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# Access to dry season water and small ruminants market integration in the Nadowli District of Upper West Region of Ghana

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Against a background of disconnect between high demand for small ruminants and limited market integration of small ruminants in the interior savannah agro-ecological zone of Ghana, the objective of this study was to assess the effects of differential access to dry season water on small ruminant production and market integration in the Nadowli District of Ghana. The study obtained data from 389 small ruminant households in the Nadwoli District. The data were analyzed using chi-square test, t-test and logistic regression. The results of the study indicate that 67% of small ruminant keepers in high dry season water access communities adopted all animal husbandry practices compared to 33% of small ruminant keepers in low dry season water access communities. The findings also show that small ruminant market integration was relatively higher for both sheep (48%) and goats (35%) in high dry season water access communities compared to 12 and 9% for sheep and goats, respectively, in low dry season water access communities. Veterinary service access, water access, shelter and free grazing show statistically significant predicting factors of small ruminant market integration. The adoption of good husbandry practices and the resultant high market integration suggests that when communities have access to dry season water, they tend to do better in taking advantage of market opportunities to reduce poverty and enhance food security.

**Key words:** Adoption, husbandry practices, institutions, sheep, goats.

## INTRODUCTION

Markets depend on institutions (Greif, 2005). Two of such institutions identified in the field of new institutional economics are the 'contract-enforcement' institutions that determine the range of transactions in which individual actors can commit to keep their contractual obligations and the 'coercion-constraining' institutions that determine

whether individual actors will bring their goods (for example, small ruminants) to the market in the first place (Greif, 2005). According to Xinshen et al. (2007), sustainable market integration of goods will improve production, augment growth, and assuage poverty. It is therefore assumed that market-led production of small ruminants is one of the strategies for small ruminant households to enhance food security and alleviate poverty.

Market integration is the result of the action of traders and the operating environment determined by the infrastructure available for trading such as transportation, credit, communication, storage facilities and the policies affecting price transmission (Goletti et al., 1995). Market integration can therefore be expressed as a function of market infrastructure, policy volatility and production (Goletti et al., 1995; Pasquariello, 2014). Policy volatility such as price stabilization, trade restrictions and credit regulations can either have a positive or negative influence on small ruminant market integration. Small ruminant market integration is relevant and generates certain benefits including reduction in the cost of agricultural products and strengthening of the backward and forward linkages between farm and non-farm production systems (Greif, 2005). Backward linkages is defined as the linkages from the farm to the non-farm sector that provides inputs for example, agrochemicals for agricultural production, while forward linkages is defined as the part of the non-farm sector that uses agricultural output as an input.

Unlike financial markets which became more integrated globally in the last few decades due to the progressive reduction of trade barriers for example, capital controls or taxes on repatriation to foreign investment around the world (Carrieri et al., 2013), there is lack of market integration of small ruminants. The lack of market integration of small ruminants is blamed on information asymmetry, lack of credit access, high incidence of pests and diseases, lack of feed in terms of quality and quantity, inadequate veterinary services, and shortage of water especially during the dry season (Amankwah et al., 2012; Musimwa et al., 2008; Zuwarimwe and Mbaai, 2015).

Ortmann and King (2010) suggest that smallholder livestock farmers' involvement in small ruminant markets is immaterial owing to the perception that small ruminants are kept as a form of non-monetary assets. Also, small ruminant households do not participate in livestock markets because they have doubts about the prices offered for animals at the market outlet (Ortmann and King, 2010).

According to Peden et al. (2007), there is a direct relationship between access to dry season water and marketing of small ruminants. Water and other resources help animals to adapt to adverse weather conditions (Araujo et al., 2010). Yet, dry season water is not accessible in some communities for home and animal production (Araujo et al., 2010).

In Ghana, small ruminants are concentrated in the guinea savannah agro-ecological zone, which is characterized by guinea grass (*Panicum maxicum*) and elephant grass (*Pennisetum purpureum*). Small ruminant production is important because it contributes to farmers livelihoods, asset savings and employment provision (Adzitey, 2013). Small ruminant production is also important because it contributes to about 8% of Ghana's gross domestic product (Ghana Statistical Service, 2012).

Due to the potentials of small ruminants to the economy of Ghana, institutional support to increase small ruminant production has been a key component of agricultural development programmes since the 1990s. For instance, between 1996 and 2003, the Upper West Agricultural Development Project under the International Fund for Agricultural Development introduced the Sahelian sheep and goats aimed at improving the size of local breeds in the region. Also, the Livestock Development Project implemented between 2003 and 2010 was aimed at increasing the income of smallholder livestock and diary farmers, processors and traders in the region. As part of the projects, smallholder farmers were trained and equipped with basic animal health care and husbandry practices. Under the Livestock Development Project for example, farmers were trained to establish between 0.2 and 0.4 ha of *Stylosanthes* and *Cajanus* spp. pasture for their small ruminants.

Despite these interventions, Ghana is yet to experience sustained small ruminant market integration (Xinshen et al., 2007) as available data on livestock indicates that there is an annual deficit of over 95,000 tonnes of chevon and mutton (Adzitey, 2013). Ghana only produces 30% of her meat demand and the rest is supplemented through importation of live small ruminants from northern neighbouring countries such as Burkina Faso, Mali and Niger (Adzitey, 2013; Amankwah et al., 2012).

The high and growing demand for small ruminants in local and international markets, the competitive advantage in small ruminant markets, the potential natural resource base/vegetation cover in Northern Ghana, ample policies and programmes to support small ruminant smallholder households' market participation and the experience of farmers keeping small ruminants are practical opportunities to enhance the contribution of the agricultural sector. Unfortunately, poverty is still the highest (63%) and so is food insecurity in northern Ghana (e.g., 10% in Northern region, 18% in Upper West region and 28% in Upper East region) (World Food Programme, 2012).

Considering that there is increasing water scarcity due to lack of functioning dams/dugouts in many communities in the Nadowli District and the expectant increasing demand for small ruminant products, the need to understand how small ruminant market integration can stimulate domestic and export markets growth is necessary.

The literature suggests that few studies have focused on correlation coefficients of spatial prices as a measurement of market integration and the use of time series methods to estimate cointegration between non-stationary prices at the expense of structural factors responsible for market integration (Pukthuanthong and Roll, 2009).

According to Ayantunde et al. (2008), in order to identify the potentials of small ruminant farming for poverty alleviation in the transitional zone through market integration, water access for animal production, farmers' agronomic practices and farmers' adoption of improved technology should first be sought.

The objective of this study was to assess how water access during the dry season at the community level affects market integration of small ruminant households in the Nadowli-Kaleo District of Northern Ghana. Specifically, the study sought to:

(1) Examine the difference in small ruminant production practices of small ruminant households between communities with low and high dry season water access.
(2) Investigate the predicting factors of small ruminant households' adoption of husbandry practices, (3) Identify the effects of differential access to dry season water on small ruminant market integration, and
(4) Investigate the predicting factors of small ruminant households' market integration.

## Significance of the study

An understanding of the determining factors of market integration will help the Ghana Government to be more interested in policy interventions and strategies to improve the degree of integration of small ruminants. The knowledge of such factors will also help the Ministry of Food and Agriculture in Ghana, the International Fund for Agricultural Development, the District Assemblies and a number of organizations and private individuals to know the impact of their resources such as capacity building/training, technical and infrastructural intervention strategies on the livelihoods of rural people. Also, the understanding of such information will provide useful insights towards future programme/project design and implementation of strategies to alleviate dry season water challenges. Furthermore, the study will aid in the understanding of the underlying structural factors responsible for market integration because this current study departs from the use of time series approach in the estimation of market integration.

## MATERIALS AND METHODS

### Description of the study area

The study was carried out in the Nadowli-Kaleo District of the Upper West Region of Ghana. The district was chosen because of the role of small ruminants in the livelihoods of the people, the suitable

vegetation, the district's proximity to the animal research institute and cross boarder markets. The Nadowli-Kaleo District lies between latitude 10.8° 28' and 9.8° 18' North and longitude 2.7° 10' and 1.9° 10' West (Figure 1). The district has a mean annual temperature of 32°C, and a mean monthly temperature ranging from 36°C in March to 27°C in August. Farming is the main occupation of majority of the people. Consequently, most rural development programmes and projects aimed at alleviating poverty in the district are largely related to crop and livestock farming. The district has several livestock markets with high participation of citizens from neighbouring countries such as Burkina Faso and Ivory Coast. The district has about eight hundred thousand small ruminants of which, 90% are owned by smallholder mixed crop-livestock farmers and 10% owned by pastoralists (Department of Agriculture, 2012).

### Study design and sampling technique

The study design was a cross-sectional survey. A list of all communities were obtained from the Planning Department of the Nadowli-Kaleo District Assembly. The communities were grouped into two on the basis of availability of dams and/or dugouts. A purposive sampling technique was used to select Dakyia and Tabiasi communities because of the communities' access to dry season water, while Musama and Tangasie communities were selected because of their lack of access to dry season water. Dry season water is defined as the availability of dams and/or dugouts in communities for the purpose of agriculture. In each community, a list of small ruminant households was obtained from the Veterinary Service Directorate of the Department of Agriculture in the Nadowli-Kaleo District. For the selection of small ruminant households, a simple random sampling technique was used. Using Krejcie and Morgan (1970) sample size determination table, a population of 100,005 will require a sample size of 389 respondents.

### Data collection and analyses

A questionnaire was used to collect data on the socio-demographic characteristics of household heads such as gender, age, education level, years of experience in small ruminants farming, income level, reasons for keeping small ruminants, and the number of small ruminants kept.

Data collection also covered husbandry practices such as feeding practices, watering, housing, veterinary services access and use, animal mortality, access to and use of animal vaccines and medicines. Finally, data were collected on marketing and transaction costs such as the price of sheep and goats, cost of transporting sheep and goats, major season in which animals are sold and types of market for sheep and goats sales (for example, auction, private, butcheries, abattoirs, etc).

Data were entered into the Statistical Package for Social Sciences (SPSS) version 20. Data analysis involved comparing results of high dry season water access communities with results from low dry season water access communities. The test for differences of categorical variables was carried out using Chi-square analysis and t-test.

Additionally, the logistic regression procedure applying the backward likeli-hood-ratio (LR) test was used to investigate the set of socio-demographic characterisitics and adoption of good animal husbandry practices on market integration of small ruminants.

Logistic regression allows the prediction of market integration from a set of categorical and/or continuous variables (x). The dependent variable is dichotomous and takes the value of 1 if households participate in commercial livestock markets or the value of 0 if otherwise. The logistic regression function was applied in this study because the relationship between the dependent variable and independent variables is a non-linear function.
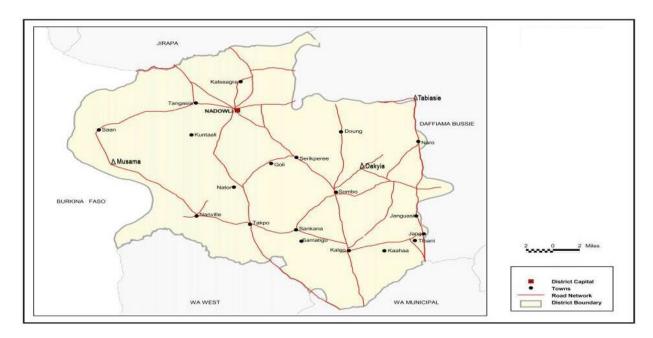
**Figure 1.** Map of the study area (Nadowli Kaleo).

Logit $(y(x)) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_j x_j$      (1)

where      $\alpha$ = the constant of the equation and $\beta$ = the coefficient of the independent variables.

The positive or negative sign of the coefficient indicates the direction of the relationship between a given independent variable (x) and the dependent variable (y), while the odds ratio gives the magnitude of the change in the odds of having the dependent variable event for a one unit change in the given independent variable.

## RESULTS AND DISCUSSION

### Socio-demographic characteristics of small ruminant households

Table 1 shows the socio-demographic characteristics of small ruminant keepers in the study area. The bivariate analysis of the study shows that there is no statistically significant difference in small ruminant keepers' age, education and experience in rearing small ruminants. However, the study results indicate a statistically significant difference ($p < 0.01$) in gender between low and high dry season water access communities. The findings show that there are more female small ruminant keepers in high dry season water access communities probably due to dry season water accessibility. The purpose of keeping small ruminants was found to be statistically significant ($p < 0.01$) for cash income. The results indicate that 99% of farmers in low dry season

water access communities keep small ruminants for cash.

### Adoption of husbandry practices

Table 2 presents bivarate analysis which shows a statistically significant difference ($p < 0.041$) in adoption of good husbandry practices between high and low dry season water access communities. The results show that 67% of small ruminant keepers in high dry season water access communities, and 33% of small ruminant keepers in low dry season water access communities adopted all husbandry practices taught them during the implementation of the Upper West Agricultural Development Project and the Livestock Development Project. The adoption of good husbandry practices contributed to low animal mortality in high dry season water access communities. The findings indicate that 60% of small ruminant households in high dry season water access communities and 64% of small ruminant households in low dry season water access communities reported animal mortalities between 2010 and 2012 (Table 3). The average number of animal deaths in both low and high dry season water access communities was 5, which is lower than the national average of 7 animals. The causes of animal mortality were generally pest and diseases such as pneumonia, diarrhoea and worms. The respondents attributed the high mortality to unavailability of vaccines in the district to vaccinate animals against Peste des Petits Ruminants and Contagious Caprine Pleuro-Pneumonia.

**Table 1.** Socio-demographic characteristics of smallholder small ruminant households.

| Characteristic | Dry season water access communities | | | | District | | $\chi^2$ test | P value |
| | Low | | High | | | | | |
| | Frequency | % | Frequency | % | Frequency | % | | |
|---|---|---|---|---|---|---|---|---|
| **Gender** | | | | | | | 7.781 | P =0.005 |
| Male | 156 | 45.3 | 188 | 54.7 | 344 | 100.0 | | |
| Female | 10 | 22.2 | 35 | 77.8 | 45 | 100.0 | | |
| | | | | | | | | |
| **Age** | | | | | | | 0.000 | P =1.000 |
| <35 | 44 | 42.7 | 59 | 57.3 | 103 | 100.0 | | |
| ≥35 | 122 | 42.7 | 164 | 57.3 | 286 | 100.0 | | |
| | | | | | | | | |
| **Education** | | | | | | | 0.252 | P =0.620 |
| No formal | 132 | 41.9 | 183 | 58.9 | 315 | 100.0 | | |
| Formal | 34 | 45.9 | 40 | 54.1 | 74 | 100.0 | | |
| | | | | | | | | |
| **Years of experience** | | | | | | | 0.448 | P =0.500 |
| <10 | 61 | 36.8 | 81 | 36.3 | 135 | 34.7 | | |
| ≥10 | 105 | 63.2 | 142 | 63.7 | 254 | 65.3 | | |
| | | | | | | | | |
| **Cash income** | | | | | | | 3.752 | P =0.005 |
| Yes | 165 | 99.4 | 216 | 96.9 | 381 | 97.9 | | |
| No | 1 | 0.6 | 7 | 3.1 | 8 | 2.1 | | |

**Table 2.** Adoption of animal husbandry practices.

| Adoption package | Dry season water access communities | | | | District | | $\chi^2$ test | Sig. |
| | Low | | High | | | | | |
| | Frequency | % | Frequency | % | Frequency | % | | |
|---|---|---|---|---|---|---|---|---|
| Some | 115 | 49.1 | 119 | 50.9 | 234 | 100.0 | 9.402 | P =0.041 |
| All | 51 | 32.9 | 104 | 67.1 | 155 | 100.0 | | |

**Table 3.** Mortality of animals between 2010 and 2012.

| Mortality | Low dry season water access community | | | High dry season water access community | | | Statistics (t-test) |
| | N | Mean | Std dev. | N | Mean | Std dev. | |
|---|---|---|---|---|---|---|---|
| Sheep | 166 | 5.902 | 0.178 | 223 | 2.087 | 0.081 | *** |
| Goats | 166 | 5.890 | 0.126 | 223 | 3.281 | 0.094 | *** |

***p < 0.001.

## Predicting factors of adoption of good animal husbandry practices

Results from the logistic regression analysis are presented in Table 4. Overall, the model was able to correctly assign 60% of small ruminant households in high dry season water access communities. The results show that the model is good at 22% but not great. The results also indicate that 17% probability of small ruminant households adoption is explained by the logistic model. However, while it identified correctly 68% of high dry season water access communities, the classification of low dry season water access community was poor. The logistic regression confirms that the adoption of good animal husbandry practices is influenced by:

(1) Education level of household head (P<0.05)
(2) Herd size/number of animals kept (P<0.05)

**Table 4.** Logistic regression: Pedicting factors of adoption of good husbandry practices by smallholder small ruminant household heads.

| Predictor | B (Coefficient) | SE of β | Wald's $\chi^2$ | df | P | $e^\beta$ (Odds ratio) |
|---|---|---|---|---|---|---|
| Constant | -2.322 | 0.476 | 23.746 | 1 | 0.000 | 0.098 |
| Gender | -0.132 | 0.367 | 0.129 | 1 | 0.719 | 0.876 |
| Education | 0.626 | 0.292 | 4.595 | 1 | 0.032 | 1.870 |
| Dry season water access | 0.601 | 0.238 | 6.352 | 1 | 0.012 | 1.824 |
| Herd size | 0.016 | 0.008 | 4.142 | 1 | 0.042 | 1.016 |
| Income level | -0.210 | 0.241 | 0.759 | 1 | 0.384 | 0.811 |
| Veterinary access | 1.880 | 0.283 | 44.129 | 1 | 0.000 | 6.551 |
| | | | | | | |
| **Test** | | | $\chi^2$ | **df** | **P** | |
| Overall model evaluation (Model $\chi^2$) | | | 68.634 | 6 | 0.000 | |
| Goodness-of-fit test (Hosmer and Lemeshow) | | | 11.022 | 8 | 0.200 | |
| -2 Log-Likelihood = 445.470 | | | | | | |
| Cox and Snell $R^2$ = 0.165 | | | | | | |
| Nagelkerke $R^2$ = 0.223 | | | | | | |

(3) Households access to veterinary services (P<0.01); and
(4) Households access to dry season water (P<0.01).

The findings corroborate Legesse et al. (2013) and Sandeep et al. (2006) that farmers' adoption of improved animal husbandry practice vary by agro-ecological zones, and between farmers facing different markets and institutions in watershed and non-watershed villages. The coefficient of herd size was positive, which implies that the more the number of small ruminants kept by households, the higher the probability of accessing vertinary services for small ruminants. Furthermore, the findings show that education of household heads has a positive coefficient, which indicates that education has a direct influence on farmers' adoption of good husbandry practice. The findings imply that farmers with formal education are likely to be aware of more sources of information and then make informed decisions regarding their farming activities. This assertion confirms the findings of Moyo and Salawu (2016) that the education of farmers influence adoption of agricultural technology in Nigeria. Gender and income level of small ruminant household heads were also tested in the model but did not indicate a statistically significant effect on adoption of husbandry practices. This findings contradicts Legesse et al. (2013) that higher income farmers have greater access to resources and are able to assume risk than those with lower income level.

**Predicting factors of small ruminant households market integration**

As shown in Table 5, the models that explained best the likelihood of smallholder small ruminant household heads' market integration were marketing infrastructure, volatility of policy and production. The model had an overall accuracy of 77%. The results show that the model is good at 42% yet still not great. The results also indicate that 31% probability of small ruminant households market integration is explained by the logistic model.

Production shocks show a positive correlation effect on market integration of small ruminants suggesting that during production period of mild or low animal deaths due to pest and disease for instance, more animals are raised resulting in inflows across the markets leading to higher market integration. This finding agrees with Pukthuanthong and Roll (2009) that during crisis periods shocks facing an inverstor tend to be more positively correlated with market integration.

The findings also indicate that the price of animals sold has a negative correlational effect on market integration. This suggests that if the price of animals sold falls, the probability of households selling their animals will decrease, all other things being equal. Furthermore, the findings indicate that the coefficient of shelter/housing is negative suggesting that when households do not have shelter for their animals, the probability of market integration becomes high in other to avoid loss through accidents and theft. Free grazing and water access were found to be significant and would lead to improvement in market integration by small ruminant households.

In high dry season water access community, 48 and 35% of households participate in commercial livestock markets to sell sheep and goats, respectively, while 12 and 9% of small ruminant keepers sold sheep and goats, respectively in low dry season water access community. The high market participation of small ruminant keepers

**Table 5.** Logistic regression: Predicting factors of market integration of smallholder small ruminant households.

| Predictor | B (Coefficient) | SE (β) | Wald's $\chi^2$ | Df | p | $e^\beta$ (odds ratio) |
|---|---|---|---|---|---|---|
| Constant | -1.870 | 0.692 | 7.303 | 1 | 0.007 | 0.154 |
| Shelter/Housing | -0.780 | 0.320 | 5.938 | 1 | 0.015 | 0.458 |
| Free grazing | 0.565 | 0.272 | 4.311 | 1 | 0.038 | 1.760 |
| Price of animal | -1.276 | 0.279 | 20.942 | 1 | 0.000 | 0.279 |
| Transportation | 0.735 | 0.261 | 7.929 | 1 | 0.005 | 2.085 |
| Market information | 0.994 | 0.561 | 3.143 | 1 | 0.076 | 2.703 |
| Number of animals in stock | 3.482 | 0.606 | 32.972 | 1 | 0.000 | 32.530 |
| Production shocks | 0.755 | 0.319 | 5.591 | 1 | 0.018 | 2.127 |
| Water access | 1.489 | 0.320 | 21.671 | 1 | 0.000 | 4.432 |
| Veterinary access | 0.617 | 0.279 | 4.888 | 1 | 0.027 | 1.853 |
| | | | | | | |
| **Test** | | | $\chi^2$ | df | p | |
| Overall model evaluation (Model $\chi^2$) | | | 144.410 | 9 | 0.000 | |
| Goodness-of-fit test (Hosmer and Lemeshow) | | | 6.754 | 8 | 0.563 | |
| -2 Log-Likelihood = 391.705 | | | | | | |
| Cox and Snell $R^2$ = 0.310 | | | | | | |
| Nagelkerke $R^2$ = 0.415 | | | | | | |

in high dry season water access community suggests that when there is access to dry season water, farmers have a tendency to take advantage of the resource to raise more small ruminants.

In low dry season water access community, small ruminant keepers are unable to participate in livestock markets due to low multiplication of animals caused by poor access to drinking water and grasses. The lack of access to dry season water and grazing field in low dry season water access community has always been a precursor of conflict between pastoralist and farming communities in the Nadowli-Kaleo District. This finding concurs with Zuwarimwe and Mbaai (2015) in Namibia that the lack of quality grazing and water facilities adversely affects smallholder livestock farmers' market participation.

## CONCLUSION AND RECOMMENDATIONS

This paper has investigated issues related to adoption of good husbandry practices and market integration of small ruminants. The logistic regression test shows that factors influencing the adoption of good husbandry practices are education level of small ruminant keepers, the herd size/number of animals kept, small ruminant keepers' access to veterinary services and access to dry season water.

The adoption of good husbandry practices have led to farmers having low animal mortality. The results of the study also show that market integration is positively

affected by production shocks, number of animals in stock, veterinary access and water access, whereas it is negatively affected by price of animal and animal shelter. The study finding on water access suggests that water availability and accessibility will enhance small ruminant production because it would help farmers to water and feed animals better.

The adoption of good husbandry practices and the resultant high market integration of small ruminants suggest that when communities have access to dry season water, they tend to do better in taking advantage of market opportunities to reduce poverty and enhance food security. However, considering that not all farming communities in the district have access to dry season water (e.g., dams and dugouts), there is the need for a policy that would ensure that farming communities have access to dry season water in order for them to raise small ruminants for livelihood and poverty reduction.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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