

Provisioning ecosystem services-sharing as a coping and adaptation strategy among rural communities in Ghana's semi-arid ecosystem

Yaw Agyeman Bofo^{a,*}, Osamu Saito^b, Godfred Seidu Jasaw^b, Kei Otsuki^c, Kazuhiko Takeuchi^{a,b}

^a Integrated Research System for Sustainability Science (IR3S), The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8654, Japan

^b United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), 5-53-70 Jingumae, Shibuya-ku, Tokyo 150-8925, Japan

^c Department of Human Geography and Spatial Planning, Utrecht University, Heidelberglaan 2, 3584 Utrecht, CS, The Netherlands

ARTICLE INFO

Article history:

Received 8 April 2015

Received in revised form

22 March 2016

Accepted 13 May 2016

Keywords:

Adaptation

Households

Provisioning ecosystem services

Resources

Semi-arid Ghana

Sharing

ABSTRACT

As complex challenges linked to changing socio-economic, environmental, political, and cultural conditions continually hamper the delivery of ecosystem services to natural resource dependent communities, local level adaptation needs attention. This paper presents the findings of an empirical survey in rural semi-arid Ghana investigating how households are employing communal sharing as a strategy to enhance access and management of nine provisioning ecosystem services (provisioning ES) namely crops and vegetables, livestock and poultry, bushmeat, freshwater, wildplants, fodder and forage, traditional medicine, fuelwood, and building materials. The results indicate that the variations in the sharing patterns of the nine provisioning ES can be linked to a mix of closely-linked socioeconomic, cultural, and environmental factors. Traditional medicine is the most commonly shared, whilst building materials are the least commonly shared. Sharing intensifies during the long dry season for majority of the provisioning ES. Logistic regression modeling indicates annual household income to be the most significant socio-demographic variable influencing participation in sharing. A greater proportion of interviewed household heads (64%) perceive sharing to be on the decline. These findings provide important baseline data for further quantitative and qualitative research exploring sharing's potential contribution to rural households' livelihoods sustenance and ecosystem sustainability under changing conditions.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Historically, communities in semi-arid dryland ecosystems have adapted to chronic environmental stresses, such as drought and floods (Smit et al., 1999, 2000; Hammill, 2007). However, well-established evidence has shown that the increasing adverse effects of climate variability and change, coupled with socio-economic, cultural, and political changes over the last few decades, have heightened community vulnerabilities and undermined the supply, utilization, and management of ecosystem services. This implies the weakening of local adaptive capacities (Fisher et al., 2005; Thornton et al., 2006).

The situation is highly precarious in Sub-Saharan Africa because of its geographical location (IPCC, 2007), widespread poverty, and the extensive dependence of individuals and communities on ecosystem services (Cavendish, 2000; Shackleton and Shackleton, 2006; Boko et al., 2007; Paumgarten and Shackleton,

2011; Fagerholm et al., 2012; Egoh et al., 2012). By ecosystem services, we reference the Millennium Ecosystem Assessment (MA) definition, which refers to ecosystem services as “benefits people obtain from ecosystems” (MA, 2005: 5). These benefits are further classified into four categories: provisioning, regulating, cultural, and supporting services. Of these four categories, this study emphasizes on provisioning ecosystem services (hereafter provisioning ES) which are the material goods or benefits that can be harvested and easily quantified and are derived from the ecosystems to be directly used by local people. Examples of such provisioning ES include food, fuelwood, water, timber, and fiber (Maass et al., 2005).

Climate change and unsustainable human actions are exacerbating the pressure on various ecosystems to supply critical provisioning ES, thus posing a major challenge for ecosystem sustainability and human livelihood sustenance. Across global ecological regions, semi-arid ecosystems have been found to be among the most vulnerable to these challenges (MA, 2005; Thomas, 2008). In order to face this challenge, researchers and development agencies recommend community-based, natural resource utilization and management strategies underpinned by reciprocal

* Corresponding author.

E-mail address: ybofo@gmail.com (Y.A. Bofo).

relationships and social capital. Ayers and Hug (2006) argued that community-based adaptation strategies offer at least a more sustainable and participatory avenue to strengthening the adaptive capacity of vulnerable communities in the face of current and future stresses associated with climate change although it is often difficult to measure. In the case of rural natural resource-dependent semi-arid communities of Sub-Saharan Africa, the existence of strong communal relationships means that households with limited income may be able to cope with food shortages caused by droughts by actively participating in the non-market “gift economy”. This is made possible through social relationships and networks that value reciprocity (Bugra, 2002). Common-pool resource management suggests that resources are managed through community-based rules (Agrawal and Gibson, 1999; Agrawal, 2002; Gibson and Koontz, 1998; Armitage, 2005; Conrad and Hilchey, 2011) and through the use of social capital (Ostrom, 1990, 2000; Ostrom and Ahn, 2003; Ostrom et al., 1994; Pretty, 2003; Adger, 2003; Poteete and Ostrom, 2004). These authors contend that, because vulnerability and adaptive capacities are location-specific, it can be more effective to employ community-level adaptation strategies with an emphasis on place-based knowledge, technology, social structures, and institutions.

In semi-arid developing tropics, community-based coping and adaptive strategies, including the sale of productive and non-productive assets, out-migration, petty trading, wage labour, and changes in diet, among others are well acknowledged (Chirwa et al., 2008; Kalaba et al., 2010; Paumgarten and Shackleton, 2011). However, little is known about the practice of communal sharing in the context of provisioning ES, especially in places where biodiversity decline and ecosystem degradation is evident. This collective action has been overlooked in the conventional ecosystem assessment discourses and is yet to be documented.

As a practice for redistributing essential resources among social groups, sharing has long been regarded as an important and effective mechanism for addressing the problem of scarcity (Polyani, 1958, Arrow, 1975; Becker, 1974; Lee, 1979; Gould, 1981; Kitahara-Frisch, 1982). It has been considered as essential attempt to meet or fulfill social, economic, political or cultural needs or obligations through a social interaction system (Sherry, 1983). In modern societies, evidence points to the use of sharing or resource gifting by communities and households in both rural and urban economies towards meeting the needs of vulnerable groups or to overcome resource stress (Polyani, 1944, Speth, 1990; Mingione, 1991; Chakraborty, 2007; Morton et al., 2008). Befu's (1968) study describes gift-giving in Japanese society as a minor institution guarded by complex rules of engagement. More recently, Kamiyama et al. (2016) found that the sharing of non-market food provisioning services was still prevalent in rural and semi-rural Japan. It is important to note that sharing as applied in this study is not limited to the reciprocal exchange of provisioning ES that occur at household or community levels. Sharing is used to encompass gifting or giving away provisioning ES over time and place in response to environmental stresses (drought, flood, and bushfires) or in fulfillment of socioeconomic and cultural obligations.

The literature has identified a number of factors and conditions that motivate people or communities to participate in resource exchange or gift-giving: in response to hazards or disasters (Dei 1988, Franzen, 2006), support for family members (Palmer, 1991), reciprocity (Curven et al., 2000; Curven, 2004), network or alliance building (Adger, 2003; Patton, 2005), and risk reduction (Franzen and Eaves, 2007). Compared to other community-based strategies for natural resource management, sharing may occur without any enforceable rules or regulations at the community level (Morton et al., 2008). In this sense, Morton et al. (2004) referred to sharing as voluntary “personal exchanges”, presumably

because sharing happens in communities that are naturally diverse owing to structural differences, including economic status, occupation, education, and religious affiliations. These factors are known to significantly influence community members' access to resources, knowledge, and perception of community-based practices, thus subsequently influencing their participation.

The objective of this study is to investigate how the communal practice of sharing is being used by poor rural communities as a coping and adaptation strategy in semi-arid landscape of Ghana in West Africa. We explore this through the lens of nine provisioning ES that are considered by community members to be critical for livelihood and ecosystem sustenance (Bofo et al., 2014). The provisioning ES include, crops and vegetables, livestock and poultry, bushmeat, fresh water, wild plants/food, fodder and forage traditional medicine, fuelwood, and building materials. Specifically, this paper investigates: (a) the sharing patterns and network structure of the nine provisioning ES; (b) the effect of seasonality, selected demographic variables and other factors influencing sharing of provisioning ES; and (c) household perceptions on the changing trends of the practice over the past 30 years. Our conclusion is based on examining the practical and theoretical implications of provisioning ES sharing under limited resources and competing needs.

2. Material and methods

2.1. Location and description of study area

Semi-arid Ghana consists of three autonomous administrative regions located in the northern-most extent of Ghana; namely, Northern, Upper East, and Upper West. Lying within the Guinea and Sudan Savanna agroecological zones of Ghana, they are known to be highly vulnerable to climate and ecosystem changes, owing mainly to their semi-arid climate and physical conditions (Dietz et al., 2004). The semi-arid region of Ghana is highly rural and inhabited by smallholder farmers (Ghana Statistical Service, 2008, 2013), whose poverty levels range between 68% and 88% (Canagaraah et al., 2001; Fig. 1). For many years, the cumulative effects of environmental and socioeconomic factors, such as climate change and variability, extreme disaster events like drought, floods, and bushfires, overexploitation of natural resources (Armah et al., 2011; Acheampong et al., 2014), disregard for traditional ecological knowledge (Bofo et al., 2015), and inter-tribal conflicts have been found to undermine the supply and management of ecosystem services especially provisioning ES needed to improve livelihood sustenance and security.

This study selected two rural communities, Yoggu (9°28' N, 1°5' W) and Kpalgun (9°30' N, 1°4' W) as case study sites for in-depth survey. The selected communities are located within the Tolon district, which is to the west of Tamale, the capital city of the Northern region of Ghana (Fig. 1). A district represents a second-level administrative sub-division below the level of region in Ghana (Institute of Local Government Studies, 2010). The sites were selected on the basis of: (i) the fact that they are part of six communities that have been purposely identified and used as focal areas for the international interdisciplinary project on climate and ecosystem changes, called ‘Enhancing Resilience to Climate and Ecosystem Changes in Semi-arid Africa: An Integrated Approach (CECAR Africa)’; and (ii) their proneness and high vulnerability to episodic drought conditions during the long dry season (Antwi et al., 2014). The Yoggu and Kpalgun communities are located approximately five kilometres apart and are accessible by gravel road from Tolon, the district capital. Based on a detail community survey in August 2013, Yoggu's population density can be estimated at 457 people per square kilometres whilst Kpalgun is

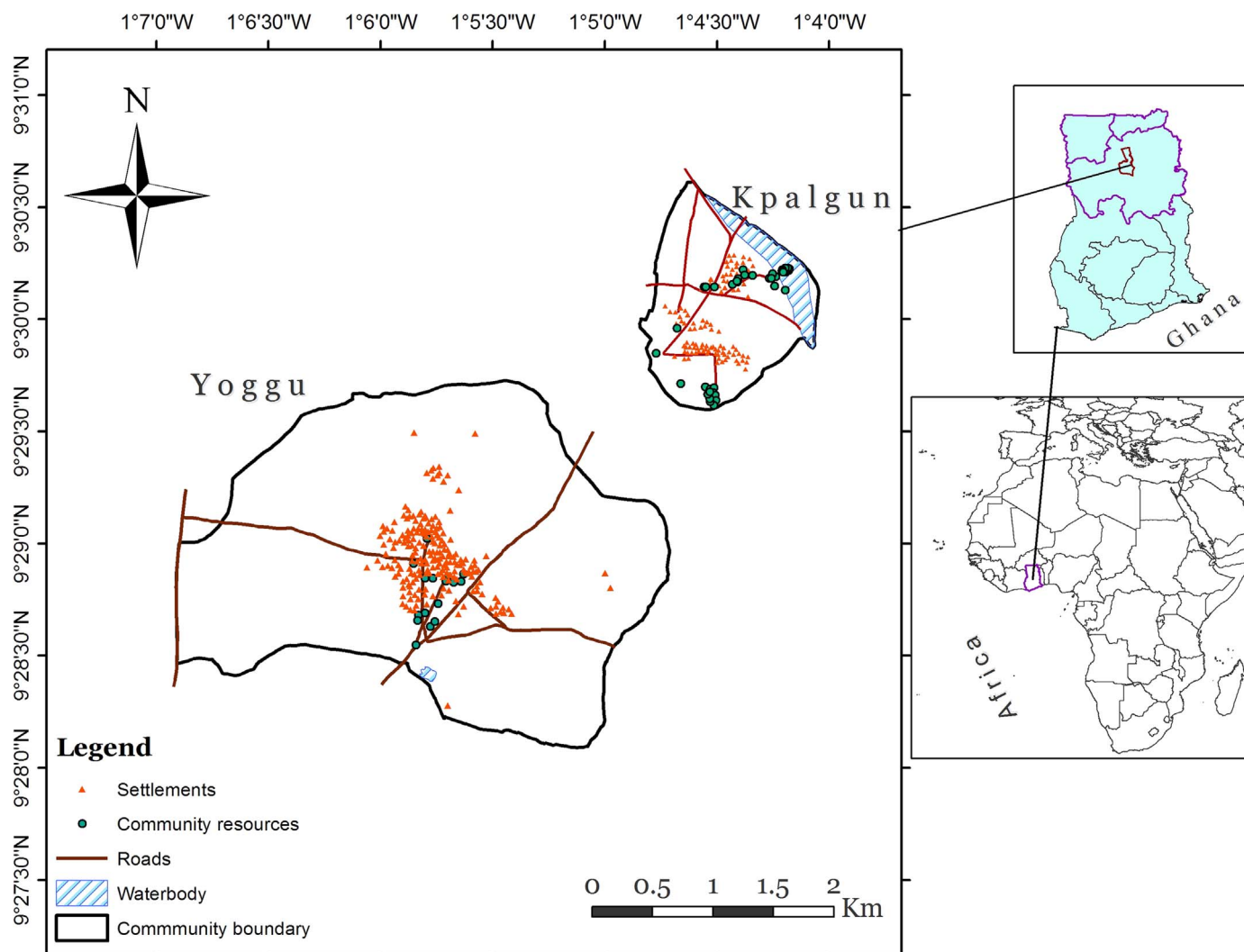


Fig. 1. Map showing the study communities in relation to Tolon district in Semi-arid Ghana.

estimated at 904 people per square kilometres (Boafo et al., 2015). Yogggu and Kpalgun can be considered as ethnically homogenous, with the majority of people being members of the Dagomba ethnic group. Political authority rests with the local or elder ('Na' in local Dagbani).

Average temperatures range from 15 °C at night to 40 °C during the day. Annual rainfall averages between 750 mm to 1000 mm.

The communities, like others in the Tolon district and the rest of semi-arid Ghana, are impacted more severely by the north-east trade winds (Harmattan dry winds). Under prevailing climatic conditions, livelihood activities are significantly influenced by the two main seasons: the wet season (usually between May and October) and the dry season (between November and April). Because of the relatively short unimodal rainy season, farmers have

Table 1

Types of provisioning ecosystem services, sources and specific examples from the semi-arid ecosystem. Source: Modified from Boafo et al., 2014

No	Type of provisioning ecosystem service	Sources and/or specific examples
1	Crops and vegetables	Maize, millet, yam, cowpea, rice, sorghum, groundnut, tomatoes, chili pepper, tobacco, okra, tobacco
2	Livestock and poultry	Cattle, goat, sheep, pig, guinea fowl
3	Bushmeat	Birds, primates, invertebrates (<i>Chelonia</i> spp., <i>Scruidae</i> , <i>Tragelaps scriptus</i> , <i>Thryonomys swinderianus</i> , <i>Cephalophus maxwellii</i> , <i>Myosciurus</i> spp., <i>Cricotomys gambianus</i>)
4	Freshwater	Ground and underground water used in households and on farms (Borehole, dugout wells, dams, rainwater)
5	Wildplants	Edible and non-edible plants, fruits, seeds, (<i>Khaya senegalensis</i> , <i>Parkia biglobosa</i> , <i>Vitellaria paradoxa</i> , <i>Solanum torvum</i> , <i>Rubus</i> spp)
6	Fodder and forage	Leaves, pods, fruits, bark of trees and shrubs (<i>Acacia albida</i> , <i>Mangifera indica</i> , <i>Leucaena leucocephala</i> , <i>Moringa oleifera</i> , <i>Carica papaya</i> , <i>Vigna unguiculata</i> , <i>Azadirachta indica</i> , <i>Lannea acida</i>)
7	Traditional medicine	Whole plant, roots, bark, fruits, leaves, seeds (<i>Securitaca longepedunculata</i> , <i>Ceiba pentandra</i> , <i>Vitellaria paradoxa</i> , <i>Eucalyptus</i> spp., <i>Crescentia cujete</i> , <i>Adansonia digitata</i> , <i>Parkia biglobosa</i> , <i>Ficus gnaphalocarpa</i> , <i>Tapinanthus bangwensis</i> , <i>Azadirachta indica</i>)
8	Fuelwood	Dried and dead stems, branches, charcoal burning (<i>Prosopis africana</i> , <i>Khaya senegalensis</i> , <i>Detarium microcarpum</i> , <i>Vitellaria paradoxa</i> , <i>Pseudocedrela kotschi</i>)
9	Building materials	Mud, thatch, dried grass (<i>Pennisetum purpureum</i>), cow dung, neem (<i>Azadirachta indica</i>), sticks and branches (<i>Parkia biglobosa</i>)

only one major cropping season. The dry season, which is much longer, is often characterized by longer periods of drought and low yields from the staple crops and vegetables. In this semi-arid ecosystem, drought-resistant plant species, most notably the *Adansonia digitata* (baobab), *Khaya senegalensis* (mahogany), *Vitellaria paradoxa* (shea), and *Parkia biglobosa* (locust tree) (dawadawa in local Dagbani), dominate the landscape. These wild tree species, along with other provisioning ES, provide critical social, economic, and cultural benefits for households and communities (Table 1).

The majority of livelihood sustenance strategies in this region are built around the provisions of the local ecosystem primarily through small-scale agricultural economy. Agriculture is composed of crop raising (mainly staple crops) and animal (livestock and poultry) production. The farming system is mainly traditional, with most food crops being intercropped. Most farming activities are undertaken during the wet season, as farmers predominantly rely on rainwater. Water shortage and scarcity in the area greatly impact crop cultivation and productivity as well as domestic activities. Off-farm activities, such as small-scale trading, perennial migration to urban centers, firewood sales, livestock sales, as well as shea and locust bean collection and butter processing, contribute significantly to meeting household needs. Like most communities of the northern region of Ghana, rural food insecurity is perennial and remains a major challenge (World Food Programme, 2009).

2.2. Research design

2.2.1. Data collection

Data for this study were collected between August 2013 and August 2014, following a pilot survey (March 2013). The secondary data was collected from published and unpublished sources. The primary data was collected through the use of participatory field work methods, including key informant interviews, observations, household questionnaire interviews and focus group discussions (Patton, 2002; Gray, 2004). The inhabitants of Yoggu and Kpalgun communities constituted our survey population.

2.2.1.1. Estimation of household wealth status. This study categorized households according to wealth classes recognizing that even in the same social and ecological context, a household's capacity to access resources or cope with stresses varies. Following Garenne and Hohmann-Garenne (2003); Shackleton and Shackleton (2006), we categorized households into wealth index classes by using ownership of physical household assets and diversity in sources of income as proxy indicators. This exercise was undertaken with the active participation of the local assemblymen (formal government representatives) and two village-based research assistants because of their relatively high level of literacy and previous involvement in field-based research in the communities in March 2013. Dummy variables were created for information collected on ownership of physical assets (mobile phone, bicycle, motorbike, tricycle (*motoking*), plows, fertilizers, hunting tools, and donkey cart) and diversity in income sources (on-farm and off-farm). For example, a zero index score meant that a household had none of the listed household assets. Scores for each household were summed to form a final representation of the proxy household wealth index. The wealth index varied from 0 to 20. Households with a wealth index score of 0–12 were ranked as *low*, whereas those with a score of 13–20 were ranked as *high*.

2.2.1.2. Key informant interviews. In August 2013, twelve key informants were sampled and interviewed in Yoggu (seven) and Kpalgun (four) communities. These key informants were aged between 53 and 85 years old and comprised three women (two

from Yoggu and one from Kpalgun) and nine men. Apart from the community head (chief) and opinion leaders (recommended by chief), the other key informants (landowners, clan heads, and traditional healers) were sampled by means of snowball sampling after the study objective had been discussed. Discussions focused on their understanding and application of the term sharing, effects of seasonality on the practice, and perceptions on changes in the trends of sharing as a communal practice.

2.2.1.3. Household questionnaires survey. Overall, 160 face-to-face interviews were conducted with household heads in the two study communities. Prior to administering the survey questionnaires (Appendix 1), each community was divided into four clusters based on location. During the main survey, random samples of 20 households from each of the four clusters were selected and interviewed, making up a total sample size of 80 households per community. The questionnaires were initially developed and tested in collaboration with eight household heads (five in Yoggu and three in Kpalgun). The targeted respondents for the interviews were household heads, meaning that they were all part of the adult segment of the community population. Household heads are the principal decision-makers when it comes to resource allocation, control, and general management within their households. When the household head was unavailable, the next-in-line, as informed by members of that particular household, was identified and interviewed. When the research team noted that household heads were predominately men in the study communities, largely due to socio-cultural customs, we used a snowball sampling technique to identify and interview other households with female heads. This resulted in 22% sample size (Appendix 2). Since all interviews were pre-arranged (meeting date and time) with respondents, this study's response rate was 100%.

2.2.1.4. Focus group discussions. Following the household questionnaires, two focus groups (mixed gender) were held in each village in August 2014. Focus group discussions involved between ten and 15 household heads, drawn from the four clusters in each village. We ensured that all households with female heads from the household surveys also participated in the group discussions. Thus, we had 100% participation of households with female heads, which brought some balance overall. Discussions included motives behind provisioning ES sharing, relevance to livelihood sustenance, and perceptions of changing trends. The discussions were audio-recorded and transcribed for further analysis.

2.2.2. Data analysis

Quantitative data (provisioning ES sharing patterns and network structure, seasonality effects, and determining factors of sharing) were analyzed using descriptive statistics (frequencies, percentages, and mean) with IBM SPSS Statistics version 20. Categorical variables were analyzed using cross tabulations to calculate Pearson's chi-square (X^2) statistics. In order to understand and appreciate the influence of selected socio-demographic variables on provisioning ES sharing across households (binary dependent variables; 0, 1; Table 1), we performed a regression analysis. The logistic regression model used to estimate household sharing abilities for particular provisioning ES is shown below:

$$Y_i = \alpha + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \text{error}$$

Y_i is the dependent variable and represents whether a household head shares a particular provisioning ES or not, α is a constant and the β_s are the explanatory variables (β_1 = education: non-formal, primary and junior high, secondary or others, β_2 = religion: muslim, christian or traditionalist, β_3 = marital status: married, never married, divorced or co-habiting, β_4 = residency

status: native or migrant, β_5 = annual household income: below GHS 1000, GHS 1000–2,999, GHS 3000–5,999, and over GHS 6000, and β_6 = household size: 1–3, 4–6, 7–10 or more than 10).

Qualitative data collected from the different field survey activities were analyzed using the inductive grounded theory approach (Strauss and Corbin, 1998). The transcribed data were categorized into themes and sub-themes. Quotes from the transcripts that addressed critical questions in the study were noted to support quantitative responses.

3. Results

3.1. Provisioning ecosystem services-sharing patterns and network structures

From the survey results, traditional medicine is the most commonly shared of the nine provisioning ES as indicated by the largest proportion of household heads (86.2%). Building materials are the least shared (23.1%). Other provisioning ES including bushmeat, wildplants, fuelwood, and crops and vegetables can be considered as being moderately shared by households across the study communities (Table 2).

When sharing pattern is stratified across household wealth ranks, we observe a significant difference across the study communities. At Yogggu, high-wealth ranked households are more likely to share bushmeat, fresh water, and fuelwood (all at a 0.05 significance level), whereas low wealth-ranked households tend to better at sharing livestock and poultry and wildplants. Similar to Yogggu, high-wealth ranked households at Kpalgun appear to be more active in the sharing of fresh water in addition to crops and vegetables. On the other hand, low-wealth-ranked households at Kpalgun are the more active when it comes to sharing fodder and forage and building materials (Table 2).

Sharing network examines household heads perception of the most important spatial direction — (i) within community, (ii) outside community or (iii) both,— for gifting or exchanging each of the nine provisioning ES as illustrated in Table 3. The results generally indicate that the majority of sharing takes place within

community for all but two of the nine provisioning ES, traditional medicine and wildplants. With traditional medicine, sharing appears spread nearly evenly across the three network structures, although both are slightly higher. In the case of wildplants, sharing is fairly balanced between within community and outside community in Yogggu, but is variable in Kpalgun. The statement by a traditional healer from Kpalgun may be corroborating the above:

‘Our ancestors have taught us that we must share medicine from plants free of charge irrespective of where one comes from. We believe that if you take money, the medicine will lose its efficacy. You can only take kola as a token of appreciation. I have known this practice since I was born. However, this practice is changing as some herbalists’ charge money, and I blame all this on increased poverty’.

3.2. Effects of seasonality on provisioning ecosystem services-sharing

A statistically significant relationship is observed between seasonality and provisioning ES sharing across the study communities (Table 4). According a large proportion of survey respondents, bushmeat, fresh water, wild plants, fodder and forage, and fuelwood sharing is at its peak during the dry season. Distinctly, traditional medicine and building materials sharing is done all year round according to the overwhelming proportion of respondents in both Yogggu (76.4% and 60%) and Kpalgun (65.2% and 62%) respectively.

3.3. Determinants of participation in provisioning ecosystem services-sharing

3.3.1. Influence of socio-demographic variables

The results of the logistic regression analysis show a considerable variation in the effect of the selected variables on the household sharing of each of the nine provisioning ES (Table 5, Appendix 2). Annual household income has the most significant influence on sharing, where higher income households are the more likely to share provisioning ES. This is reflected in the significant relationship between income and the sharing of bushmeat, freshwater, wildplants, fodder and forage, traditional medicine, and livestock and poultry (all at a 0.05 significance level). With regards to education, non-formally educated households are more likely to share traditional medicine ($p < 0.05$). Muslim households are more likely to share livestock and poultry ($p < 0.05$) compared to Christian or Traditionalist households. Furthermore, married households are the most likely to share bushmeat, as the regression model showed a significantly greater relationship ($p < 0.01$). Natives compared to migrants appear to be more active when it comes to livestock and poultry sharing ($p < 0.05$).

3.3.2. Influence of socioeconomic, cultural, and environmental factors

Beyond the effect of socio-demographic variables (Table 5), sharing is influenced by a number of closely linked environmental, cultural, and socioeconomic factors according household heads interviewed (Appendix 3). As an example of environmental drivers, the most frequently cited reason by respondents was to ‘reduce pressure on endangered plant and animal species,’ with a score of 90%; the least cited reason in the same category was to ‘help address overharvesting and wastefulness,’ which received a score of 85%. Among the cultural drivers, the most frequently cited reason was ‘an important religious duty as a muslim,’ which was mentioned by 77% of respondents; the least cited reason was the ‘expectation of a reward in the next world,’ mentioned by 46% of respondents. The most frequently cited socioeconomic motivation

Table 2
Provisioning ecosystem services-sharing pattern stratified by community and household wealth rank.

Type of provisioning ecosystem service	Overall (n=160)	Sharing patterns across communities and wealth ranks (%)				
		Yogggu		Kpalgun		
		Wealth rank		Wealth rank		X ²
		Low (n=52)	High (n=28)	Low (n=61)	High (n=19)	
Crops and vegetables	50.6	53.8	60.7	36.8	47.5	*
Livestock and poultry	48.8	50.0	35.7	50.8	57.9	
Bushmeat	58.8	57.7	71.4	54.1	57.9	
Fresh water	50.6	46.2	64.3	45.9	57.9	*
Wild plants	58.1	61.5	50.0	60.7	52.6	
Fodder and forage	37.0	36.5	35.7	34.4	47.4	*
Traditional medicine	86.2	92.3	85.7	80.3	89.5	
Fuelwood	54.4	48.1	60.7	47.5	52.6	
Building materials	23.1	17.3	25.0	32.8	5.3	**

n = number of observations, χ^2 = chi square (Pearson's) test of significance, *: $p < 0.05$, **: $p < 0.01$

Table 3
Provisioning ecosystem services-sharing network structure.

Type of provisioning ecosystem service	Sharing network structure (%)							
	Yoggu				Kpalgun			
	Within community	Outside community	Both	X ²	Within community	Outside community	Both	X ²
Crops and vegetables	75.6	4.4	20.0	**	66.6	16.7	27.8	*
Livestock and poultry	64.0	14.0	22.2	*	57.1	14.3	28.6	*
Bushmeat	70.0	14.0	16.0	*	79.5	13.6	6.8	**
Freshwater	59.5	23.8	16.7	*	55.3	21.1	23.7	*
Wildplants	43.5	45.7	10.9	*	53.2	29.8	17.0	*
Fodder and forage	79.3	6.9	13.8	**	71.0	9.7	19.4	**
Traditional medicine	26.4	33.3	40.3	*	21.2	36.4	42.4	*
Fuelwood	71.4	4.4	14.3	**	51.3	16.7	10.3	*
Building materials	80.0	6.7	13.3	**	71.4	14.3	14.3	*

χ^2 = chi square (Pearson's) test of significance, *: $p < 0.05$, **: $p < 0.01$

Table 4
Effects of seasonality on provisioning ecosystem services-sharing pattern.

Type of provisioning ecosystem service	Period of the year (season) (%)							
	Yoggu			X ²	Kpalgun			X ²
	Wet (farming)	Dry (Drought)	All year		Wet (farming)	Dry (Drought)	All year	
Crops and vegetables	57.8	35.6	6.7	**	61.1	33.3	5.6	**
Livestock and poultry	25.0	30.6	44.4	*	16.7	52.6	31.0	*
Bushmeat	20.0	70.0	10.0	**	25.0	61.4	13.6	*
Fresh water	19.0	64.3	16.7	*	18.4	71.1	10.5	**
Wild plants	26.1	52.2	21.7	*	21.3	66.0	12.7	*
Fodder and forage	20.7	69.0	10.3	*	29.0	58.1	12.9	*
Traditional medicine	8.3	15.3	76.4	**	7.6	27.3	65.2	**
Fuelwood	23.8	57.1	19.0	*	17.9	74.4	7.7	**
Building materials	20.0	20.0	60.0	*	28.6	9.4	62.0	**

χ^2 = chi square (Pearson's) test of significance,
*: $p < 0.05$, **: $p < 0.01$

was to 'show unity, love, and togetherness,' which was mentioned by 89% of respondents; the least frequently cited reason for sharing was 'just reward for labour in the farm,' which was mentioned by 45% of respondents.

3.4. Perceptions on changing trends in provisioning ecosystem services-sharing

Based on memories and experience of the 1981–1983 drought across Ghana (Ofori-Sarpong, 1986) as an example extreme disaster event and how it impact of livelihood systems, respondents' were asked to evaluate their perception on how sharing as a communal practice has been changing since. A higher proportion of respondents (64%) are of the opinion that provisioning ES

sharing is decreasing over the stated timeline. Approximately 27% say that the practice has been increasing, whereas the remaining 9% answered 'I do not know' to the question citing the difficult in measuring such changes (Appendix 4). According to respondents, the decreasing trends in sharing should be blamed on persistent poverty in their region (92%), increasing disregard for traditional values on resource management (88%), weakening extended family systems (83%), and emergence of larger family sizes (65%). A statement by a focus group discussant at Yoggu best summarizes the above:

'Before the big and extensive drought and subsequent bushfires of 1983, there was so much food and even water in this village. My father used to share his catch from hunting with most of

Table 5
Logistic regression results showing the influence of selected socio-demographic variables on provisioning ecosystem services-sharing, N = 160.

Independent variables	Dependent variables (Do you share? 0 = No, 1 = Yes)								
	CV	LP	BM	FW	WP	FF	TM	F	B
1 = Education	−0.043	0.392	−0.223	−0.033	0.289	−0.356	0.696*	0.082	0.361
2 = Religion	−0.124	−0.656*	0.283	−0.339	0.990	−0.165	0.526	−0.222	0.445
3 = Marital status	−0.254	0.300	−0.951*	−0.278	0.036	0.346	−0.045	0.097	−0.032
4 = Residency status	0.123	−1.213*	0.086	0.107	0.214	0.495	−0.451	0.015	0.186
5 = Annual household income	0.004	0.000*	0.000*	0.000	0.000*	0.000*	0.001*	0.000*	8.570
6 = Family size	0.050	0.111	−0.183	0.131	−0.086	−0.119	0.133	−0.015	0.162
Constant	0.635	0.982	1.203	0.636	−0.981	−1.685*	−0.151	−0.290	−2.299

N = number of observations, *: $p < 0.05$, **: $p < 0.01$

(CV: Crops and vegetables; LP: Livestock and poultry; BM: Bushmeat; FW: Fresh water; WP: Wild plants; FF: Fodder and forage; TM: Traditional medicine; F: Fuelwood; B: Building material)

our neighbors and our relatives who live in the next village. However, nowadays we experience a lot of shortages especially during the dry season, the land is infertile so we cannot access or cultivate enough yam and maize for our household, although sharing has decreased in recent years, it has helped us survive famine in times past.’

Conversely, respondents who perceive sharing to be increasing described interrelated reasons, including the increasing loss of biodiversity leading to scarcity of provisioning ES (96%), persistent poverty among households (90%), proliferation of social and cultural factors (85%), and increase in the frequency of natural disasters (81%), among others.

4. Discussion

4.1. Provisioning ecosystem services-sharing patterns and network structures

Our survey results show that sharing is a widely recognized community-based practice that affects the utilization and redistribution of critical provisioning ES (Boafo et al., 2014) among rural households in semi-arid Ghana. Generally, the observed patterns of sharing can be directly linked to their fundamental utilization forms and management systems, which according to locals continually being shaped by changing socioeconomic, cultural and environmental conditions.

We explore two practical factors in the study sites to plausibly explain why traditional medicine is the most commonly shared of the nine provisioning ES by households as other studies have found (Buchmann, 2009). First, local beliefs and customs at both Yaggu and Kpalgun maintain that it is a taboo for traditional healers (main suppliers of herbal medicine) to collect money from community members who seek their service because ‘the gods have given it freely.’ Typically, payment is expected in the form of kola nuts (*Cola acuminata*). Traditional medicine is perceived to lose its efficacy if one charges money. Second, the increasing scarcity of medicinal plant species as has been reported across Ghana’s semi-arid ecosystem (O’Higgins, 2007) negatively impacts the ability of individuals to collect their own plants for medicine. People are therefore being forced to look for herbal medicine beyond their household or community. During several direct field observational walks with a traditional healer at Kpalgun, he emphasized on the challenges in his profession due to the impacts of biodiversity species loss and scarcity.

From the questionnaire surveys, we notice more than half of respondents’ claiming to share bushmeat, wildplants, fuelwood, livestock and poultry as well as crops and vegetables (Table 2). This result may be re-emphasizing the safety net function of provisioning ES for majority of rural households and communities in semi-arid regions (Fafchamps and Gubert, 2007; Dercon, 1998, 2002; McSweeney, 2004; Moll, 2005; Akter et al., 2007; Wouterse and Taylor, 2008; Paumgarten and Shackleton, 2011; Fagerholm et al., 2012). From our participant observations survey, livestock and poultry in addition to being a source of food is sold to generate income to cope with low crop yield, a form of insurance, a source of manure or traction, and a symbol of wealth in the community. Fundamentally, households are likely to share all of the above provisioning ES in order to fulfill daily and seasonal livelihood needs and obligations although they are all widely collected and used (Boafo et al., 2014). At both study communities it is not uncommon for hunters to give away some of bushmeat catch after hunting. Building materials and fodder and forage low sharing pattern as our survey results (Table 2) show, can be attributed to their innate characteristics as provisioning ES. First, building

materials are among the most sparingly used provisioning ES despite the critical nature. For example, thatch roofs, according to a number of interviewees, are often replaced once a year and that according to most household heads is considered as an ‘individual’s own task’. Observed fluctuations in quantity and quality of fodder and forage at different times of the year best explains its sharing pattern as our survey results show. In dry season, when the rainfall that is needed to enhance natural fodder growth is inadequate and irregular, shortage and scarcity arises. Conversely, forage is often in ample supply in the wet season, thus allowing individual households to collect as much as needed without relying on others.

The analysis of sharing patterns according to wealth ranks shows differentiation in sharing of the nine provisioning ES between high-wealth ranked and low-wealth ranked households (Table 2). The most plausible explanation for the observed variation is in locals’ ability to access and produce physical or technical capital. High-wealth ranked households being the most active in sharing bushmeat, fuelwood, crops and vegetables, and freshwater can be linked these particular provisioning ES often requiring additional technical input or capital in order to access or produce them. Known for possessing multiple physical assets and income sources, high-wealth ranked households may be able to buy ancillary assets such as guns to hunt bushmeat, fertilisers to improve crop yields, and materials to construct more wells or buy water tank to store water (Shackleton and Shackleton, 2006; Chirwa et al., 2008; Kalaba et al., 2010; Paumgarten and Shackleton, 2011). Low-wealth ranked households high propensity to share livestock and poultry, wildplants, building materials, as well as fodder and forage can best be explained by the limitation of substitutes. Thus, even though livestock’s contribution to the household’s asset base is well-acknowledged by all, for most low-ranking households in terms of wealth giving away livestock, usually in the form of goats and sheep, is necessary in case of crises or in fulfillment of social obligations, like marriage. This finding give credence to the old adage which says, ‘you cannot give what you don’t have’.

The information on sharing network structure suggests that majority of households share all but two provisioning ES, traditional medicine and wildplants within their community (Table 3). This result may be indicative of the existence of greater connectivity, social capital, and interactions within and across households and communities. From our observations however, geographical proximity (Conley and Udry, 2010) may be the most plausible explanation for this network structure. Traditional medicine and wildplants distinctiveness as earlier discussed is evidence of the strong influence of socio-cultural beliefs and norms as well as local environmental conditions impacting of their use and management. We will provide two illustrative examples to explain this pattern. First, beyond the inherent socio-cultural values linked to traditional medicine’s use, households here have limited access to and cannot afford modern or western health services, hence their reliance on it all year round. Second, communal collection and processing of wildplants like *Vitellaria paradoxa* (shea) by women outside communities for home consumption and income generation is widely undertaken (Jasaw et al., 2015).

4.2. Effects of seasonality on provisioning ecosystem services-sharing

Our survey found that bushmeat, fresh water, wild plants, fodder and forage, and fuelwood sharing increases in the dry season across both communities. The upsurge in sharing during this time of high dependence can be linked directly to shortage and scarcity of these goods. Studies in other semi-arid regions of Africa provide evidence increased dependence on nature-based resources needed for livelihood sustenance (Dei 1998, Shackleton

and Shackleton, 2006; Thornton et al., 2006; Boko et al., 2007). From our field survey, we found that the above provisioning ES are not necessarily considered by locals to contribute greatly to the erosion of household asset bases compared to other provisioning ESs like livestock and poultry, and crops and vegetables. Comments, such as the following were widely expressed by participants during focus group meetings in both study communities: "...even common grasscutter (*Thryonomys swinderianus*) has become scarce so we have to share as much as possible."; "...the dua (*Vitellaria paradoxa*) fruiting is very poor in recent years and most of them are being cut down."; "...water shortage is our biggest problem in this community, especially in the drought prolongs that normal."

Local farming practices coupled with the highly communalistic relationships in the study sites can best explain why majority of interviewees say crops and vegetables are shared the most during the wet season. In the early part of the wet season as we found during our field survey, seeds or seedlings sharing is common while land preparation and planting is taking place. In the late wet season, when harvesting begins and ends, farmers share a percentage of their yields with land tenants in fulfillment of agreements over the use of a plot of land, a practice known as sharecropping. At times, farmers give away some of their yields to needy community members (vulnerable groups: the elderly, sick, those affected by disaster) or institutions (religious leaders and chiefs) within or outside the community as a form of thanks to the gods for a good harvest. Lastly, sharing also occurs if farmers pay hired labour (who help with the harvest) with farm output (for example, dry maize and groundnut).

Considering that traditional medicine is the most shared provisioning ES among households and communities, it does not come as a surprise that majority of locals claim to share it all year round. The dominantly all year round sharing characteristic of traditional medicine can practically be explained by households' limited access to and inability to afford modern or western health services (Bofo et al., 2014). This was succinctly stated by the community head and herbalists at Yoggu community:

'People fall sick every day, get bitten by snakes, give birth and so I am regularly called upon to prepare medicine. As you can see now, I am preparing this medicine for my neighbor whose child has convulsion. Even when people are not sick, I still prepare medicine as some diseases are recurring and people prefer to keep it in case of emergency'.

4.3. Determinants of participation in provisioning ecosystem services-sharing

Households' ability or willingness to share a particular provisioning ES is influenced by a mix of demographic, socioeconomic, environmental, and cultural variables (Table 5, Appendix 4). The significant relationship between annual household income and sharing patterns of majority of provisioning ES as results (Table 5) show is not surprising. This finding reinforces earlier discussions in this study which states that households with better financial and physical capital as well as assets are typically expected produce more or access variety of provisioning ES compared with those with limited assets. This plausibly explains why higher income households are better at sharing more diverse provisioning ES. Lino et al.'s (1998) study conducted in the United States similarly found that income status significantly influenced the exchange ability of household goods. Hofferth and Iceland (1998) have also reported similar evidence in their comparison of social capital in rural and urban communities of the United States of America.

Our survey results indicating Muslim headed households to be

more likely to share livestock and poultry be explained using two empirical outcomes. Firstly, Muslims form the largest cohort of the religious groups (57%) in the study communities (Appendix 2). By the local sociocultural customs, cattle, sheep, and goats are to be presented as part of the dowry during marriage ceremonies to the bride's family. Secondly, during annual religious festivals and celebrations, such as *Eid-al-Fitr* (Breaking the Fast Feast), *Eid-al-Adha* (Sacrifice Feast) and *Bugum Chugu* (Fire Festival), livestock and poultry are slaughtered to provide meat for sharing among friends, relatives or neighbors and guests.

One plausible explanation for married households being the more likely to share bushmeat relates to the highly polygamous nature of the study communities. Polygamous household heads may be required to give some of their catches to their wives, who may or may not live in the same compound house. Although we found little evidence to explain why migrant household heads are less likely to share livestock and poultry compared to natives, we hypothesize that migrants may have less social interaction and connectivity with other members of the community, and therefore less sharing partners. The survey finding showing non-formally educated households to be the more likely to share traditional medicine may be corroborating existing studies (Alilio et al., 1998; Fawole and Onadeko, 2001) which have all reported that uneducated compared to educated households have more knowledge of and use traditional medicine and also the more likely to consult a traditional healer. In the context of our study communities, this results buttresses earlier discussions on the wide use of traditional medicine in the absence of western medicine (Bofo et al., 2014).

In addition to the above demographic variables, which our survey results show as weakly determining individual households participation in provisioning ES sharing, other variables linked to local beliefs, customs and rites as well as regulations were found to be affect peoples' willingness or ability to participate in sharing. The results from the questionnaire point to a number of closely related factors, indicating households' positive perception of sharing as an action which contributes to safeguarding ecosystems. Among the socioeconomic, environmental, and cultural categorizations, further analysis shows that the environmental reasons are mentioned more frequently by a large proportion of the household heads interviewed (Appendix 3). This result provides further evidence of how environment-related changes and the resulting disasters, notably floods, bushfires, irregular rainfall, and droughts, are increasingly exposing the vulnerability of households in semi-arid Ghana.

4.4. Perceptions on changing trends in provisioning ecosystem services-sharing

The surveyed respondents' perceptions pertaining to the observed changes in trends in the sharing of provisioning ES with their communities is best understood through an analysis of changing local socioecological factors (Appendix 4). Interestingly, a significant proportion of respondents from both groups mention poverty as a major driver of the observed changing trends in provisioning ES sharing. In our opinion, this reflects the broken relationships between ecosystem services and human well-being. Practically, we can analyze this from two perspectives. On the one hand, this result provides further evidence of persistent poverty in semi-arid Ghana compared to the rest of Ghana despite the progress made over the past two decades (Ghana Statistical Service, 2014). In the event of hazards such as drought and floods, poor rural households provisioning ES, which are integral livelihood assets and source of food, are either lost or becomes scarce. On the other hand, this is ample evidence of how provisioning ES still provide a safety net function for the majority of households and communities that do not have the capacity to mobilize other assets

beside what the local ecosystem provides. The perception that provisioning ES sharing is decreasing is a recognition of how ecosystem degradation is undermining not just the supply, access, and management of provisioning ES, but also people's ability to practice long-held social and cultural customs.

4.5. Theoretical and practical implications

This study has both practical and theoretical implications. The outcomes provide evidence on how sharing as a local level adaptation strategy in the utilization and management of provisioning ES applies in rural households in semi-arid ecosystems of Ghana. In a region where people are struggling to adapt to changes in their ecosystem due to persistent socioeconomic poverty coupled with climate variability and change effects, sharing readily allows individuals and households to gain access to critical and increasingly scarce provisioning ES. The fact that respondents surveyed perceive sharing as a useful and practical strategy for ensuring equitable access, and promoting sustainable harvesting among others (Appendix 4), provides a basis for policy makers and external interventionists to carefully consider local level knowledge and practices in natural resource management efforts. From the survey, a household's motivation for sharing points to a perception of the practice as serving both a reactive and proactive function. Given the limited adaptive capacity options and lack of social support systems for rural households in semi-arid Ghana, sharing's reactive function may be critical in helping to redistribute resources in times of exposure and vulnerability to common extreme disasters, such as drought, bushfires, and floods. The perceived proactive function of sharing on the other hand indicates locals' appreciation of the long-term benefits for livelihood sustenance and ecosystem sustainability as a result of their participation in the practice.

Whereas high intra-community sharing as is the case of our studied communities, might be particularly significant for enhancing household social capital and cohesion or for reducing risk, its contribution to safeguarding ecosystems and the services they provide may be limited in the long term. The existing inequalities within each community present a major challenge for intra-community sharing. Our survey found that inherent differences in wealth (physical or economic endowments) meant that not all households would have the incentive, motivation, or capacity actively to participate in provisioning ES sharing (Varughese and Ostrom, 2001). Considering that these inequities were not expected to be overcome in the short term, we suggest that communities improve their provisioning ES sharing to extend beyond household and communities, as a way to enjoy the collective benefits and risks. Increasing inter-community sharing will not only enhance household access to scarce provisioning ESs, but will also provide the opportunity for households to widen their social interactions and capital and improve their social capital, encourage the exchange of local knowledge and information for managing ecosystem services, as well as promote a sense of shared responsibility for sustainably using and managing ecosystem services. For example, the increased inter-community sharing of common-pool resources (Ostrom, 1990), like water from small-scale dams in the study area, although driven largely by scarcity, could help in safeguarding the semi-arid ecosystem's water resources.

5. Conclusion

Climate change and environmental degradation are expected to significantly alter the supply of ecosystem services across all socio-ecological production landscapes of the world, and semi-arid

regions are known to be among the most vulnerable. Considering that ecosystem services, especially provisioning ES, will remain part of the wider livelihood strategy portfolio of natural resource-dependent communities, knowledge of practical and sustainable local level responses and adaptations will be critical in framing external interventions. Our present work has provided empirical evidence of how the traditional and communal practice of sharing is being employed by climatically vulnerable rural households in semi-arid Ghana to enhance access and redistribute provisioning ES including crops and vegetables, livestock and poultry, bushmeat, freshwater, wildplants, fodder and forage, traditional medicine, fuelwood, and building materials.

No single coping or adaptation strategy can sufficiently enhance the resilience of households and communities that are vulnerable to the effects of climate and ecosystem changes. Moreover, resilience is based not only on one factor but also on the simultaneous functioning of social, ecological, economic, and political factors. As a practice that is strongly connected to the social elements of communities and involves local knowledge, values, and practices, sharing can complement other forms of community-based coping and adaptation strategies when considered as both a short term and long term adaptive strategy. The findings from this research in many ways provides evidence of how collective action based on reciprocity, trusts and networks can promote community resilience as several scholars have discussed (Adger, 2003; Ostrom and Ahn, 2003). However, with the lack of data to quantify and value the impacts of sharing on household and communities livelihood sustenance, we recommend further studies to gain a deeper understanding of sharing's role in enhancing resilience to climate and ecosystem changes.

Acknowledgements

The authors are very grateful to all stakeholders in the Tolon district of Northern region especially people from Yaggu and Kpalgun communities for the time and knowledge that they have devoted. The financial support provided by the Japan International Cooperation (JICA) and the Japan Science and Technology Agency (JST) under the framework of the international project "Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa: An Integrated Approach (CECAR Africa)" made this study possible. The invaluable support of our researcher assistants namely Abdalla Alhassan, Awal Mohammed, and Romanus Ziem from the University for Development Studies (Nyankpala campus) who helped with field data collection is worth mentioning here. Inputs from Prof. Toshiya Okuro and Dr. Alexandros Gasparatos from The University of Tokyo at the drafting and revision stages has greatly enriched the scope of this paper. We are also grateful to three anonymous reviewers for comments, and suggestions on early drafts of this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.ecoser.2016.05.002>.

References

- Acheampong, E., Ozor, N., Owusu, E., 2014. Vulnerability assessment of Northern Ghana to climate variability. *Change* 126 (1–2), 31–44.
- Adger, W.N., 2003. Social capital, collective action and adaptation to climate change. *Econ. Geogr.* 79 (4), 387–404.
- Agrawal, A., Gibson, C.C., 1999. Enchantment and disenchantment: The role of community in natural resource conservation. *World Dev.* 27 (4), 629–649.

- Agrawal A. 2002. Common resources and institutional sustainability. In 'The drama of the commons', Elinor Ostrom, Thomas Dietz, Nives Dolák, Paul C. Stern, Susan Stonich, and Elke U. Weber (Eds.), Washington DC, National Academy Press.
- Akter, S., Farrington, J., Deshingkar, P., Rao, L., Freeman, A., 2007. Species diversification, livestock production and income in the Indian State of Andhra Pradesh. *Livestock Research for Rural Development* 19 (11), 65–89.
- Alilio, M., Bammek, J., Eversole, H., 1998. A KAP Study on malaria in Zanzibar: implications for prevention and control. A study conducted for UNICEF Sub-Office Zanzibar. *Eval. Program Plan.* 21 (4), 409–413.
- Antwi, E.K., Otsuki, K., Saito, O., Obeng, F., Gyekye, A.G., Boakye-Danquah, J., Bofo, Y.A., et al., 2014. Developing a community-based resilience assessment model with reference to Northern Ghana. *J. Integrated Disaster Risk Manag.* 4 (1), 73–92.
- Armah, F.A., Odoi, J.O., Yengoh, G.T., Obiri, S., Yawson, D.O., Afrifa, E.K.A., 2011. Food security and climate change in drought-sensitive savannah zones of Ghana. *Mitig. Adapt. Strateg. Glob. Change* 16 (3), 291–306.
- Armitage, D., 2005. Adaptive capacity and community-based natural resource management. *Environ. Manag.* 35 (6), 703–715.
- Arrow, K., 1975. Gifts and exchanges. In: Phelps, E.S. (Ed.), *Altruism, morality and economic theory*. Russell Sage, New York.
- Ayers, J., Hug, S., 2006. The value of linking mitigation and adaptation: A case study of Bangladesh. *Environ. Manag.* 43 (5), 82–92.
- Becker, G., 1974. A theory of social interaction. *J. Political Econ.* 82 (6), 1063–1093.
- Befu, H., 1968. Gift-giving in a modernizing Japan. *Monum. Nipponica* 23 (3/4), 445–456.
- Bofo, Y.A., Osamu, S., Takeuchi, K., 2014. Provisioning ecosystem services in rural savanna landscapes of Northern Ghana: an assessment of supply, utilization and drivers of change. *J. Disaster Res.* 9 (4), 501–515.
- Bofo, Y.A., Osamu, S., Kato, S., Kamiyama, C., Takeuchi, K., Nakahara, M., 2015. The role of traditional ecological knowledge in ecosystem services management: the case of four rural communities in Northern Ghana. *Int. J. Biodiversity Sci., Ecosyst. Serv. Manag.* . <http://dx.doi.org/10.1080/21513732.2015.1124454>
- Boko M., Niang I., Nyong A., Vogel C., Githeko A., Medany M., Osman-Elasha B., Tabo R., Yanda P. 2007. Imate change: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Lalutikof, P.J. van der Linden and CE Hanson, (Eds). Cambridge University Press, Cambridge, UK.
- Buchmann, C., 2009. Cuban home gardens and their role in socio-ecological resilience. *Human. Ecol.* 37 (6), 705–721.
- Bugra, A., 2002. Political and moral implications of reciprocity networks in modern societies. In: Adaman, F., Devin, P. (Eds.), *Economy and Society, Capitalism and Transition*. Montreal, Canada: Black Roses Books.
- Canagaraah, S., Newman, C., Bhattamishra, R., 2001. Non-farm income, gender and inequality: Evidence from rural Ghana and Uganda. *Food Policy* 26 (4), 405–420.
- Cavendish, W., 2000. Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. *World Dev.* 28 (11), 1979–2003.
- Chakraborty, R.N., 2007. Sharing culture and resource conservation in hunter-gatherer societies. *Oxf. Econ. Papers* 59 (1), 63–88.
- Chirwa, P.W., Syampungani, S., Geldenhuys, C.J., 2008. The ecology and management of the Miombo woodlands for sustainable livelihoods in southern Africa: the case for non-timber forest products. *South. Forest* 70 (3), 237–245.
- Conley, T.G., Udry, C.R., 2010. Learning about a new technology: pineapple in Ghana. *Am. Econ. Rev.* 100 (1), 35–69.
- Conrad, C.C., Hilchey, K.G., 2011. A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ. Monit. Assess.* 178 (1), 273–291.
- Dei GSJ, 1988. Crises and adaptation in a Ghanaian forest community. *Anthr. Q.* 61 (2), 63–72.
- Dercon, S., 1998. Wealth, risk and activity choice: cattle in Western Tanzania. *J. Dev. Econ.* 55 (1), 1–42.
- Dercon, S., 2002. Income risk, coping strategies, and safety nets. *World Bank Res. Obs.* 17 (2), 57–73.
- Dietz AJ, Millar D, Dittoh S, Obeng F, Ofori-Sarpong E. 2004. Climate and livelihood change in North East Ghana. In Dietz AJ, Ruben R, Verhagen J. (Eds). The impact of climate change on drylands with a focus on West Africa. 149–172. Kluwer Academic Publishers. Dordrecht. The Netherlands.
- Egoh, B.N., O'Farrell, P.J., Charef, A., Gurney, J.L., Koellner, T., Abi, N.H., Egoh, M., Willemen, L., 2012. An African account of ecosystem service provision: Use, threats and policy option for sustainable development. *Ecosyst. Serv.* 2, 71–81.
- Fafchamps M, Gubert F. 2007. The formation of risk sharing networks. *American Economic Review Papers and Proceedings* 97 (2): 75–79.
- Fagerholm, N., Kayhko, N., Ndumbaro, F., Khamis, M., 2012. Community stakeholders' knowledge in landscape assessments: Mapping indicators for landscape services. *Ecol. Indic.* 18, 421–433.
- Fawole, O.I., Onadeko, M.O., 2001. Knowledge and home management of malaria fever by mothers and care givers of under five children. *West Afr. J. Med.* 20 (2), 152–157.
- Fisher G, Shah M, Tubiello FN, van Velthuisen. 2005. Socio-economic and climate change impacts on Agriculture: An integrated assessment, 1990–2010. *Philosophical Transactions of the Royal Society B* 370 (1666): 2067–208.
- Franzen, M., 2006. Evaluating the sustainability of hunting: a comparison of harvest profiles across three Huorani communities. *Environ. Conserv.* 33 (1), 36–45.
- Franzen, M., Eaves, J., 2007. Effects of market access on sharing practices within Huorani communities. *Ecol. Econ.* 63 (4), 776–785.
- Garenne, M., Hohmann-Garenne, S., 2003. A wealth index to screen high risk families: application to Morocco. *J. Health Popul. Nutr.* 21 (3), 235–242.
- Ghana Statistical Service. 2008. Ghana Living Standards Survey Report of the Fifth Round (GLSS 5). (Ghana Statistical Service, Accra, Ghana).
- Ghana Statistical Service. 2013. 2010 Population and Housing Census: Demographic, Social, Economic and Housing Characteristic. Ghana Statistical Service, Accra, Ghana.
- Ghana Statistical Service. 2014. Ghana Living Standards Survey Round 6 (Main Report). Ghana Statistical Service, Accra, Ghana.
- Gibson, C.C., Koontz, T., 1998. When community is not enough: institutions and values in community-based forest management in southern Indiana. *Human Ecol.* 26 (4), 621–647.
- Gould, R.A., 1981. Comparative ecology of food-sharing in Australia and California. In: Harding, R.S.O., Teleki, G. (Eds.), *In Omnivorous primates*, pp. 422–454 (New York Columbia University Press).
- Gray, D.E., 2004. Doing research in the real world. Sage Publications, London.
- Gurven, M., 2004. Reciprocal altruism and food sharing decisions among Hiwi and Ache hunter-gatherers. *Behav. Ecol. Sociobiol.* 56 (4), 366–380.
- Gurven, M., Allen-Arave, W., Hill, K., Hurtado, M., 2000. "It's a Wonderful Life": Signaling generosity among the Ache of Paraguay. *Evolution and Human Behaviour* 21 (4), 263–282.
- Hamill A. 2007. CRISTAL application in Mufulira District, Zambia. International Institute for Sustainable Development. Winnipeg, Canada.
- Hofferth, S., Iceland, J., 1998. Social capital in rural and urban communities. *Rural Sociol.* 63 (4), 574–598.
- Institute of Local Government Studies, Friedrich-Ebert-Stiftung Ghana. 2010. A guide to district assemblies in Ghana. Friedrich-Ebert-Stiftung Ghana, Accra, Ghana.
- IPCC. 2007. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Lalutikof, P.J. van der Linden, C.E. Hansson (Ed's). (Intergovernmental Panel on Climate Change (IPCC)), (Cambridge University Press, New York).
- Jasaw GS, Saito O, Takeuchi K., 2015. Shea (Vitellaria paradoxa) butter production and resource use by urban and rural processors in Northern Ghana. *Sustainability* 7: 3592–3614.
- Kalaba, K.F., Chirwa, P., Syampungani, S., Ajayi, C.O., 2010. Tropical rainforests and agroforests under global change: Ecological and Socio-economic Valuations. Springer, New York.
- Kamiyama, C., Shizuka, H., Ryo, K., Osamu, S., 2016. Non-market food provisioning services via homegardens and communal sharing in satoyama socio-ecological production landscapes on Japan's Noto peninsula. *Ecosyst. Serv.* 17, 185–196.
- Kitahara-Frisch J., 1982. Nature of the basic early hominid dietary adaptation. *Life Science Institute Annual Review*. International Life Sciences Institute. Washington DC.
- Lee, R.B., 1979. *The Kung San: Men, women and work in a foraging society*. Cambridge University Press, New York.
- Lino M, Gerrior S, Basiotis P. 1998. The healthy eating index 1994–96. CNPP-5. Washington DC. United States Department of Agriculture.
- MA, 2005. (Millennium Ecosystem Assessment). *Ecosystems and human well-being: Synthesis*. Island Press, Washington, D.C.
- Maass, J., Balvanera, P., Castillo, A., Daily, G.C., Mooney, H.A., Ehrlich, P., Quesada, M., Miranda, A., Jaramillo, V.J., García-Oliva, F., Martínez-Yrizar, A., Cotler, H., López-Blanco, J., Pérez-Jiménez, A., Búrquez, A., Tinoco, C., Ceballos, G., Barraza, L., Ayala, R., Sarukhán, J., 2005. Ecosystem services of tropical dry forests: insights from long-term ecological and social research on the Pacific coast of Mexico. *Ecol. Soc.* 10 (1), 1–23.
- McSweeney, K., 2004. Forest product sale as a natural insurance: the effects of household characteristics and the nature of shocks in Eastern Honduras. *Soc. Nat. Resour.* 17 (1), 39–56.
- Mingione, E., 1991. *Fragmented societies: a sociology of economic life beyond the market paradigm*. Basil Blackwell, Oxford, UK.
- Moll, H.A.J., 2005. Costs and benefits of livestock systems and the role of market and nonmarket relationships. *Agric. Econ.* 32 (2), 181–193.
- Morton, L.W., Worthen, D.I., Weatherspoon, L.J., 2004. Rural food insecurity and health. In: Glasgow, N., Morton, L.W., Johnson, N.E. (Eds.), *Critical issues in rural health*. Blackwell Publishing, Ames, IA.
- Morton, L.W., Bitto, E.A., Oakland, M.J., Sand, M., 2008. Accessing food resources: Rural and urban patterns of giving and getting food. *Agric. Human. Values* 25 (1), 107–119.
- O'Higgins, R.C., 2007. Savannah Woodland Degradation Assessments in Ghana: integrating ecological indicators with local perceptions. *Earth Environ.* 3 (1), 246–281.
- Ofori-Sarpong, E., 1986. The 1981–83 drought in Ghana. *Singap. J. Trop. Geogr.* 7 (2), 108–127.
- Ostrom, E., 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press, New York.
- Ostrom, E., 2000. Collective action and the evolution of social norms. *J. Econ. Perspect.* 14 (3), 137–158.
- Ostrom, E., Ahn, T.K., 2003. Introduction. In: Ostrom, E., Ahn, T.K. (Eds.), *Foundations of social capital*. Cheltenham, UK.
- Ostrom E, Gardner R, Walker J. (Eds.). 1994. Rules, games, and common-pool resources. University of Michigan Press, Ann Arbor.
- Palmer CT. 1991. Kin selection, reciprocal altruism, and information sharing among Maine lobsters. *Ethology and Sociobiology* 12 (3): 221–235.

- Patton, J.Q., 2005. Meat sharing for coalitional support. *Evol. Human Behav.* 26 (2), 137–157.
- Patton, M.Q., 2002. *Qualitative research and evaluation methods*, 3rd edition. Sage Publications, Newbury Park, California.
- Paumgarten, F., Shackleton, C.M., 2011. The role of non-timber forest products in household coping strategies in South Africa: the influence of household wealth and gender. *Popul. Environ.* 33 (1), 108–131.
- Polyani, K., 1958. The economy as an institutional process. In: Polyani, K., et al. (Eds.), *In Trade and markets in the early empire*. Free Press, New York.
- Polynani, K., 1944. *The Great Transformation*. Boston, MA. Beacon Hill Press, USA.
- Poteete, A.R., Ostrom, E., 2004. In pursuit of comparable concepts and data about collective action. *Agric. Syst.* 82 (3), 214–232.
- Pretty, J., 2003. Social capital and the collective management of resources. *Science* 302 (5652), 1912–1914.
- Shackleton, C.M., Shackleton, S.E., 2006. Household wealth status and natural resource use in the Kat River Valley South Africa. *Ecol. Econ.* 57 (2), 306–317.
- Sherry, J.F., 1983. Gift-giving in anthropological perspective. *J. Consum. Res.* 10 (2), 26–29.
- Smit, B., Burton, I., Klein, R.J.T., Wandel, J., 2000. An anatomy of adaptation to climate change and variability. *Clim. Change* 45 (1), 223–251.
- Smit, B., Burton, I., Klein, R.J.T., Street, R., 1999. *The science of adaptation: A framework for Assessment*. Mitigation and Adaptation Strategies for Global Change 4 (3–4): 199–213.
- Speth, J.D., 1990. Seasonality, resource stress and food sharing in so-called 'egalitarian' foraging societies. *J. Anthr. Archaeol.* 9, 148–188.
- Strauss, A.L., Corbin, J.M., 1998. *Basics of qualitative research: Techniques and procedures for developing grounded theory*, 2nd edition. Sage Publications, London.
- Thomas, R.J., 2008. Opportunities to reduce vulnerability of dryland farmers in Central and West Asia and North Africa to climate change. *Agric. Ecosyst. Environ.* 126 (1–2), 36–45.
- Thornton PK, Jones PG, Owiyo TM, Kruska RL, Herero M, Kristjanson P, Notenbaert A, Bekele N et al. 2006. Mapping climate vulnerability and poverty in Africa, Report to the Department for International Development, ILRI, Nairobi.
- Varughese, G., Ostrom, E., 2001. The contested role of heterogeneity in collective action: Some evidence from community forest in Nepal. *World Dev.* 29 (5), 747–765.
- World Food Programme. 2009. Ghana Comprehensive Food and Security and Vulnerability Analysis (CFSVA). World Food Programme, VAM Food Security Analysis. (Available at) <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp201820.pdf>. (Accessed on 27/12/2014).
- Wouterse, F., Taylor, J.E., 2008. Migration and income diversification. Evidence from Burkina Faso. *World Dev.* 36 (94), 625–640.