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Asssesing the effectiveness and impact of agricultural water management interventions: the case of small reservoirs in northern Ghana

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ABSTRACT

Agricultural water management, particularly management of multi-purpose small reservoirs (SRs) in drier savanna areas of the northern Ghana, is being promoted as a key solution to improve agricultural production, enhance food security and livelihoods of smallholder farm households. However, little empirical evidence exist on how effective these small water infrastructures are in terms of delivering multiple benefits and their impact on the livelihood of smallholder farmers. This study assessed the effectiveness and impact of the small reservoirs on smallholder vegetable farmers in northern Ghana. A participatory rating method using a 5-point Likert-scale was used to assess the effectiveness of SRs in delivering multiple livelihood benefits and an endogenous switching regression model was applied to assess the SRs' impact using a primary data collected from 328 randomly sampled vegetable farmers. Results from the Likert scale analysis show that most of the SRs are either dysfunctional or underutilized and not effective in delivering multiple benefits. Results from the endogenous switching regression model show that there is only about 3% increase in the income of vegetable farmers participating in irrigated vegetable production using SRs against the counterfactual situation but this change is insignificant statistically. The current low level effectiveness and impact of SRs could be enhanced by improving their management, for example, through the provision of incentive mechanisms such as subsidies to the private sector involvement in rehabilitation, management and irrigation service provision and strengthening the capacity of existing water users associations. Furthermore, small reserviors should be recognized not only as water sources for small scale irrigation but also as providers of multiple livelihood benefits to local communities and consequently should attract due attention in public resource allocation in their rehabilitation and management/institutional capacity building.

1. Introduction

Rain-fed agriculture is the dominant form of agricultural production in northern Ghana[1]. Its productivity is severely curtailed by the unimodal rainfall pattern. Food grown during the rainy season is often insufficient to meet year-round household food needs with some households frequently experiencing severe food insecurity for about four to five months annually (Timler et al., 2014). On the other hand, studies show that high potential exists for irrigated agriculture in northern Ghana. Northern Ghana is drained by the Volta River system consisting of the White Volta, Black Volta, Oti, and Darka Rivers. Ghana's total renewable water resources are estimated to be about 53.2 km^3/year. Groundwater is estimated at 26.3 km^3/year (FAO, 2016). In the Volta Basin, water for irrigation is sourced from rivers, groundwater, and stored water in natural and built infrastructure or reservoirs (Johnston and McCartney, 2010; Payen et al., 2012). There are 22 medium and large public irrigation schemes in Ghana covering about 14,700 ha irrigable area of which only about 9000 ha is actually under irrigation. Five out of the 22 schemes (Tono, Vea, Golinga, Bontanga and Libga with storage capacities ranging from 5.9 to 93 Mm^3) are located in northern Ghana. Additionally, there are more than 500 small reservoirs and over 6280 boreholes managed by communities and smallholder farmers (Liebe et al., 2005; Johnston and McCartney, 2010). Water is also stored on-farm in ponds and wetlands (McCartney et al., 2013). Shallow wells are widely used for small scale irrigation (SSI) in several communities in northern Ghana (Molden, 2007; Namara et al., 2011; Payen et al., 2012). Small reservoirs and dugouts are also in high demand because they support multiple

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[1] Northern Ghana comprises of the three administrative regions in the north of the country, i.e., Northern, Upper East, and Upper West Regions.

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livelihood benefits including irrigation, livestock production, fisheries and brick fabrication (van de Giesen et al., 2002; Birner, 2008; Namara, 2010).

However, there is seasonality in the availability of some of these water resources because of the variability of the annual rainfall and climatic condition in northern Ghana. Excess rainfall and runoff that is available during the wet season is underutilized, while there is acute water shortage for agricultural use during the dry season. Thus, agricultural water management (AWM) interventions are progressively being suggested and promoted as a first step to enable positive development, alleviating food insecurity and poverty among the smallholder farm households that dominate the agriculture sector in Ghana (Mikhail et al., 2011). AWM is generally perceived as a key step towards improving low yielding smallholder farming systems in sub-Sahara Africa (Barron et al., 2008). Particularly, small scale irrigation using small water infrastructures uch as small reservoirs[2] and shallow wells for water storage and appropriate irrigation technologies are important complements to increase agricultural production and enhance the livelihoods of smallholder farmers.

Northern Ghana is endowed with a number of multi-purpose small reservoirs (SRs). Many of the existing SRs were established since the independence of Ghana (1960's) by various donor agencies and the Government of Ghana to provide water for irrigation to promote dry season farming among smallholders. Good water storage infrastructure combined with SSI technologies can allow farmers to practice dry season farming and supplementary irrigation during dry spells in the rainy season, thereby avoiding crop failure and allowing higher yields compared with sole reliance on rainfall (Evans et al., 2012; FAO, 2012). Balana et al. (2016) found that dry season irrigation as the major benefit derived from small reservoirs. Small reservoirs, over the last three decades, have been increasingly seen as a way to develop small-scale irrigation (Venot and Krishnan, 2011). Besides their use for irrigation, SRs also provide multiple livelihood benefits such as livestock watering, construction, fishing and domestic uses. Small reservoirs are typically owned and managed communally through water users' associations (WUAs), though in some cases individuals own and manage the reservoirs (Namara et al., 2011; Namara et al., 2014).

However, the multiple benefits communities derive from the SRs, in recent times, are said to be declining posing negative consequences on the livelihoods of the smallholder farmers. The Northern Rural Growth Programme (NRGP)[3] funded by African Development Bank (AfDB), which started in 2007, and the Ghana Social Opportunity Project (GSOP)[4] supported by the World Bank, which commenced operations in 2010, have both recently invested in rehabilitation of small reservoirs for water storage and irrigation through gravity-based water flow to improve agricultural production and provide other multiple livelihoods benefits to farmers.

However, little is known about the effectiveness and livelihood impacts of small reservoirs in northern Ghana. To the best of our knowledge, two key knowledge gaps exist with regard to our understanding of the SRs in northern Ghana: (1) how effective these water bodies are in terms of delivering multiple livelihood benefits, and (2) how important the SRs are to the livelihoods of smallholders farmers in the area? Using primary data collected from randomly smapled smallholder farmers located around selected multi-purpose small reservoirs in the Upper East region of Ghana and applying a five-point Likert-scale analysis and the endogenous switching regression model; this paper assessed the effectiveness of SRs in delivery of multiple benefits and their impacts on the livelihoods of smallholder vegetable farmers in Upper East region of Ghana.

2. Methodological approach

2.1. The study area

The Upper East Region is located in the north-eastern corner of Ghana between longitude 00° and 10° West and latitudes 10° 30″N and 11° N. The land is relatively flat with a few hills to the east and southeast. The total land area is about 8842 km^2, which translates into 2.7% of the total land area of the country. Initial field visits (for site selection and characterization) was conducted in Upper East region to help identify the SRs and understand their delivery of multiple livelihood benefits to the various communities in the region. Based on the information gathered during the field work, the study was conducted in purposively selected communities in four districts in Upper East Region (Fig. 1a, b and Table 1). The selection of communities was based on the availability of multi-purpose small water bodies (reservoirs). The field studies also helped to identify and establish key local contacts (local government units and farmers) to facilitate the actual fieldwork.

Based on information gathered during the site selection and field characterization, reconnaissance surveys were conducted to help gather information for the preparation of final field instruments. The reconnaissance survey helped us in the identification and listing of various stakeholders, particularly Water Users Associations (WUAs) – farmers' groups using SRs for crop production and other uses such as domestic and livestock drinking –and local and government institutions facilitating the management of the SRs. WUAs are being actively promoted in the northern regions of Ghana. Table 2 shows the distribution of active farmer groups in irrigated agriculture in the three northern regions of Ghana. As a result of rehabilitation of several small reservoirs and dugouts since 2007 by various agencies (e.g. Ghana Social Opportunities Project (GSOP) which rehabilitated 56; Northern Rural Growth Programme (NRGP) which rehabilitated 42; and the World Food Programme (WFP) which rehabilitated 12), dormant WUAs have been revived (MOFA, 2014).

Crops produced under rain-fed are mostly grains such as maize, rice, millet, sorghum, groundnut and soybean whereas irrigated crops are mainly vegetables including tomato, onion, pepper, okra and leafy vegetables. Competition to land for irrigated and rain-fed crops is minimal. Farmers use the irrigable areas to cultivate cereals in the rainy season (rain-fed) and vegetables in the dry season (irrigated). In some areas in the region, e.g., Kamega and Binaba communities, the irrigable area is used solely for rice production during the rainy season. This enables them to do supplementary irrigation of rice during periods of dry spells. Land preparation for dry season production starts immediately after harvesting the wet season crops to take advantage of residual soil moisture.

2.2. Sampling and data collection

Based on the list of farmers provided during the reconnaissance surveys,[5] a simple random sampling technique was used to select 328

[2] Small reservoirs are artificially-created aquatic ecosystem. The World Commission on Dams defines small reservoirs as "a structure that has a height less than 15 meters and a storage capacity that ranges from fifty thousand to 1 million m^3. However, defining small reservoirs by volume, height, and irrigated area, type of infrastructure or mode of management is site and situation specific and is often not easily comparable. For example, most reservoirs in Burkina Faso are large but very shallow with seasonal variations so storage capacity is not taken into account in the same way as for reservoirs in other locations. There are more than 500 small reservoirs with irrigation potential in northern Ghana.

[3] Details of NRGP activities can be seen here: http://mofa.gov.gh/site/?page_id=713. (Accessed 0n 2 June 2018).

[4] Details of GSOP activities can be seen here: http://projects.worldbank.org/P115247/ghana—social-opportunities-project?lang=en. (Accessed on 2 June 2018).

[5] This includes visits to study sites, interviews with key informants, consultation with agricultural extension workers, discussion with community