoods in the crop-livestock systems of the Volta Basin. *Water Resources and Rural Development* 6: 92-104.

Fowe, T.; Karambiri, H.; Paturel, J.E.; Poussin, J.C.; Cecchi, P. 2015. Water balance of small reservoirs in the Volta Basin: A case study of Boura Reservoir in Burkina Faso. *Agricultural Water Management* 152: 99-109.

INSD (Institut national de la statistique et de la démographie). 2015. *Annuaire statistique 2014 - Burkina Faso.* Burkina Faso: Institut national de la statistique et de la démographie (INSD).

Leemhuis, C.; Jung, G.; Kasei, R.; Liebe, J. 2009. The Volta Basin water allocation system: Assessing the impact of small-scale reservoir development on the water resources of the Volta Basin, West Africa. *Advances in Geosciences* 21: 57-62.

Opoku-Ankomah, Y.; Dembele, Y.; Ampomah, B.Y.; Some, L. 2006. *Hydro-political assessment of water governance from the top-down and review of literature on local level institutions and practices in the Volta Basin.* Colombo, Sri Lanka: International Water Management Institute (IWMI) xix, 36p. (IWMI Working Paper 111).

Petit, O.; Baron, C. 2009. Integrated Water Resources Management: From general principles to its implementation by the state. The case of Burkina Faso. *Natural Resources Forum* 33(1): 49-59.

Poda, J.N. 2007. *Les maladies liées à l'eau dans le bassin de la Volta : Etat des lieux et perspectives.* Volta Basin Focal Project Report No. 4. Colombo, Sri Lanka: CGIAR Challenge Program on Water and Food (CPWF). 87p.

Poussin, J.C.; Renaudin, L.; Adogoba, D.; Sanon, A.; Fowe, T.; Dogbe, W.; Fusillier, J.L.; Barbier, B.; Cecchi, P. 2015. Performance of small reservoir irrigated schemes in the Upper Volta Basin: Case studies in Burkina Faso and Ghana. *Water Resources and Rural Development* 6: 50-65.

Sally, H.; Lévite, H.; Cour, J. 2011. Local water management of small reservoirs: Lessons from two case studies in Burkina Faso. *Water Alternatives* 4(3): 365-382.

Statistical Analysis System Institute. 1987. SAS/STAT for personal computers. Cary, North Carolina, USA: SAS Institute, Inc.

Turner, M.D.; Ayantunde, A.A.; Patterson, K.P.; Patterson III, E.D. 2012. Conflict management, decentralization and agropastoralism in dryland West Africa. *World Development* 40(4): 745-757.

Venot, J.P.; Cecchi, P. 2011. Valeurs d'usage ou performances techniques: Comment apprécier le rôle des petits barrages en Afrique subsaharienne? *Cahiers Agricultures* 20(1-2): 112-117.

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