The importance of bushmeat in the livelihoods of cocoa farmers living in a wildlife depleted farm-forest landscape, SW Ghana

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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May 2011

Declaration

I, Björn Schulte-Herbrüggen, hereby declare that this thesis was composed by myself and that the work described within is my own, except where explicitly stated otherwise.

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May 2011

Abstract

Bushmeat is an important source of cash income and animal protein in rural sub-Saharan Africa. However, hunting levels are largely unsustainable, resulting in the widespread depletion and local extinction of prey species. This is a problem for both the conservation of biodiversity and the sustainable development of rural African communities.

This thesis investigates the consequences of wildlife depletion for the livelihood security of Ghanaian cocoa farmers with diversified incomes. The overarching hypothesis that runs through the study is that the importance of bushmeat in livelihoods increases with household vulnerability (*i.e.* poor households and female-headed households), especially during the agricultural lean season.

The study is based primarily on repeated socio-economic questionnaires (N=804), conducted over twelve months among 63 households in Wansampo: an agricultural community situated in a forest reserve in SW Ghana.

The research found that the amount of bushmeat harvested was low and limited to small-bodied species, suggesting severe depletion of wildlife populations around the study village. Protein insecurity and income poverty were widespread but neither co-varied strongly with household vulnerability. While income poverty was highest during the lean season, total protein consumption/security did not vary across seasons. Hunting was efficiently integrated into agricultural activities, with bushmeat being a minor part of household income and protein consumption. Contrary to expectations, household vulnerability had little effect on the importance of bushmeat in livelihoods. However, during the lean season, the bushmeat harvest increased. Since most bushmeat was consumed by the hunter's household, the relative dietary importance of bushmeat was highest during the lean season, enabling households to reduce their meat/fish expenditures while maintaining protein consumption levels. Moreover, when income shortages were highest, bushmeat sales increased, preventing some households from falling into income poverty.

In summary, despite local wildlife depletion, the importance of bushmeat for both income and protein security increased during the lean season. This suggests that bushmeat is an important safety-net for some households in this community. The thesis concludes by outlining the study's limitations, before suggesting further research and policy implications.

Acknowledgements

I am deeply grateful to my supervisors, Katherine Homewood, Marcus Rowcliffe and Guy Cowlishaw for their support, encouragement and advice during the course of this Ph.D.. You were always there when needed and gave me the freedom that I wanted.

This study would not have been possible without the friendly and sometimes challenging but mostly very cooperative people of Wansampo. Now you are on the map! I am in great debt to my research assistants Raphael Asare, Albert Tawia, Dora Amponsah and Albert Asieyie. Without your hard work this study would be based on only half the sample size. Thank you for helping me appreciate the complexities of cocoa farmers' livelihoods. I owe special thanks to the volunteers who accompanied me on this journey and were great company both to me and the people of Wansampo: Emily Coleman, Anthony Turner and Hazel Watson. I will always be grateful to Laura Kurpiers for friendship, company, hard work and sharing uncounted bags of Socker. You suffered the most during this project and bore it with deeply humbling strength.

My research scholarship, field expenses and funding for language training were jointly provided by the Economic and Social Research Council (ESRC) and the Natural Environment Research Council (NERC). Additional funding for field expenses was provided by The Parkes Foundation, and both the British Ecological Society and UCL Graduate School are thanked for funding conference fees and travels. I am grateful to John Bitar Ltd. and Logs and Lumber Ltd. for logistical support and invaluable help in dealing with Ghanaian custom officials.

Thanks to Diana Goforth, Amrit Dehal and Jo Keogh for making sure that I filled in all the forms and helping out in countless situations! I wish to thank Katherine Homewood for encouraging me to present my work to the Human Ecology Research Group. Discussions in the group greatly improved this study - thanks to everyone! I owe special thanks to Phil Burnham and Barrie Sharp for challenging my early views on how field work should be conducted, providing a thorough reality check and helping me to understand the difference between a biological and a social anthropologist. Sara Randall is thanked for her early comments on economic household budgets ("impossible") that made me think harder. This hopefully resulted in a credible study.

For a second home on the hill, much fun, excellent food, sanity and taking care of me when I was ill, I am grateful to Steffen Köhler, Nicole Grafe and Johann Köhler. Thanks to Gregor Walczak for hospitality, fun and getting me online; Lars Holbech for reminding me of the biological aspects of sustainability after spending months in the world of hunting statistics and gift exchange patterns; Nana Azule and the people of Betenase for allowing me to stay in their village and for taking part in the pilot study; the people of Kessekrom for more piloting of questionnaires; Adu for trying to teach me Twi and introducing me to the Sefwi culture; Tiina Heussala for company and accommodation in Takoradi, and making the Twi sessions more fun; and Basil and Sridher for helping out on computer issues in the field.

Thanks to Daria Dadam, Nick Hill and Sophie Allebone-Webb for lively discussions and a sofa in London. Thanks to Emmanuel Blei for introducing me to LaTeX and providing the template that I used for writing this thesis; Alex Friedmann for suggesting to use MySQL and help with the initial intricacies of query writing; Ben Phalan for company in Ghana and providing last minute literature; and the Ubuntu community for providing help when the computer crashed.

I am grateful to my family for always being there for me and encouraging me to choose my own path. Finally, thank you Helfrid, for not giving up on me during the long months in the field, paying the telephone bills, storing my stuff, visiting me in Wansampo for yet another weeding session and sharing and enriching my life during the last years!

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List of Abbreviations

Abbreviation	Explained
AIC	Akaike's Information Criterion, a measure of model fit
AME	Adult male equivalent, a standardised measure of household size
bm	Bushmeat
ΔAIC_i	Difference in AIC values of model and model with lowest AIC
ΔAIC_N	Difference in AIC values of model with lowest AIC and null model
FHH	Female-headed household
FR	Forest reserve
g	Gramme
GLMM	Generalized linear mixed effect model
kg	Kilogramme
km	Kilometre
NTFP	Non-timber forest product
ha	Hectare
hh	Household
hhsex	Gender of the household head
hr	Hour
MHH	Male-headed household
pppUS$	US$ at purchasing power parity
PWR	Participatory wealth ranking
RDA	Recommended daily allowance
SE	Standard Error
SD	Standard Deviation
t	Tonne
Wansampo	Wansampobreampa, the study village
ZSL	Zoological Society of London

Chapter 1

An introduction to bushmeat within a West African livelihood's context

1.1. Chapter overview

This chapter reviews the conceptual background for studying the importance of depleted wildlife populations in the livelihoods of diversified cocoa farmers. It begins by describing the “bushmeat crisis“, providing a review of the scale and biological impact of the wildlife harvest in West and Central African forests before addressing the drivers of unsustainable wildlife exploitation (Section 1.2). It then outlines the importance of bushmeat in rural livelihoods (Section 1.3) and considers the potential of bushmeat for poverty alleviation and as a safety-net for vulnerable households (Section 1.4). Finally, the chapter outlines the shortcomings of the existing literature, states the aims of the thesis and explains the structure of the remaining chapters (Section 1.5).

1.2. The bushmeat crisis

The term “bushmeat“ refers to the meat derived from wild animals for human consumption (Milner-Gulland *et al.*, 2003). Humans have hunted wild animals for millennia and many communities continue to depend on bushmeat as a vital part of their livelihood. Yet in recent years the term ”bushmeat” has become an infamous synonym for the unsustainable harvest of wildlife throughout the tropics. The increasing demand for bushmeat by a growing human population, facilitated by improved hunting technologies and easier access to remote areas all have contributed to increasing offtake levels above the natural rate of production, resulting in widespread declines in wildlife populations across regions: the term “bushmeat crisis” indicates that the threat of unsustainable hunting is rapidly expanding both geographically and across taxa which were previously not at risk (BCTF, 2009). This is particularly true in Africa, where levels of wildlife harvest are especially high, and where offtake may exceed production by a factor of 2.4 (Fa *et al.*, 2002). Since unsustainable harvests threaten not only the survival of the exploited species but also livelihoods of those people who depend on bushmeat, an understanding of the drivers of the "bushmeat crisis" is imperative from both a conservation and livelihoods perspective (Brown, 2003; Bennett *et al.*, 2007).

1.2.1. The scale of the bushmeat harvest

Humans have harvested wild animals for consumption for millennia (Shipman *et al.*, 1981; Grubb *et al.*, 1998) and some prehistoric societies are known to have caused strong impacts on prey populations in the Americas and Australia etc., especially when first colonising new areas (Olson & James, 1982; Holdaway & Jacomb, 2000; Steadman & Stokes, 2002; Koch & Barnosky, 2006). Such extinctions have not occurred in Africa, apparently because African wildlife coevolved with human populations (Diamond *et al.*, 1989). In more recent times (*e.g.* over the last 500 years), traditional hunting has often been sustainable, despite optimal foraging behaviour, because of the limited number of hunters and "primitive" technologies available (Hill & Padwe, 2000; Ohl-Schacherer *et al.*, 2007). However, hunting has now become less sustainable, as the number of hunters has increased and hunting technologies have improved, resulting in the widespread depletion and local extinction of harvested populations (Struhsaker & Oates, 1995; Maisels *et al.*, 2001).

Contemporary continental-level patterns of hunting in the tropics suggest that hunting has been most severe in Asia, followed by Africa, and then the Neotropics (Fa & Brown, 2009). The West African wildlife officer Emmanuel Asibey was one of the first to publicise wildlife depletion in the forest areas of sub-Saharan Africa in the 1960s, stating that "the wildlife which used to provide large quantities of protein is now in short supply" (Asibey, 1966, 1974).

The "bushmeat crisis" is the result of hunting of wild animals on an enormous scale (Table 1.1). Bushmeat hunting targets the majority of forest mammals (Fa & Peres, 2001) and at current exploitation levels it is a multi-million dollar business. Harvest volumes have been estimated at 12,000 tonnes per year in the Cross-Sanaga rivers region of Nigeria and Cameroon (Fa *et al.*, 2006), at 120,000 tonnes per year in Côte d'Ivoire (Caspary, 1999), at 385,000 tonnes per year in Ghana (Ntiamoa-Baidu, 1998) and at total of 1 to 4.9 million tonnes per year in Central African forests (Wilkie & Carpenter, 1999; Fa *et al.*, 2002). Strong variation in the estimates for Ghana highlight the problems with extrapolation of survey data to national or regional levels and the effects of sampling strategies (hunter versus market surveys), timing of survey (open season versus lean season), survey location, and extrapolation methods. Most surveys have been restricted to relatively small areas or market catchments from which national estimates were extrapolated. The first large scale survey of 89 rural and urban bushmeat markets by Fa *et al.* (2006) in the Cross-Sanaga Region, for example, recorded the volumes of bushmeat traded but not consumed. Individual figures should therefore be treated with caution but the overall message remains: bushmeat is a heavily exploited resource.

Table 1.1.: Estimates of bushmeat harvest and economic value of the harvest in West and Central Africa (– = no estimate provided)

Area	Biomass (t/yr)	million US$/yr
Cross-Sanga Region (Cameroon/Nigeria) [a]	12,000	–
Yaoundé (Cameroon)[b]	840-1,080	–
Côte d' Ivoire[c]	120,000	–
Nigeria[d]	2.6	–
Nigeria[e]	–	225-3,600
Takoradi (Ghana)[f]	191	0.58
Ashanti Region (Ghana)[g]	–	52
Gabon[h]	12,000-17,000	–
Gabon[i]	24,500-35,100	–
Ghana[j]	385,000	350
Congo Basin[k]	1m	–
Congo Basin[l]	4.9m	–

[a] Fa *et al.* (2006) [b] Bahuchet & Ioveva (1999), cited in Nasi *et al.* (2008)
[c] Caspary (1999) [d] Adeola *et al.* (1987) [e] Martin (1983)
[f] Cowlishaw *et al.* (2005a) [g] Tutu *et al.* (1993) [h] Steel (1994) [i] Starkey (2004)
[j] Ntiamoa-Baidu (1998) [k] Wilkie & Carpenter (1999) [l] Fa *et al.* (2002)

1.2.2. The biological impacts of unsustainable bushmeat harvesting

The biological effects of unsustainable bushmeat hunting act at four different levels. The first level describes the direct effects of harvesting on wildlife prey populations. Comparisons of wildlife populations at sites with varying hunting pressure provide strong evidence for the negative effects of hunting on the abundance of prey populations (Lahm, 1993; Alvard *et al.*, 1997; Carrillo *et al.*, 2000; Peres, 2000b; Hart, 2001; Laurance *et al.*, 2006; Parry *et al.*, 2009b; Zapata-Rios *et al.*, 2009). A comparison of vertebrate community structures at 25 Amazonian sites with different hunting pressure, recorded a declining density and biomass of prey populations as hunting pressure increased (Peres, 2000a): mammalian biomass was reduced from 1,200kg/km^2 at unhunted sites to 200kg/km^2 at heavily hunted sites (Peres, 2000b). Such impacts do not fall equally across the community, which can lead to substantial changes in community structure (Laurance *et al.*, 2006). The impact of hunting is generally highest among large-bodied species, which are both preferred by hunters (Bodmer, 1995) and are less resilient to exploitation due to their low intrinsic rates of reproduction (Hennemann, 1983; Robinson & Redford, 1986). The proportion of biomass in mammalian communities coming from large-bodied animals, therefore tends to decline as hunting pressure increases (Peres, 1999).

A decade-long study of a Central African bushmeat market documented the progressive depletion of large-bodied wildlife species and the increasing importance of small-bodied species up to a point where rodents comprised 37% of biomass sold (Fa *et al.* 2000). Some of the most extreme levels of wildlife depletion have been reported from a bushmeat market in Takoradi, Ghana, where rodents comprised 59% of the biomass sold and large-bodied animals were entirely absent. The long history of high hunting pressure meant that prey populations had gone through an extinction filter with only the most resilient, small-bodied species remaining within the commodity chain (Cowlishaw *et al.*, 2007).

Persistent levels of high hunting pressure can result in the local extinction of prey species (Struhsaker & Oates, 1995; Brashares *et al.*, 2004). Moreover, prey species of high trophic level that occur in low population density, have a slow rate of reproduction and, in particular, occur in a small geographical area have a high extinction risk when their populations are declining, for example due to hunting (Purvis *et al.*, 2000). One example of this may be provided by Miss Waldron's red colobus (*Procolobus badius waldroni*), a West African primate species (Oates *et al.*, 2000). It has been estimated that 60% of mammalian taxa, including most ungulates (93% of taxa), primates and carnivores (63%) hunted in Central Africa are harvested at unsustainable levels (Fa *et al.*, 2002). Currently, overexploitation is classed as the main threat for 33% of the 760 globally threatened mammals for which data are available (Baillie, 2004).

Secondary effects on prey populations include changes to animal behaviour. For example, primates become more secretive by reducing their calling frequency and not giving alarm calls (Watanabe, 1981), whilst ungulates may flee and whistle when approached in a hunted area but rely on freezing behaviour to avoid detection in unhunted sites (Croes *et al.*, 2007). Similarly, hunting may also increase nocturnal activities of prey species (Y. Ntiamoa-Baidu, pers. comm.).

Less obvious than the "silencing" of a forest through unsustainable hunting - but with wide-ranging implications for ecosystem functioning - is the effect of changes in wildlife abundance on plant communities. These may occur due to changes in browsing patterns, seed dispersal and pollination, with knock-on effects for tree recruitment and forest structure (Guariguata *et al.*, 2000; Wright *et al.*, 2000; Guariguata *et al.*, 2002; Silman *et al.*, 2003; Peres & Palacios, 2007; Nunez-Iturri *et al.*, 2008). This is especially true for the dispersal and reproduction of large-seeded trees, characteristic of forests with a high wood density, which in turn influences the economic value of forests for timber production and the amount of carbon stored (Brodie & Gibbs 2009 but see response by Jansen *et al.* 2010 confirming the overall conclusion but questioning the pathway and relationship between large-seeded trees and carbon storage. Instead they suggested that as animal seed dispersal is reduced wind dispersed plant species become more dominants and these generally store less carbon than animal dispersed trees).

Overall, there is strong evidence that bushmeat hunting is largely unsustainable and that this has strong negative effects on both prey populations and wider ecosystem functioning.

1.2.3. The drivers of unsustainable bushmeat hunting

The current unsustainable hunting at regional levels has been primarily caused by socio-demographic changes in human populations (Wilkie & Carpenter, 1999). Africa's human population has risen from 100 million at the end of the 19th century to 905 million in 2005, and is expected to double again by 2045 (UNDP, 2009). Across West and Central Africa human population densities have increased to 19-50 people/km^2 (UNPD 2008), well above the density of 1 pers/km^2 considered to be the maximal for a sustainable bushmeat harvest (Robinson & Bennett, 2000a). Moreover, ecological impacts on prey populations have been detected at human populations as low as 0.2 person/km^2 (Laurance *et al.*, 2006). With few alternative animal protein sources available and slow economic growth to provide alternative economic opportunities, human population growth has been closely linked to increasing hunting intensity (Rushton *et al.*, 2005).

Secondly, increasing urban demand and the integration of rural societies into cash economies has led to an increasing commercialisation of bushmeat. Where hunting may previously have largely served to satisfy the subsistence need of rural populations, it is now increasingly supplying affluent urban societies, some of which may prefer bushmeat to other types of meat, *e.g.* domestic meat (East *et al.*, 2005; Schenck *et al.*, 2006), and others that find it a (currently) relatively cheap source of animal protein. Traditionally it has been argued that bushmeat demand is driven primarily by protein needs, however the potential for bushmeat to be under further demand as a ”luxury good“ has also recently been highlighted (Barrett & Ratsimbazafy, 2009).

The increase in the demand for bushmeat has been accompanied by changes in hunting technology and improvements in hunting efficiency. Modern guns have a 7 to 25-times higher rate of return compared to traditional weapons (Wilkie & Curran, 1991) and substantially increase the ease and cost-effectiveness of hunting (Alvard, 1995).

Hunting efficiency has also been increased as a result of remote forests becoming increasingly accessible as timber companies build logging roads and transects in remote forests, and provide transportation for hunters and bushmeat (Wilkie *et al.*, 1992; Auzel & Wilkie, 2000). For example, the construction of more than 140 km of roads in a timber concession in Northern Congo reduced the average time for a hunting trip from 12 hours to 2 hours (Wilkie *et al.*, 2001). Timber companies attract a large number of workers and their families to remote locations, increasing bushmeat demand, especially when no hunting regulations are in place and alternative protein sources are not provided (Auzel & Wilkie, 2000; Bennett & Gumal, 2001; Poulsen *et al.*, 2009). Logging related increases in bushmeat hunting were responsible for a 50% reduction of ape populations in Gabon between 1983 and 2000 (Walsh *et al.*, 2003).

In addition to facilitating access and increasing the demand for bushmeat in remote areas, industrial logging is often accompanied by the expansion of farming in previously inaccessible forests, resulting in large scale deforestation and rapidly diminishing wildlife habitat (FAO, 2009).

The impacts of high hunting pressure are exacerbated by the low productivity of wildlife populations in tropical forests. The productivity of tropical forests has been estimated to be at least an order of magnitude lower than tropical savannahs, making forest species more prone to overexploitation (Robinson & Bennett, 2004).

On the other hand, there is evidence that secondary forest and farm-fallow landscapes, which are widespread in West Africa, may be more productive for wildlife (Wilkie, 1989; Lopes & Ferrari, 2000; Robinson & Bennett, 2000a). Using literature estimates of wildlife abundance and productivity, Wilkie & Lee (2004) estimated that African agroforestry landscapes could sustainably support a hunting pressure four-times the rate of high forests. In contrast to these estimates, field surveys in the Brazilian Amazon concluded that secondary forest was less productive than primary forest, and that one person would require 3km^2 of secondary forest (rather than 1km^2 of primary forest) to obtain sufficient amounts of animal protein from bushmeat hunting alone at sustainable harvest rates (Parry *et al.*, 2009b). Across the Amazonian population, this would supply only 2% of the required protein intake. However, it is uncertain how applicable the study by Parry *et al.* is for African landscapes, since Neotropical forests may be substantially less productive than African forests due to differences in species composition: primates with low rates of intrinsic increase comprising the majority of wildlife biomass in Neotropical sites and ungulates with higher rates of intrinsic increase being more important in African forests (Fa *et al.*, 2002).

Overall, it is unclear whether potentially more productive human-modified landscapes in Africa can satisfy protein needs. There is however, good evidence to suggest that the low productivity of forest wildlife contributes to the largely unsustainable harvest of bushmeat in forests.

1.2.4. Comparing wildlife depletion in West and Central Africa

The outlined drivers of increasing levels of bushmeat hunting and impacts on wildlife populations apply across West and Central Africa. However, the extent to which wildlife populations have been impacted through hunting and habitat transformed is substantially higher in West African than Central Africa forest landscapes. In this respect, Bennett *et al.* (2007) noted that West African populations of large-bodied mammals have already declined or have been extirpated in the largely agricultural landscape, while these species are still abundant in the continuous and often remote forests of Central Africa.

Assessing the relative level of wildlife decline across regions is difficult - hampered by natural variation in both wildlife population densities and offtake rates, and by the reliability of information describing these patterns. Market data are one source of information that is relatively easy to collect and can potentially provide a useful indicator of wildlife abundance and offtake. Although the interpretation of market data must be carried out with great care, especially due to variation in catchment sizes and hunting technology etc. (for a discussion of this topic see Milner-Gulland 2006; Allebone-Webb *et al.* 2011), there is evidence that species become less common in bushmeat markets as their wild abundance decreases, and they are gradually replaced (both in the wild and in the market) by more resilient or previously unhunted species (Fa *et al.*, 2000). On this basis, the comparison of bushmeat sales profiles in West and Central African markets indicates that wildlife populations in West Africa are more depleted than those in Central Africa. A recent survey of a West African bushmeat market in Takoradi, Ghana, recorded the economic extinction of large-bodied species across taxa, and rodents comprised the majority of sales (Cowlishaw *et al.*, 2007). Similarly, primates were of minor importance in the bushmeat market of Kumasi, Ghana, and seven species of rodents and ungulates comprised 99% of the value of traded bushmeat (Crookes *et al.*, 2005). In contrast, primates comprised 36% to 43% of traded biomass in Equatorial Guinean markets (Fa *et al.*, 1995) and 20-45% of carcasses in Gabon (Steel, 1994).

The higher levels of wildlife depletion in West Africa are the result of stronger human pressure on natural resources in this region. With the exception of a few countries in Central Africa, *i.e.* Rwanda and Uganda, human population densities in West African countries are substantially higher than in Central Africa (Table 1.2). Notably, most West African countries had higher human population densities in 1990 than are currently found in Central Africa.

The long history of high human population density and land pressure in West African countries has resulted in a higher level of human land pressure that is reflected in more extensive deforestation and an increasing ratio of forest-farm mosaic to dense high forest (Table 1.2). Indeed, agricultural expansion has been identified as the most significant cause of deforestation in the West African Guinea Forest (Norris *et al.*, 2010).

Table 1.2.: Development of human population densities and land cover across West and Central African countries. Human population densities are based on medium variant (source: UNPD 2008). Land cover shown for dense forest (DF) and forest-farm mosaic (FF) (source: Mayaux *et al.* 2004)

	Humans (pers/km^2)			Land cover (area in 1000ha)		
Country	1990	2010	2030	FF	DF	Ratio FF:DF
West Africa						
Côte d'Ivoire	39	67	101	13,792	1,124	12.27
Ghana	63	102	146	6,525	1,193	5.47
Liberia	19	37	58	6,211	2,488	2.50
Nigeria	105	171	245	8,736	3,411	2.56
Sierra Leone	57	81	125	5,156	603	8.55
Central Africa						
Cameroon	26	42	60	7,378	21,436	0.34
C.A.R	5	7	10	21,395	8,227	2.60
Congo	7	11	16	1,221	25,914	0.05
DRC	16	29	46	22,707	124,566	0.18
Equatorial Guinea	14	25	38	312	1,843	0.17
Gabon	3	6	8	1,006	21,190	0.05
Rwanda	271	390	611	60	131	0.46
Uganda	74	140	252	5,839	1,096	5.33

1.2.5. Cocoa landscapes and impacts on wildlife

In light of the negative effects of agricultural expansion on biodiversity, wildlife-friendly farming strategies such as agroforests may be part of a win-win-scenario.In as much as they resemble natural forests, agroforests can provide wildlife habitat outside protected areas, act as a corridor in fragmented landscapes and reduce the pressure on protected areas by providing resource users with livelihood opportunities (Bhagwat *et al.*, 2008; Gockowski & Sonwa, 2008; Rice & Greenberg, 2000; Schroth *et al.*, 2004).

One example of agroforestry is the growth of cocoa within natural forest. In this case, cocoa plants are cultivated beneath mature forest trees that may have been thinned to promote light penetration but otherwise maintain relatively natural conditions. Cocoa agroforests, such as the Brazilian 'cabrucas' harbour diverse and abundant wildlife communities of small mammals, birds leaf-litter frogs, reptiles, butterflies, ferns and bromeliads (Delabie *et al.*, 2007; Faria *et al.*, 2006, 2007; Harvey & Gonzalez, 2007; Pardini, 2004; Van Bael *et al.*, 2007). Overall, 'cabrucas' may harbour 70% of the species found in the surrounding landscape mosaic, comprising primary and secondary forest and different types of agricultural land (Cassano *et al.*, 2008).

However, the long-term survival of 'cabrucas' has recently been questioned by evidence showing that farmers are increasing the thinning of the canopy and the clearing of native trees (Rolim & Chiarello, 2004). Elsewhere, the intensification of cocoa farming has been observed on a large scale for several decades due to the spread of highly productive hybrid cocoa varieties that do not require shade. This marked the start of the 'zero-shade movement' and the progressive demise of cocoa agroforests in West Africa as early as the 1950s (Cunningham & Lamb, 1958), with the sun-grown variety being widely adopted since the 1980s (Bentley *et al.*, 2004; Ruf, 1995, 2011; Kazianga & Masters, 2006). A recent assessment of the presence of shade-grown cocoa in the world's second-largest cocoa producer, Ghana, showed that about 50% of farms received zero-to-light shade, while in some regions 79% of farms had little or no forest canopy. These figures indicate that - at least in Ghana - most cocoa agroforests have already been turned into cocoa monocultures with low levels of structural diversity and few food resources for wildlife (Gockowski & Sonwa, 2008; ICCO, 2011).

Botanical surveys in Ghana highlight the structural differences between sun- and shade-grown cocoa plantations (Ruf, 2011). The shade-grown Amelonado "Tetteh Quarshie" variety is cultivated at a density of 992 cocoa trees/ha with 50 forest trees/ha (of >10m height). In contrast, the sun-grown modern hybrid is cultivated at 1493 cocoa trees/ha with only 3.4 forest trees/ha (of >10m height). Similarly, Asase *et al.* (2009) showed that non-cocoa plant species richness decreased from mature forest to shaded cocoa to unshaded cocoa. The same pattern (for shade-grown and sun-grown cocoa farms) was observed by Ofori-Frimpong *et al.* (2007) across several other taxa (see also Table 1.3).

Table 1.3.: Number of species encountered in shade-grown and sun-grown cocoa farms (source: Ofori-Frimpong *et al.* 2007)

Taxa	Shade-grown cocoa	Sun-grown cocoa
Plants	41	12
Birds	122	55
Butterflies	68	50
Mammals	20	9

A second factor influencing biodiversity in cocoa farms is distance to natural forests. One study comparing bird and bat species in Brazilian cocoa agroforests found that farms located in a landscape dominated by natural forests comprised a species assemblage resembling the interior of intact tracts of native forest. In contrast, cocoa agroforests located within a landscape dominated by cocoa agroforests rather than native forest, hosted impoverished communities of bats and birds (Faria *et al.*, 2006). Similarly, Clough *et al.* (2011) found that species richness in forest trees, herbs, and endemic birds in smallholder cocoa agroforestry systems in Sulawesi, Indonesia, was strongly associated with distance to natural forests. A second study from Sulawesi also confirmed the negative relationship between biodiversity and distance to natural forest for a group of endemic rat species (Weist *et al.*, 2010).

A more complex relationship between distance to forest, structural diversity and species presence was found by Farias and Faria 2007 (cited by Cassano *et al.* 2008) in a Brazilian cocoa agroforest. Their study of bat populations showed that *Artibeus obscures*, a forest-dwelling bat species sensitive to habitat disturbance was more abundant in cocoa agroforests than in natural forest irrespective of distance to forest and canopy cover. The suggested explanation for this surprising pattern was that there was a higher food abundance for this species in the cocoa agroforest than in natural forest. Hence, the negative effect of distance to forest (source habitat) can be ameliorated or even eliminated if food resources are sufficient for populations to become permanent resident populations in farmland. Overall, however, it remains unclear whether forest-dependent species can be supported by cocoa agroforests or whether species presence in agroforests depends on constant re-colonisation from nearby source forest patches (Cassano *et al.*, 2008). A landscape dominated by agroforests and distant or non-existent natural forest is unlikely to ensure the survival of many species, especially forest-dependent species (Rice & Greenberg, 2000).

In combination, varying levels of structural diversity and distance to source habitat describe a gradient of expected wildlife diversity in cocoa farms, with the extremes being 'cocoa agroforests inside a natural forests' (high diversity) and 'cocoa monocultures distant from wildlife source habitats (low diversity). The strong decline in mammal species richness from shade-grown to sun-grown cocoa farms reported in Ghana (see Table 1.3) suggests that similar patterns of impact could also be expected for terrestrial mammals, with corresponding implications for bushmeat harvesting.

1.3. The importance of bushmeat in livelihoods

There is a growing literature showing that natural forests worldwide provide vital ecosystem services. These services include acting as a global carbon and climate regulator (IPCC, 2007) and supplying a source of genetic material for the development of new crops and pharmaceutical products (Myers, 1996). Forests are also utilised by communities around the world that harvest non-timber forest resources (NTFPs) (Scoones *et al.*, 1992; Townson, 1995a; Sunderlin *et al.*, 2005). An estimated 300 million people living close to tropical forests depend for part of their livelihood on forest resources with NTFPs alone being worth about $90 billion per year (Pimentel *et al.*, 1999). This suggests that the contribution of NTFPs is substantial and makes an important contribution to the livelihood security and welfare of rural people (Byron & Arnold, 1999).

Why do people harvest non-timber forest resources? First of all, the extraction of NTFPs generally requires little capital investment and is accessible to a wide range of socio-economic groups, including the poor and women, who may face difficulties entering alternative livelihood activities (Falconer, 1994; Paloti & Hiremath, 2005). Secondly, the distribution of forests and hence NTFPs is generally restricted to more marginalised areas where people have little access to alternative sources of income and are often poorer than elsewhere (Sunderlin *et al.*, 2005). As such the importance of the NTFP harvest is generally higher in areas with a high level of natural resource abundance and economic marginalisation.

The primary contributions of NTFPs to rural livelihoods are for subsistence use to meet everyday needs and as a source of income. The subsistence use of NTFPs is manifold including firewood and charcoal for energy provisioning, as a source of food, for use as medicine, and material used for construction and production of crafts (for a review and case studies of various uses of NTFPs, see Falconer 1990; Scoones *et al.* 1992). The subsistence use of NTFPs provides households with an alternative to commercial products that may not be available in rural areas and enables households to reduce their expenditures (Shackleton & Shackleton, 2004). Where households decide to sell harvested NTFPs, they can form an important source of income, especially in remote areas where alternative sources of income are not available and when households experience temporal income shortages, such as during the agricultural lean season (*e.g.* Sunderlin *et al.* 2005)

One important non-timber forest resource are wild animal populations. Where these are abundant, bushmeat can be an important NTFP and form a vital component in the livelihoods and well-being of millions of people living in tropical forest areas (Elliott, 2002; Milner-Gulland *et al.*, 2003).

1.3.1. Bushmeat as a source of protein

Bushmeat is a widely available source of animal protein throughout sub-Saharan Africa. The consumption of bushmeat has cultural connotations for many Africans and bushmeat is preferred over domesticated meat by many people (Njiforti, 1996; Schenck *et al.*, 2006). In addition, bushmeat is often less expensive than domesticated meat in many urban and especially rural areas (Caspary, 1999; Robinson & Bennett, 2000b). These patterns in part reflect the difficulty of livestock production in Africa's tropical forest belt. During the last two decades the consumption of livestock has decreased in most West African countries (Chardonnet *et al.* 1995, cited in Caspary 1999) and Africa has become a net importer of beef after being a net exporter in the 1970s (Tambi & Maina, 2003). Similarly, fish imports have also increased as a response to insufficient domestic animal protein production, reaching 50,000 tons in the Côte d'Ivoire during the 1980s and 1990s (Caspary, 1999), and has recently been estimated as 380,000 metric tonnes per year in Ghana (World Resources Institute, 2003). In addition, bushmeat is basically an open access resource, leading to lower production cost than the cost of raising livestock and thereby making it a less expensive source of animal protein than domesticated meat in many urban and especially rural areas (Caspary, 1999; Robinson & Bennett, 2000b).

Consequently, bushmeat is widely utilised in both urban and rural areas, but it is especially important in the diets of rural populations (Table 1.4). In rural Cameroon, for example, Muchaal & Ngandjui (1999) estimated that bushmeat provided 80 - 98% of total animal protein intake for people living in villages and 80% to those in a nearby town. In rural Gabon hunters similarly derived 73% of their animal protein from bushmeat (Lahm, 1993). It has been suggested that in Ghana during the 1960s, bushmeat was the only source of animal protein available to inland forest communities that lacked access to fish from rivers (Asibey, 1966). As such, it was instrumental in facilitating the development of Ghana's cocoa industry by providing animal protein to migrating farmers who entered remote forest locations where alternative protein sources were not available.

Nevertheless, healthy wildlife populations do not always translate into high levels of bushmeat consumption. For example, households in a rural area of Equatorial Guinea, where wildlife was abundant within the community's catchment, consumed relatively little bushmeat and derived most of their animal protein from fish and livestock (Kumpel, 2006). Similarly, in a rural area of the Democratic Republic of Congo, households consumed bushmeat on average 5.8 days per month, comprising only 3% of the total value of the food consumed (de Merode *et al.*, 2003).

These counterintuitive patterns may be explained by a variety of factors, including the price of bushmeat relative to its substitutes and the availability of alternative income sources. In the case of the Equato-Guinean community, fresh bushmeat was a highly prized commodity and hunters could sell their catch and buy less expensive alternatives, such as frozen fish and livestock. Furthermore, bushmeat was likely the only commodity produced in rural communities for which sufficient demand and value existed to make commercial trade worthwhile (Kumpel, 2006). Similarly, hunters in the second case, sold over 90% of their bushmeat and fish harvest (since there were very few alternative sources for income generation), thereby substantially reducing the importance of wild foods in household consumption (de Merode *et al.*, 2004). This may be particularly important where households derive a large part of their protein consumption from plants and therefore rely less on bushmeat for protein consumption.

1.3.2. Bushmeat as a source of income

In addition to the subsistence use, NTFPs offer an important option for generating cash income. The processing and sale of NTFPs increases household income and creates opportunities for people who may find it difficult to access alternative labour markets to earn a living (IFAD, 2008). Analysing the results of 51 studies across 17 developing countries, Vedeld *et al.* (2007) estimated that the average contribution of forest environmental income

Table 1.4.: Overview of bushmeat consumption estimates for rural and urban consumer in West and Central Africa

Region/Country	Site	Consumption/day
Sub-Saharan Africa[a]	rural-farmer	43g/pers.
Sub-Saharan Africa[a]	rural-hunter	105g/pers.
Sub-Saharan Africa[a]	urban	13g/pers.
Central Africa		
Congo Basin[b]	region	282g/pers.
Congo Basin[c]	rural	130g/pers.
Congo Basin[c]	urban	13g/pers.
CAR[d]	urban	39g/pers.
Equatorial Guinea[e]	urban/rural	32g/AME
Congo[f]	urban/rural	60-200g/pers
Cameroon[g]	rural	75-164g/pers.
Cameroon[h]	rural	185g/pers.
Congo[i]	rural	116-164g/pers.
Congo[j]	rural	70g/pers.
DRC[k]	rural-hunters	160g/pers.
DRC[l]	rural	40g/household
DRC[m]	rural	120g/pers.
Equatorial Guinea[n]	rural	12-25g/AME (p)
Gabon[o]	urban	4-94g/pers.
Gabon[p]	urban	20-120g/AME
Gabon[p]	rural	50-260g/AME
Gabon[q]	rural	268 g/AME
Gabon[r]	rural-urban	47g/pers
West Africa		
Côte d'Ivoire[s]	country	22g/pers.
Ghana[t]	urban	46g/pers.
Ghana[u]	urban	10g/pers.
Ghana[v]	urban	46g/pers.
Ghana[w]	rural	36g/adult
Ghana[t]	rural	33g/pers.
Ghana[x]	rural	185g/hunter
Ghana[v]	rural	33g/pers.
Liberia[y]	rural	288g/pers.

[a] Chardonnet *et al.* (1995) [b] Fa *et al.* (2002) [c] Wilkie & Carpenter (1999)
[d] Fargeot & Dieval (2000), cited in Nasi *et al.* (2008) [e] Fa *et al.* (2009)
[f] Auzel & Wilkie (2000) [g] Delvingt *et al.* (2001), cited in Nasi *et al.* (2008)
[h] Bahuchet & Ioveva (1999) [i] Delvingt (1997), cited in Nasi *et al.* (2008)
[j] Eves & Ruggiero (2000) [k] Bailey & Peacock (1988)
[l] de Merode *et al.* (2003) [m] Aunger (1992), cited in Nasi *et al.* (2008)
[n] Allebone-Webb (2008) [o] Thibault & Blaney (2003) [p] Wilkie *et al.* (2005)
[q] Starkey (2004) [r] Steel (1994), cited in Caspary (1999) [s] Caspary (1999)
[t] Ntiamoa-Baidu (1998) [u] Cowlishaw *et al.* (2005a)
[v] Cowlishaw *et al.* (2007) [w] Dei (1989) [x] Holbech (1998) [y] Anstey (1991)

to total household income as 22%, suggesting that the trade in NTFPs is an important source of cash income in rural communities of developing countries (see Table 1.5 for examples of recent studies).

Table 1.5.: The relative importance of forest incomes across studies (ordered by increased importance)

Country	% total income	Source
Mexico	2-7%	Lopez-Feldman *et al.* (2007)
Cameroon	6-15%	Ambrose-Oji (2003)
India	14%	Mahapatra *et al.* (2005)
Malawi	15%	Kamanga *et al.* (2009)
Sri Lanka	9-19%	Illukpitiya & Yanagida (2008)
Honduras	18%	McSweeney (2002)
Peru	up to 25%	Takasaki *et al.* (2001)
Ethiopia	27%	Babulo *et al.* (2009)
Malawi	30%	Fisher (2004)
Ethiopia	34%	Yemiru *et al.* (2010)
Ghana	38%	Appiah *et al.* (2007)
Ethiopia	39%	Mamo *et al.* (2007)

The sale of bushmeat reduces the amount available for consumption by the hunter's household, but it provides an important source of cash income in areas with few alternative income sources (Table 1.6). The importance of bushmeat in household economies varies across sites and individual hunting households, ranging from 38% to more than 90% of the total cash income earned. For a specific household, the importance of bushmeat for income or consumption depends upon the hunter's decision whether to consume or sell the whole or part of the bushmeat harvest, which in turn depends on the hunter's needs at the time of the decision and the characteristics of the harvest. For example, professional hunters with few alternative sources of cash income commonly sell a large share of their harvest whereas those with more diversified incomes tend to hunt fewer animals primarily for subsistence (Kumpel, 2006). Hunters are also more likely to sell large animals and keep small animals for own consumption, because the latter fetch a lower price per animal and may be less marketable (Kumpel, 2006; van Vliet & Nasi, 2008). Finally, households facing income shortages during the agricultural lean season (*i.e.* commonly the planting season between harvests when household income is lowest) and requiring cash income to pay for urgent expenditures, such as hospital bills, are more likely to sell bushmeat than keep it for own consumption (de Merode *et al.*, 2004).

Table 1.6.: Bushmeat as a source of cash income: % of harvest sold and % of cash income earned from bushmeat sales (– = no estimate available)

Country	% sold	% total income	Source
West Africa			
Ghana	44%	38%	Crookes *et al.* (2007)
Ghana	53%	–	Ntiamoa-Baidu (1998)
Ghana	45-60%	–	Holbech (1998)
Central Africa			
Cameroon	–	56%	Infield (1988)
Cameroon	62%	95%	Tieguhong & Zwolinski (2009)
Cameroon	40-60%	–	Muchaal & Ngandjui (1999)
Cameroon	53-61%	–	Willcox & Nambu (2006)
CAR	20%	–	Noss (1997)
DRC	>90%	–	de Merode *et al.* (2003)
Equatorial Guinea	70%	–	Colell *et al.* (1994)
Equatorial Guinea	89%	–	Kumpel *et al.* (2010b)
Gabon	–	38%	Starkey (2004)
Gabon	50%	–	Coad *et al.* (2010)
Gabon	40%	–	van Vliet & Nasi (2008)

Overall, income from bushmeat sales compares favourably with alternative work in many rural places. 25 years ago indigenous farmers in the Central African Republic with little access to salaried employment could earn more than a weekly salary of timber company employees and a similar income to a NGO workers by allocating just 15% of their time to hunting (Noss, 1997). Similarly, hunters supplying markets in Central African logging concessions earned twice the income of junior technicians working at a logging company (Tieguhong & Zwolinski, 2009). In East and West Africa, hunters in rural Kenya can earn 2.5 times the average salary in the area (Fitzgibbon *et al.*, 1995), and Ghanaian hunters can earn income similar to that of a graduate entering Wildlife Service, and up to 3.5 times the government minimum wage (Ntiamoa-Baidu, 1998).

High incomes from bushmeat sales are made possible by the favourable characteristics of bushmeat. Bushmeat is a highly marketable commodity with well-established markets in urban and rural areas. Transportation from rural to urban areas is facilitated by both a high price-to-volume ratio and the ease of meat preservation through smoking/salting, making it less perishable than many other commodities produced in rural areas (Brown, 2007). To supply demand for bushmeat in distant areas, bushmeat is often traded along complex commodity chains[1] until it reaches the final destination (for three examples of bushmeat commodity chains, see: Mendelson *et al.* 2003; Edderai & Dame 2006; de Merode & Cowlishaw 2006). Such bushmeat commodity chains enable rural hunters to generate income from distant markets without incurring transportation expenditures, and create income opportunities for a large number of people along the commodity chain. From a development perspective it is important to note that bushmeat commodity chains are characterised by high social inclusivity, in both wealth and gender terms (Brown, 2003) and that depending on the locality in question hunters may gain the largest share of the final retail price (*e.g.* Takoradi, Ghana: Mendelson *et al.* 2003). In other cases, however, the hunters may only realise a small share of the final price (*e.g.* Dungu, Democratic Republic of Congo: de Merode & Cowlishaw 2006).

1.4. The importance of bushmeat for poverty alleviation

With the emergence of the "sustainable development" debate in the late 1970s/early 1980s, the value of forests to local resource users became widely recognised. Researchers started assessing the economic worth of "minor forest resources" to local forest communities in developing countries, and provided evidence for substantial economic values of such forest resources that were not timber (de Beer & McDermott, 1989; Myers, 1988; Hecht *et al.*, 1988; Falconer, 1990). To provide a case against deforestation, early studies estimated the "net

[1]A commodity chain is *'a series of interlinked exchanges through which a commodity and its constituents pass from extraction or harvesting through production to end use'* (Ribot, 1998)

present value" of an area when logged and when used for its NTFPs, with some indicating higher value from NTFPs (*e.g.* Peters *et al.* 1989). However, these studies were criticised for a variety of reasons, mainly because of the difficulty of translating potential values into tangible benefits to local resource users (Pinedo-Vasquez *et al.*, 1990; Sheil & Wunder, 2002).

While the initial interest in NTFPs focused on demonstrating the economic value of unlogged forests and thereby reducing the incentives for deforestation, more recently - and especially since the publication of the Millennium Development Goals[2] in 2000 - the argument has changed direction and people have started asking whether and how forest resources could contribute to poverty alleviation in rural areas. Similarly, conservationists have stated that there is a "widespread consensus that poverty is a significant underlying threat to conservation", providing further incentives for assessing the linkages between NTFPs and poverty (Roe & Elliott, 2004).

1.4.1. NTFPs and poverty

The contribution of NTFPs to household income generation is a strong indication of the relative economic importance of NTFP to rural households, yet it says little about the effects of the harvest/use of NTFPs on poverty. To understand this relationship it is useful to clarify the concepts of poverty and livelihoods.

Poverty is traditionally expressed in monetary terms and distinguishes between "asset poverty", which relates to restrictions on the choice of economic activities, and "income poverty", which categorises people into poor and non-poor based on their monetary income (Chambers, 1995). However, it has become apparent that poverty is more complex than this and has been described as a multidimensional concept (Alkire & Santos, 2010a). In this latter framework, poverty occurs in a variety of ways and can be summarised as "deprivation

[2]The Millennium Development Goals comprise eight international development goals, including among others the eradicating extreme poverty and ensuring environmental sustainability (UN, 2010)

of the means for a decent life" and as such includes all aspects of human wellbeing (Ellis, 2000). Such deprivation may come in the form of income shortage, inadequate access to consumption goods, insufficient knowledge, health or skills to fulfil normal livelihood functions, or inadequate living conditions, such as poor housing or an unhealthy or dangerous environment.

The multidimensional concept of poverty encompasses a range of interacting tangible and intangible assets, which can be described using the Sustainable Livelihoods Framework to explore the various dimensions of well-being and the means for achieving it (Scoones, 1998). Within this context a sustainable livelihood is defined as one that "comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base" (Chambers & Conway, 1991). The means for achieving sustainable livelihood outcomes are classed as four capitals (following Scoones 1998):

- natural capital: natural resources (*e.g.* soil, forests, water, wildlife) and environmental services (*e.g.* hydrological cycles) from which resource flows and services useful for livelihoods are derived.
- financial capital: the capital base (cash, credit, savings etc.) and other economic assets (*e.g.* infrastructure, tools) that are essential for the pursuit of any livelihood strategy[3].
- human capital: the skills, knowledge, ability to labour and good health and physical capability important for the successful pursuit of different livelihood strategies.
- social capital: the set of social relationships upon which people can draw when pursuing livelihood strategies requiring coordinated actions (*e.g.* kinship, friendship, reciprocal arrangements).

[3]Some author class the latter as an independent capital (physical capital).

Within this context, forests are important natural capitals and the harvest of forest products interacts with a range of further capitals required to achieve a sustainable livelihood. For example, the use of NTFPs for constructing shelter from hostile environments facilitates good health and thereby enhances human capital. Similarly, NTFPs used for consumption enhances peoples' diets, thus contributing to their good health (human capital), as well as reducing their household expenditure (financial capital).

According to King & Palmer (2007) three types of poverty dynamics exist. Their classification provides a useful framework for exploring the contribution of NTFPs to livelihoods and their effects on poverty. When people are lifted above a defined poverty line, their status changes from poor to non-poor ("poverty reduction"). In contrast, "poverty alleviation" occurs when the symptoms of poverty are alleviated and/or the severity of poverty is reduced but the poverty line is not crossed. Similarly, "poverty prevention" describes the process where people are prevented from falling into poverty in the first place by reducing their vulnerability.

There is some evidence that NTFP harvest may act as a “stepping stone“ and allow people to earn an income that can be invested in other livelihood activities, thus contributing to improvements in livelihood options (Kusters, 2009). However, as noted above, this is different from poverty reduction where people are lifted out of poverty (Arnold & Townson, 1998). In fact, NTFPs may have the strongest effect on poverty in human-modified areas where people are well integrated into the cash economy and some NTFP producers are able to pursue a "specialised" strategy in which NTFPs contribute more than 50% of total household income (Ruiz-Perez *et al.*, 2004).

Overall, there is little evidence that forest resource extraction results in substantial poverty reduction (Wunder, 2001). The meta-analysis by Vedeld *et al.* (2007) showed that NTFPs may contribute substantially to household economies, but that mean forest cash incomes were only in the range of US$400/household/year. This left most households below the level of extreme poverty (US$1.25/capita/day) in the absence of additional income. Similarly, a study comparing Indonesian Punan hunter-gatherers living in forest resource abundant areas against agriculturalists living in highly disturbed habitats near markets showed that the latter had substantially higher incomes, better access to education and lower infant mortality, all indicators of economic development (Levang *et al.*, 2005). The main reasons for persistent poverty in the former group appeared to be that (1) income from labour in remote areas with higher transport costs resulted in low earnings, and (2) high-value NTFPs are generally harvested from disturbed landscapes near markets rather than undisturbed forests distant from markets.

Nevertheless, there is good evidence for NTFPs to act as gap-fillers and safety nets during times of economic hardship, thereby contributing to alleviating the effects of poverty and potentially preventing people from falling into poverty (Pattanayak & Sills, 2001; Takasaki *et al.*, 2004).

1.4.2. Bushmeat as a safety net for vulnerable households

Households involved in the harvest of NTFPs are commonly among the poorest and most vulnerable in developing economies (Neumann & Hirsch, 2000). Yet even among the rural poor, socio-economic differentiation exists in the level of resource harvest and its relative importance in livelihoods. Based on data from 213 Zimbabwean households, Cavendish (1999a) showed that poorer households are more dependent on environmental resources than wealthier ones. Similarly, wealthy households may harvest more bushmeat than poorer households, since they have access to more efficient hunting tools and/or can free more household labour for hunting, but it is often among the poorer households that bushmeat comprises the largest share of household income and protein consumption (de Merode *et al.*, 2003; Coomes *et al.*, 2004; Starkey, 2004; Kumpel *et al.*, 2010b). This raises the possibility that bushmeat and NTFPs in general act as a ”safety net“[4] for poor households who have least access to alternative sources of cash income and/or access to alternative sources of animal protein.

Wealth differentiation among households is omnipresent and a defining characteristic that distinguishes people from different households (Arhin, 1988; Grandin, 1988). In contrast to wealth, which is associated with strength, access to important economic resources, authority and power, poverty is the direct opposite, associated with physical weakness, vulnerability (to hunger, illness, exploitation), powerlessness and isolation (including lack of education, services and general remoteness) (Grandin, 1988; Guijt, 1992).

While poverty occurs throughout communities, there is strong evidence that female-headed households (FHH) are more likely to be poor than male-headed households (MHH). **?** reviewed 65 studies from Africa, Asia, and Latin America and showed that in 63% of studies FHHs were over represented among the poor, 24% of studies reported that poverty was associated with attributes of FHHs, and only 13% of studies showed no evidence for greater poverty of FHHs than MHHs. The high prevalence of poverty among FHHs has been attributed to a variety of reasons, including smaller household sizes and higher dependence ratio (resulting in less efficient use of resources), and less access to education, productive assets such as land, capital and technology (Haddad, 1991; Appleton, 1996). The role of NTFPs in FHHs in West and Central Africa has not been well studied, however, evidence from rural communities in Zimbabwe with high prevalence of HIV and a large proportion of households being headed by women, concluded that NTFPs were a crucial income source for these vulnerable households. In South African communities, Paumgarten & Shackleton (2011) found that NTFPs were an important safety net during shocks and were equally utilised by both male- and female-headed households.

[4]According to Marshall *et al.* (2006) ”safety nets“ prevent people from falling into greater poverty by reducing their vulnerability to risk. These are particularly important in times of crisis and unusual needs.

Importantly, because poverty makes people more vulnerable, it increases their susceptibility to external shocks (due to a lack of formal insurance mechanisms: Alderman & Paxson 1992; Dercon 2002), such as seasonal income shortages, diseases, and crop failure. NTFPs may play a crucial role in buffering poor rural households against such shocks. In particular, in the case of seasonal stresses, although NTFPs may provide such households with income and food throughout the year, and the harvest of bushmeat may be a year-round mainstay (*e.g.* Kumpel *et al.* 2010b), their relative importance may increase in more difficult seasons. Consequently, while the harvest and trade of NTFPs may only generate a limited income, the timing of this income during a lean season when other income and consumption sources are less available may be vital for household survival (Falconer, 1990; Scoones *et al.*, 1992; Arnold & Ruiz-Perez, 2001).

Rainfall in much of the world's tropical rainforest areas is highly seasonal, resulting in seasonal variation in productivity across trophic levels (Chambers *et al.*, 1981). The seasonality of rainfall is linked both to (1) agricultural production cycles, with planting usually occurring during the rainy season and harvesting during the dry season (Upton, 1996) and (2) the seasonal availability of wild food resources (Bailey *et al.*, 1993). During the lean season prices for food staples can show a marked increase of up to 365% in some regions (de Merode *et al.*, 2004). Seasonal rainfall patterns influence the availability of food and income to agricultural societies and make rural populations susceptible to food and income shortages, resulting in seasonal hunger periods (Devereux, 2010). The wider implications of such seasonal hunger periods, or "lean seasons", are seasonal variation in body weight, susceptibility to disease, and fecundity of women leading to seasonal birth patterns (Chambers *et al.*, 1981; Bailey *et al.*, 1993). The immediate cash needs of the rural poor represents a strong incentive to sell agricultural produce as soon as it is available during the harvest season, when prices are at their lowest, and to rely on non-farm income and food sources like bushmeat during the lean season (Scoones *et al.*, 1992; Amanor, 1999). With the low opportunity costs of hunting and strong income needs, hunters in a Ghanaian village spent 36% more time hunting during the lean season than during the farming season (Dei, 1989). Whereas less than 30% of all hunters living in forest fringe communities in Côte d'Ivoire were hunting during the farming season, 70 - 90% of hunters were most active during the lean season (Caspary, 1999). Likewise, to generate income for the purchase of food staples during the lean season, bushmeat sales increased by up to 155% in DRC (de Merode *et al.*, 2004). Similar gap-filling functions of NTFPs have been observed in rural Ethiopia where 82% of all households faced seasonal food shortages and of these 36% reported firewood sales to smooth incomes and act as a "gap filler" (Mamo *et al.*, 2007).

In conclusion, NTFPs may not only provide incomes to the poorest and most vulnerable households that have no alternative livelihood options, but they may also play a crucial role in supporting households with a range of incomes during the lean season. Through a combination of these processes, NTFPs can facilitate income smoothing and have a strong income equalising effect, which in some places can bring about a 30% reduction in measured inequality (Cavendish, 1999a; Mamo *et al.*, 2007). As such, NTFPs are in many rural localities an important livelihood component within the portfolio of household activities and may alleviate the symptoms of poverty or prevent people from falling into poverty.

1.4.3. The role of income diversification in rural livelihoods

The majority of Africa's rural population practices small-scale agriculture and engages in a range of income and subsistence activities, including the harvest of NTFPs (DFID, 2010). Very few households depend entirely on one income source, hold all their wealth in a single asset, or use their assets in just one activity (Barrett *et al.*, 2001). Developing alternative income strategies is an integral part of the livelihood strategies of rural societies in sub-Saharan Africa. This range of income opportunities is the framework of livelihood diversification, which is the "process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and in order to improve their standards of living" (Ellis, 1998). Examples from across the tropics underline the pervasiveness of diverse household portfolios. An early report examining 15 studies from eight sub-Saharan countries highlighted the importance of non-farm income throughout farming communities but also the high degree of variation between case study households (Haggblade *et al.*, 1989). Similarly, Reardon (1997) showed that on average 45% (ranging from 22% to 93%) of total household income in sub-Saharan farming communities was derived from non-farm activities. An even lower household reliance on farm income was documented by national statistics in rural Ghana, where farm income comprised only 14% of total household income, ranking behind self-employment (72%) and closely followed by wage labour (11%) (Canagarajah *et al.*, 2001).

The livelihoods literature groups the motives for diversification into "push" and "pull factors" (Ellis, 1998). Environmental variation, such as droughts, family illness and uncertain commodity markets can require involuntary diversification, to reduce the risk of diminishing returns ("push factors"). Safety nets are part of these involuntarily adopted diversification activities that aim to stabilise income flows and consumption. In contrast, "pull factors" are voluntary decisions of a household. These may be made because of differences in returns between different activities (even if such differences are only a seasonal phenomenon) or because a household has reached its income/production limits within the existing activities and has surplus labour available (Reardon, 1997; Canagarajah *et al.*, 2001). There may also be complementarity across different activities, *e.g.* trapping on farms, that require little additional work but can yield substantial returns (Wilkie, 1989; Naughton-Treves *et al.*, 2003). Similarly, Khoa *et al.* (2005) recorded that among agricultural communities in Laos, 83% of households fished in rice fields for about five hours per week. With this relatively small effort, the average household gained US$90 per year, which compared favourably with the income from the otherwise full-time farming activity (average annual income per household: US$150). Infrastructure development and changes in labour and commodity markets, which alter the access to and profitability of different activities, are important determinants of "pull factors" (Rudel, 2006). Where households are well integrated into the cash economy, pull factors are frequently associated with asset accumulation by households that already have a diverse livelihood portfolio, or young people who are only starting to develop their portfolio and focus on a low barrier activity that enables them to gain access to more asset-requiring activities (Ruiz-Perez *et al.*, 2004).

In theory, household decisions regarding livelihood diversification and resource utilisation should be based on the comparison of marginal returns from different activities (Brocklesby & Ambrose-Oji, 1997). However, both ”push“ and ”pull factors“ act differently on individual households, depending on both their existing livelihood portfolio and their ability to overcome new entry barriers (Woldenhanna & Oskam, 2001). This in turn can lead to variation in income and subsistence strategies between countries/regions (Reardon, 1997), villages (Hegde & Enters, 2000) and households (Coomes *et al.*, 2004).

1.5. Summary

1.5.1. Limitations of bushmeat literature

A review of the bushmeat literature by Bowen-Jones *et al.* (2002) showed that more than 75% of the scientific literature focused on the biological and management aspects of bushmeat, and only 5% addressed livelihoods and food security issues. The situation has shown some improvement over the last decade with detailed socio-economic studies being conducted in West and Central Africa (*e.g.* Mendelson *et al.* 2003; de Merode *et al.* 2004; Allebone-Webb 2008; Coad *et al.* 2010; Kumpel *et al.* 2010b). Davies & Brown (2007) provide a valuable synthesis of this work, reviewing the current knowledge of the importance of bushmeat in rural livelihoods. Yet detailed socio-economic studies that assess the role of bushmeat in rural livelihoods as a source of cash income and animal protein and most importantly differentiating between different use patterns and their determinants remain few. This hampers our ability to understand the drivers of bushmeat hunting and ultimately manage wildlife populations inside and outside protected areas.

Existing research into the importance of bushmeat and other NTFPs to livelihoods has been severely restricted for three reasons. First, most studies have focused on the commercial aspects of bushmeat hunting without acknowledging the diverse income-generating activities that are open to and commonly utilised by hunters (*e.g.* de Merode *et al.* 2003). This approach tends to present hunting as a full-time activity, and places relatively little emphasis on the subsistence use of bushmeat. Second, little attention has been paid to the collection, processing and trading pattern, and how these fit into overall livelihood strategies, including on-farm activities. The bushmeat commodity chain is complex - it includes several actors and multi-species trade flows often coming from a large geographical area - and studies of the interaction between the different actors, for example in relation to price setting are few (Mendelson *et al.*, 2003; Swensson, 2005; de Merode & Cowlishaw, 2006). Finally, most studies have focused on a homogeneous group, thereby neglecting the heterogeneity of livelihood strategies between households and villages, and the socio-economic factors that influence livelihood strategies (Coomes *et al.*, 2004).

Much of the bushmeat literature has focused on forest-dominated landscapes in the Neotropics (*e.g.* Vickers 1988; Alvard 1995; Bodmer 1995; Peres 2000a; de Thoisy *et al.* 2005; Ohl-Schacherer *et al.* 2007) and Central Africa (*e.g.* Noss 1998b; Hart 2001; Laurance *et al.* 2006; Coad 2007; Rist *et al.* 2008; Poulsen *et al.* 2009; Kumpel *et al.* 2010a), where hunters target large-bodied species with low rates of intrinsic increase. Studies of hunting in non-forest dominated areas of the tropics such as savannahs (Loibooki *et al.*, 2002; Johannesen, 2005; Nyahongo *et al.*, 2009; Knapp *et al.*, 2010) and agricultural landscapes (Jorgenson, 1993; Escamilla *et al.*, 2003; Davies *et al.*, 2007; van Vliet & Nasi, 2008) are much more scarce, despite hunting in farms or “garden hunting” being widespread and potentially an important source of income and animal protein supply (Jorgenson, 1993; Lee, 2000). Consequently, relatively little is known about the impact of hunting on wildlife populations in human-modified landscapes and the role of hunting within local household livelihoods.

1.5.2. Thesis objectives

The primary purpose of this thesis is to explore the importance of bushmeat at the household level within a setting of depleted wildlife populations and diversified livelihoods providing alternative income sources. Crucially, in this system, the main source of income is highly seasonal, which further allows us to examine livelihood strategies for mitigating seasonal income shortages. My primary research questions are as follows:

- Chapter 4: Does farm land provide an alternative to hunting in forests? What is the level of wildlife depletion and hunting patterns in both forest and farm land?

- Chapter 5: Can depleted wildlife populations support rural livelihoods? What are the effects of household vulnerability and income seasonality on bushmeat harvest and use patterns?

- Chapter 6: Does wildlife depletion lead to protein insecurity? What are the effects of household vulnerability and income seasonality on protein security and the relative importance of bushmeat compared to other types of protein?

- Chapter 7: Can depleted wildlife populations contribute to poverty alleviation? What are the effects of household vulnerability and income seasonality on income poverty and the relative importance of bushmeat compared to other incomes?

1.5.3. Thesis structure

Following this Introduction (Chapter 1), Chapter 2 provides a description of the study site, including a review of the current levels of wildlife depletion in Ghana and the historical developments leading to this situation. Chapter 3 describes the methods used in this study and evaluates potential weaknesses. In Chapter 4, I examine the status of wildlife depletion around the study community, their hunting patterns and the potential for intensively managed farmland to provide an alternative source of bushmeat to forests. Following on from this, Chapter 5 assesses the importance of bushmeat harvest and use in relation to household vulnerability. Chapter 6 provides a detailed analysis of protein consumption and assesses the importance of bushmeat for protein security in relation to household vulnerability. In Chapter 7, the focus moves to the seasonal aspects of cocoa farmers' livelihoods, by assessing the effects of income seasonality on poverty and the strategies, including the harvest and sale of bushmeat, adopted by different socio-economic groups to mitigate these seasonality effects. Finally, in Chapter 8, I discuss the implications of this study on current debates on 'biodiversity conservation and poverty alleviation'.

Chapter 2

Study site

2.1. Chapter overview

This chapter introduces the study community 'Wansampo' and the Sefwi Wiawso district in which the village is located. It provides general information on the geography and land-use pattern, both current and historical, that are necessary to understand the setting in which this study has taken place: a cocoa farming community living in a wildlife depleted forest-farm landscape. The chapter begins with a general description of Ghana in economic and cultural terms (Section 2.2), followed by a description of the physical location of the study site and its biological characteristics (Section 2.3). Subsequently, I review the existing literature on the status of wildlife populations in Ghana's forest region and provide a historical perspective on natural resource use in the area with special reference to the interaction between logging and cocoa farming (Section 2.6). Further, details on Ghanaian cocoa farmers and their farming production system are provided in the following section (Section 2.7). Finally, I describe the study community, land-use pattern and demographic aspects (Section 2.8). This chapter is primarily based on the literature, but due to the absence of studies in the community primary data are also presented.

2.2. Ghana

2.2.1. Geography and politics

The Republic of Ghana is a West African country bordered by Côte d'Ivoire in the west, Togo in the east, Burkina Faso in the north and the Gulf of Guinea in the south (Figure 2.1). With a land size of 238,535km^2 (roughly the size of the UK), Ghana is a medium sized West African country with a population of about 24 million (Ghana Statistical Service, 2005b). The capital of Ghana is Accra, which is also the largest city in Ghana (4m), followed by Kumasi (2.6m), Tamale (0.36m) and Takoradi (0.36m). The country is divided into ten administrative regions, which are further subdivided into 138 districts with decentralised government structures. The landscape of Ghana is generally flat with undulating low hills. There are no major mountain ranges: the highest point in the country is Mount Afadjuto (885m) in the Akwapim-Togo Ranges. Despite the lack of elevational differentiation, Ghana comprises four main biogeographical zones. Starting from the south: the Guinea-Congolian zone, a transitional zone in the middle of the country, the Guinea-Congolian/Sudanian zone in the north and a sub-Sahelian zone in the far north (Ministry of Environment and Science, 2002).

The first post-independence human population census counted 6.7 million inhabitants in 1960. The 2000 national census in 2000 counted 20m inhabitants (Ghana Statistical Service, 2005b) and it is estimated that 22.9m people lived in Ghana in 2007. The population is expected to rise to 29.6m in 2020. For the period between 2005 and 2010, the estimated rate of natural increase has been 2.1%. During the same period, the average number of births per woman was 4.3, constituting a decline from 5.3 between 1990 and 1995. A total of 51.5% of Ghana's population lives in urban areas (UNDP, 2009).

The main ethnic groups in Ghana are the Akan, living in the mid-southern part of the country and comprising 45% of the population; the Ewe and the Ga-Adangbe in the south and south-east, comprising 12% and 7% of the population respectively; the Mole-Dagomba (15%) predominating in the northern savannahs, and the Guan (4%) and the Gurma (4%) live in the north-east territory (Ghana Statistical Service, 2005b). Akan is a matrilineal culture and every Akan by birth belongs to the mother's matrilineal clan *'abusua'*. The official language is English, but more than 60 different languages are spoken in Ghana, including Akan, Dagbani, Dangme, Ewe, Ga, Gonja, Hausa, Konkomba and Nzema, and most Ghanaians speak at least one local language.

Ghana was the first African country to declare independence on the 6th of March 1957 under the leadership of Kwame Nkrumah. The early years of post-colonial rule, which saw major investments in infrastructure, such as ports, roads and the Akosombo dam, were followed by a series of coups between 1966 and 1981, resulting in the suspension of the constitution and banning of political parties under Flight Lieutenant Jerry Rawlings in 1981. The following years were characterised by economic stagnation, leading to Ghana adopting a structural adjustment plan with the International Monetary Fund in 1987. The constitutional democracy was reenacted in 1992 restoring a multi-party parliament and free elections. Since then Ghana has had two successful peaceful changes in government and is considered one of Africa's democratic success 'stories'.

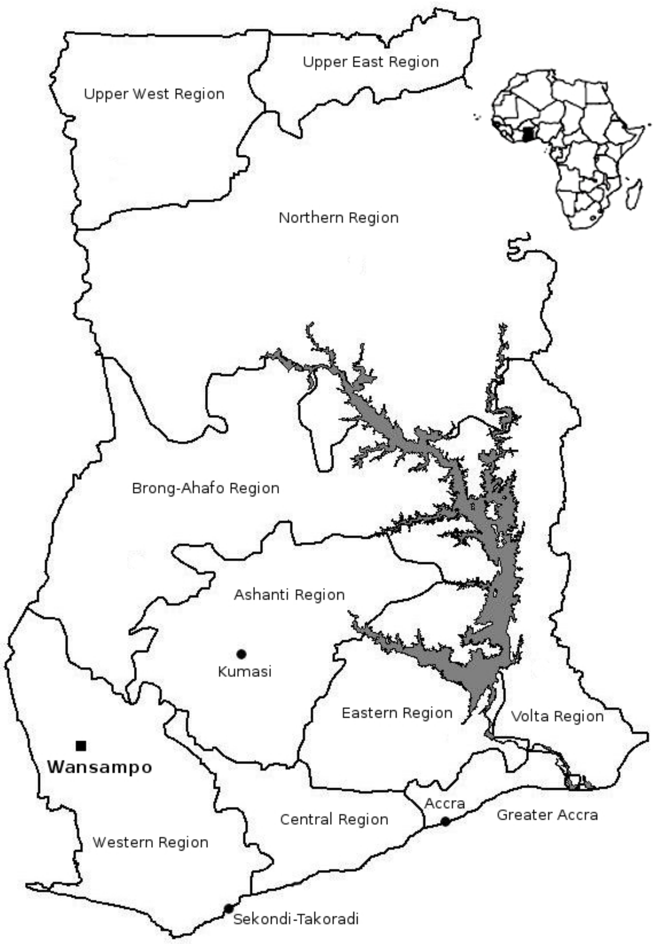

Figure 2.1.: Map showing Ghana at the west coast of Africa and the study village in the Western Region of Ghana.

2.2.2. Economic development & poverty in Ghana

Ghana has a diverse and rich resource base with gold, cocoa, timber, diamond, bauxite, and manganese being the main export commodities. The two most important commodities, gold (US$2,246m) and cocoa (US$1,162m) comprised 48% of total export earning in 2009 (Ghana Statistical Service, 2010). With the recent discovery of oilfield along the Ghanaian coast, oil may soon become an additional export commodity, raising hopes that Ghana may achieve 'middle income' status (income of >US$1000/capita/year) by 2015 (see also Table 2.1).

Table 2.1.: Key economic summary statistics for The Republic of Ghana in 2008 (Source: Ghana Statistical Service 2010).

Indicator	Value
GDP	US$ 28,249m
GDP/capita	US$1,234
GDP growth rate	8.4%
Inflation (annual average)	16.5%
Balance of trade	US$-5,496m
Government Debt	US$7,989m
Nominal Minimum Wage	US$2.15/day

The political stability and economic liberalisation have promoted macroeconomic growth, resulting in one of the fastest poverty reduction rates in Africa. Yet, Ghana remains heavily dependent on international financial and technical assistance. A third of the population still lives in extreme poverty (per capita income: <US$1.25/day), while 54% are classed as poor (per capita income: <US$2/day) (Alkire & Santos, 2010b). Income inequality is high (gini index = 42.8) with the poorest 10% of the population earning only 2% of the total national income while the richest 10% gain 33% of total income (UNDP, 2009). Moreover, due to its dependence on primary commodities for export earnings, Ghana is vulnerable to fluctuations in world market prices and external shocks, raising doubts whether Ghana will reach the Millennium Development Goals in a number of key areas - and reach middle income status - by 2015.

Ghana's manufacturing sector remains weak and the domestic economy revolves around subsistence agriculture, accounting for 36% of GDP and employing 60% of the work force, mainly small landholders (ISSER, 2007). Poverty is largely a rural phenomena with more than 80% of poor people living outside urban centres. Poverty at the national level has decreased, but at the same time the disparity between rural and urban areas has increased. Poverty has been reduced most strongly in urban areas, especially the capital Accra, and remains widespread in rural areas and the largely farming households that comprise the majority of poor people in rural areas. Further, within the rural areas, the level of poverty has remained constant or increased in the savannah zone but decreased among cocoa farmers living in the forest zone, primarily due to increases in producer prices for cocoa (Coulombe & McKay, 2007).

2.3. Study site location

The study was conducted in one village called Wansampobreampa (Wansampo). The village lies inside the Sui Forest Reserve, which is situated in the Akontombra district (formerly Sefwi Wiawso district), Sefwi Wiawso Traditional Area, Western region, SW Ghana.

In an attempt to decentralise government structures and thereby to transfer power, functions, competence and resources to the district level, the Ghanaian government has created several new district administrative units since 1988 (Crawford, 2010). In February 2008, this led to the establishment of the Akontombra district in which Wansampo falls. While this may have important implications for Wansampo through the re-allocation of development funds, people in Wansampo maintained their long-established economic and cultural links with Sefwi Wiawso, capital of the Sefwi Wiawso district. For this reason I decided to base the study site description on the administrative situation prior to the establishment of the Akontombra district.

2.4. Physical characteristics

The Sefwi Wiawso district (2,397km^2) comprises an undulating landscape of forest reserves and off-reserve areas, *i.e.* areas outside forest reserves. Major rivers are found within the area, including the Tano and Yoyo. The Forest Management plan for the Sui River Forest Reserve (334km^2, hereafter Sui FR), which comprises the area surrounding Wansampo, can be described as follows: “This narrow strip of Forest Reserve consists of a range of hills running from north-east to south, and ranging from 500-1,500 feet above sea level the highest point being 1,825 feet. The range contains the sources of many small streams, and forms a watershed between the Sui to the West, and the Tano to the east. The Yoyo arises in the southern portion. In the centre of the range is a low-lying swamp“ (Asiamah, 1994).

The climate is tropical with average temperatures of 22-27^{0}C and a long-term average annual rainfall of 1,461 mm (for the period 1964-2001; Boni *et al.* 2004). The rainfall pattern is bimodal with the major rainy season from the end of March to early July, a brief drier season in July, followed by the minor rainy season in August to October. The main dry season occurs from November to March and is characterised by the dry harmattan winds. However, this seasonal rainfall pattern varies strongly on an inter-annual and inter-decadal timescale, due in part to variations in the movements and intensity of the Intertropical Convergence Zone, and variations in the timing and intensity of the West African Monsoon (McSweeney *et al.*, 2008).

2.5. Biological characteristics

Sefwi Wiawso lies within the northern part of the Upper Guinea forests, which has been recognised as a global biodiversity hotspot (Myers *et al.*, 2000). Forest species of global conservation importance include the white-breasted guineafowl *(Agelastes meleagrides)*, white-necked picathartes *(Picathartes gymnocephalus)*, Diana monkey *(Cercopithecus diana* *rolloway)*, chimpanzee *(Pan troglodytes)*, and the West African sitatunga *(Tragelaphus spekii)*.

The Upper Guinea forest stretches from Guinea and Sierra Leone eastwards to the Sanaga River in Cameroon, and includes the countries of Liberia, Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria. The Guinea Forest is divided into two distinct sub-regions (Upper and Lower Guinea Forests) separated by the Dahomey Gap, an area of savannah, dry forests and farmland, ranging from southeastern Ghana across to southern Benin.

West African forest types correlate well with annual rainfall pattern, as determined by the total amount of rainfall and length of the dry season (Parren & de Graaf, 1995). Rainfall in Ghana follows a gradient of decreasing annual rainfall from the south-west (wettest) to the north-east (driest). The forest types resulting from this rainfall gradient are shown in Figure 2.2. Sefwi Wiawso falls within the moist semi-deciduous forest zone.

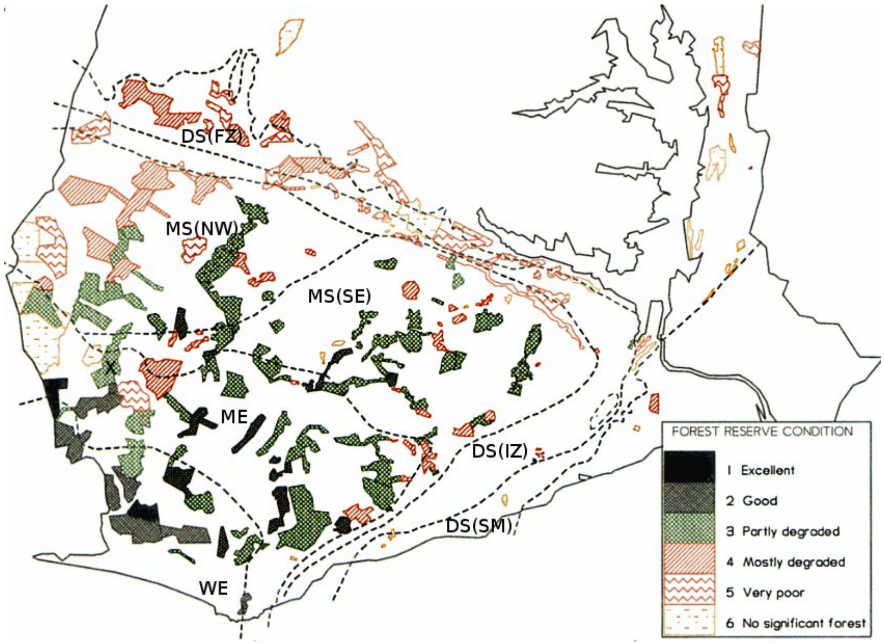

Figure 2.2.: Map of Ghana's forest zone, showing the status of the Forest Reserves, the distribution of forest types within the zone and the location of the study village inside the Sui Forest Reserve (X) (adapted from Hawthorne & Abu-Juam 1995). Abbreviations of forest types and annual rainfall for each zone, based on (Ministry of Environment and Science, 2002): WE = wet evergreen (1,700-2,030mm); ME = moist evergreen (1,500-1,700mm); MS = moist semi-deciduous (1,200-1,500mm) (NW = north-west subtype; SE = south-east subtype); DS = dry semi-deciduous (1,100-1,200mm) (FZ = fire zone subtype; IZ = inner zone subtype; SM = southern marginal). For detailed descriptions of the forest types see Parren & de Graaf (1995).

2.6. Deforestation and wildlife decline

Wildlife populations across Ghana have declined to the point where the Ghanaian government acknowledges that "there are few areas outside conservation areas where viable populations of larger mammal are now found" (Ministry of Environment and Science, 2002). While this may imply a better situation inside protected areas, there is strong evidence from extensive surveys showing that the same situation prevails in protected areas where medium- to large-bodied primates (Struhsaker & Oates, 1995; Whitesides & Oates, 1995; Abedi-Lartey, 1998; Oates *et al.*, 2000; White & Berry, 2000; Magnuson, 2002; Gatti, 2009) and other mammalian taxa have become very rare or locally extinct (Forestry Commission Ghana, 2002; Holbech, 2005; Burton *et al.*, 2011). An example of the precarious state of wildlife in

Ghana is the likely extinction of Miss Waldron's Red Colobus (*Procolobus badius waldroni*) in Ghana, constituting the first extinction of a primate species in more than a century (Oates *et al.* 2000, but see McGraw 2005). The high level of wildlife decline in Ghana is the result of decades of habitat conversion and high hunting pressure that have exploited wildlife populations to the point where only the most resilient species remain in a fragmented and highly disturbed farm-forest landscape (Cowlishaw *et al.*, 2005b).

2.6.1. Historical perspective on resource depletion

Ghana has a long history of land use in the forest zone, dating back to 500BC when migrants from the north entered the forest zone marking the beginning of agricultural development in the area (Agbodeka, 1992). Early on trade in gold and salt developed between the auriferous areas in the "Akan forest" and coastal towns, followed by international trade between the south of Ghana and the great towns of the Niger Bend, which formed the termini of the trans-Saharan caravan routes in the 13th and 14th century. The trade intensified with the start of the colonial period in the 15th century when the Portuguese occupied the coastal areas and established markets and trading centres, primarily for the slave trade (Buah, 2007).

During the early seventeenth century the forest areas already had a relatively high human population that practised small-scale farming and hunting. This is likely to have already resulted in substantial deforestation with a low point in forest cover around this time. The following wars among rivalling tribes over access to coastal markets and control over the slave trade probably resulted in decreasing human population densities, allowing some regeneration of secondary forests (Fairhead & Leach, 1998). Signs of early forest use and deforestation in the forest zone's interior were observed during the first forest survey conducted by H. N. Thompson in 1907, who noted: "I was rather disappointed in these forests as we were led to understand by the guides that they were extensive and practically virgin in character. This we found to be very far from the case, and the whole tract of the country showed unmistakeable signs of villages, having been once pretty well inhabited. Large tracts of forests were found to be of secondary origin, and signs of villages having once existed here" (Thompson 1910, cited in Leach & Fairhead 2000)

Early timber exploitation focused on high value species, principally mahogany, giving the forests the name "mahogany forests" (Collins, 1961). In the early 19th century logging was reported in coastal areas and sites near rivers but remained largely unmechanised and - if not in conjunction with farming - had a relatively low impact on the environment until the 1950s. However, where logging opened the forest and farmers followed, large-scale deforestation ensued. Alfred Moloney who observed the development of this process as early as 1887, was the first to argue for the need for forest conservation measures in British territories in West Africa (Moloney, 1887). In response to unsustainable forest use, the first regulation was laid down in the Concession Ordinance of 1900. This was followed by the Timber Protection Ordinance of 1907 and the Forest Ordinance Act of 1927 (Parren & de Graaf, 1995). The former prohibited the felling of immature trees of certain tree species, while the latter gave the newly established Forestry department the right to reserve forested areas, which would be managed by the state (a) to safeguard water supply; (b) to assist forest and agricultural crops grown in the vicinity; and (c) to secure the future supply of forest products to the inhabitants of the villages situated on adjacent land (Hawthorne & Abu-Juam, 1995). As a consequence of the Act, about 20% of the forested land was converted into forest reserves until the 1950s.

The development of the logging industry in Ghana is best exemplified by timber exports, starting in the late 19th century with 2000m^3/year and increasing to 19,000m^3 in 1938. The strong demand for West African hardwoods during the Second World War, in conjunction with the support provided to logging companies from the colonial administration increased exports to 76,400m^3. During the following reconstruction period in the 1950s, exports rose to 236,000m^3/year. During the early logging period, timber companies focused on off-reserve areas and felled only large trees in on-reserve areas. However, with the onset of industrial logging in the 1950s and the rapid depletion of trees in off-reserve areas, timber companies increasingly turned to logging forest reserves (Dickson, 1969). The second peak of commercial timber exploitation was reached during the 1970s when legal restrictions on log exports were dropped: log exports reached 198,000m^3 in 1979 before dropping to 54,000m^3 in 1981 (Asamoah *et al.*, 2006).

Cocoa farming accelerated both forest conversion into farm land and the depletion of forest wildlife through bushmeat hunting. Cocoa farmers migrating to remote forests had little access to alternative sources of meat and relied heavily on bushmeat, resulting in unsustainable hunting levels. The first warnings about declining primate populations and the possible extinction of Miss Waldron's red colobus came in the 1950s, stating that the species' extinction "in the near future must be regarded as a probability, unless effective legislation to protect both the animal and its environment is forthcoming" (Booth, 1956). This was followed by wider concerns about dramatic declines in wildlife populations from the 1960s onwards (Asibey, 1966; Jeffrey, 1970)

Early attempts at cocoa cultivation by the Basel missionaries at Akropong in Akwapin were recorded in 1858 (Franc, 2008) and the first beans were exported to Europe in 1893. Cocoa was quickly adopted as the principal cash crop in the forest zone, since its production expenses compared favourably with those of oil palm farming, the main cash crop until it was replaced by cocoa in 1906. Migrating cocoa farmers spread quickly in the south of Ghana, across Ashanti-Brong-Ahafo (before spreading in the west of Ghana) by purchasing large tracts of land and operating in groups called "companies" (Hill, 1956). As early as 1911 the Gold Coast superseded Brazil as the largest exporter of cocoa. However, it was not until the expansion of logging activities and road developments during the 1950s when large tracts of previously inaccessible forests were opened to migrant cocoa farmers, that large-scale deforestation resulted (Boni, 2005). Similar patterns of forest conversion have been observed in neighbouring Côte d'Ivoire. Ruf & Schroth (2004) noted that although deforestation due to selective logging is relatively low, the road infrastructure left by the timber concessionaires facilitated, the influx of agricultural migrants, and that this resulted in agricultural expansion, particularly of cocoa, causing rapid deforestation.

With the depletion of virgin forest land in Ghana, it became difficult for farmers to acquire farm land, leading to the shortening of fallow periods to as little as two years during the 1970s (Benneh, 1973). In Sefwi Wiawso, one of the last cocoa frontiers in Ghana, all the land available for farming outside forest reserves had been converted by the 1970s (Boni, 2005).

Ghana's total forest cover at the beginning of the 20th century has been estimated as 8.2m hectares (about 43% of the total land area), of which only 1.6m hectares remained in 2000 (Bank of Ghana, 2004). Most of the remaining forest is located inside forest reserves. These are used for commercial timber exploitation and have been heavily degraded with only 16% of such forest cover now being in good condition (Hawthorne & Abu-Juam 1995, see also Figure 2.2). The current timber harvest is about 3.7 million m^3 per year of which more than 50% is harvested by illegal chainsaw operators. In contrast, the annual allowable cut is only 1 million m^3. The current harvest results in a deforestation rate of 65,000ha per year.

2.6.2. Wildlife management in Ghana

Traditionally wildlife was managed at the community level using a system of protected areas and species. Hunters required the permission of the chief before hunting and had to give part of the animal to the chief. Tribes commonly associated a species with their ancestral heritage and prohibited the killing of such totems (CI, 2005). There are an estimated 1900 sacred sites throughout Ghana that often hold mature forest within a heavily modified human landscape. Indeed, the Boabeng-Fiema Monkey Sanctuary, where ancient beliefs associated with the local monkeys have conserved the species and its habitat, has become a well-known tourist attraction (Wild & McLeod, 2008).

The current governmental approach to wildlife management was enacted with the Wild Animals Preservation Act of 1961. It provides the legal basis for the conservation and protection of wildlife in Ghana and designated the Wildlife Division of the Forestry Commission as the agency responsible for implementing the Act (Government of Ghana, 2002). Since its establishment, the Wildlife Division has suffered from a lack of funding and largely relied on foreign donors for budget support and the training of staff (Asibey, 1972). Continuous wildlife declines over decades suggests that the Wildlife Division has not been able to control the exploitation of wildlife populations. The wildlife laws have never been strongly enforced nor have they been a serious deterrent to hunters (Asibey, 1972; Gatti, 2009), and the current situation has been described as “the state, by assuming authority for these resources without the capacity to exercise its responsibilities, has created at best an open-access system” (World Bank, 2006). Similarly, official Ghanaian documents rate the state of the supportive environment for “integrating the principles of sustainable development into country policies and programmes and reversing the loss of environmental resources” as “weak but improving” (National Development Planning Commission, 2005)

Ghana’s wildlife legislation stipulates that wildlife should be managed through four principal components (Government of Ghana, 2002):

1. Protected areas in the form of national parks and wildlife production reserves are designated throughout the country. Five areas (three of which comprise a twinned park and forest reserve complex) exist for wildlife protection in the forest zone: Nini-Suhien National Park with Ankasa Resource Reserve, Bia National Park with Bia Resource Reserve, Kakum National Park with Assin Attandanso Resource Reserve, Bomfobiri Wildlife Sanctuary, and Owabi Wildlife Sanctuary. Activities damaging to wildlife are prohibited in these areas. However, all have been strongly affected by illegal hunting and logging, except Ankasa Resource Reserve and Nini-Suhien National Park which have not been logged.

2. A system of species protection categorises species according to their level of vulnerability and either protects these species throughout the year (*e.g.* most large-bodied animals but also more common species such as nile monitor and tree pangolin), or during the annual closed season from 1st of August to 1st of December. Two groups of species are distinguished in the latter: the first group comprises most medium-sized mammals, which are protected during the annual closed season or at any time of the year if it is a young animal or an animal accompanied by young; while the second group, including small-bodied animals such as giant pouched rat and squirrels, is only protected during the closed season.

3. A licensing system requires hunters and bushmeat traders to purchase a license from the district wildlife officer.

4. Certain hunting techniques, such as the use of fire or gin traps are outlawed at any time.

At the local level the relevant guidelines for forest resource management are set out in the Forest Reserve Management plans published by the Forestry Commission. The management plan for the Sui FR states that ”communal rights also exist and are exercised over the Reserves by Sefwi and Wassaw people. The include the right to hunt, fish, and to collect snails and deadwood. The Communal right to hunt is however, restricted by Section XI of the Wild Animals Preservation Act, 1961“. Elsewhere in the management plans it states that the ”yield of NTFPs will be regulated by the district forest office in consultation with the regional forst office“ and that NTFPs must be harvested on a sustainable basis (Forestry Division, 1960).

2.7. The Ghanaian cocoa farmer

Cocoa is Ghana's second most important export commodity after gold. In 2005/2006, it provided employment for about 250,000 households, thereby contributing to the livelihoods of 1.9m people (6.3% of the total population) (Coulombe & Wodon, 2007).

Cocoa farming in Ghana is primarily a smallholder production system. The majority of cocoa farms (75%) are less than 2 hectares in size and most households cultivate between two and three cocoa farms. The most important tool is the cutlass, while mechanical inputs and irrigation systems are virtually absent. Few households apply pesticides (37%) and even fewer use fertiliser (21%). As a consequence productivity is low (Hainmueller *et al.*, 2011). Most farm labour is provided by household members but day labourers may be employed for weeding farms. The exchange of labour among households is common during the harvest season.

The majority (>70%) of households own the farms they cultivate. However, share-cropping and contract farming is common, particularly among migrants who lack access to family land (Boni, 2005). Farm land is rarely sold to the extent that there is basically no functioning market for farm land in the cocoa growing area (see also Arhin 1988). Land titles are passed on through matrilineal succession but it is also possible - and indeed relative common nowadays - for a man to allot property to his wife and children (Boni, 2005). Land ownership remains within the matriline and land reverts to the matriline if it is no longer used.

Migrants coming to the forest zone or indigenous farmers wanting to get more farms can obtain access to land through contract farming of which two forms are common. Firstly, a farmer can engage in an abunu (division into two) contract, whereby a farmer is given land to plant and cultivate cocoa trees until they reach maturity (after about five years) at which time the farm will be divided into two equal parts and the farmer obtains the title to half the land that he cultivated. The second form is abusa (division into three) sharecropping. In this contract a farmer cultivates a farm and receives one third of the harvested cocoa each year. Under the abusa agreement, the sharecropper does not get legal rights to the land and the contract can be cancelled by the land owner at any time (Takane, 2002).

Despite the widespread absence of mechanical and chemical input, cocoa farming in Ghana and especially the Western Region is intensive and occurs in the form of plantations. Most cocoa farms are established on forest land, after the forest has been cleared. This process is initially time consuming, but it has economic advantages over using already converted farm land. These advantages, interpreted as 'forest rent', primarily relate to lower production costs due to lower maintenance effort, higher soil fertility and reduced risk of crop pests. Utilising the 'forest rent' has been estimated to halve the investment cost compared to replanting after fallow (Ruf & Schroth, 2004). The second stage in the cocoa production cycle involves the planting of cocoa seedlings and food crops. For the following three to five years, the farm work involves intensive weeding to protect the cocoa seedlings from being overshadowed. The final stage initiates once the cocoa trees have reached maturity and start bearing fruits. The cocoa trees have formed a closed canopy and light levels at the ground are substantially reduced. While this results in drastically reduced food crop production (only a few food crops, such as cocoyam (*Colocasia esculenta*) and white yam (*Dioscorea alata*) may be grown in low density under the cocoa trees) it also reduces the regeneration of weeds and labour requirements for weeding. The main labour input on mature farms is the pruning of trees, spraying of pesticides and harvesting of cocoa pods. These activities are concentrated within a period of about six months each year, allowing the farmer to focus household labour on establishing the next cocoa farm.

Most mature cocoa farms are monocultures that do not revert to fallow for decades due to the longevity of the trees. Moreover, maintaining cocoa trees on the land provides secure land tenure. Once a farmer has planted cocoa trees and has obtained rights to the land, the farmer owns the cocoa trees and the land cannot easily be taken away from him. Hence, in addition to the longevity of the cocoa trees, which reduces the potential for farm fallows, there is a tenurial disincentive for farmers to let the farm revert to fallow.

The sale of cocoa beans is the main source of cash income among cocoa farming households. Hainmueller *et al.* (2011) estimated a mean daily cash income from cocoa sales of US$0.41/capita and only US$0.05/capita from other farm crops, suggesting that cocoa comprises 90% of crop income. Similarly, Barrientos & Asenso-Okyere (2008) estimated a mean daily income from cocoa of US$0.42/capita, comprising 66% of total cash income (US$0.63/capita/day). However, neither of these two recent estimates of income suggest that cocoa can lift households out of poverty. This contrasts with recent evidence from the Ghana Living Standards Survey (GLSS), which recorded a substantial reduction in poverty levels among Ghanaian cocoa farmers between 1992 (60%) and 2006 (24%) (Coulombe & Wodon, 2007).

While the evidence about the effect of cocoa farming on poverty reduction is ambiguous, farmers themselves may not consider cocoa farming a desirable livelihood. Less than a quarter of farmers reported that their children are planning to continue in cocoa farming and only 40% of farmers want their children to continue in cocoa farming. The most common reasons stated are that ”the work is too hard” and “there are better opportunities in other fields“ (Hainmueller *et al.*, 2011).

2.8. Sefwi Wiawso

The kingdom of Sefwi Wiawso in the north of the Western Region comprises five districts, Sefwi Wiawso, Sefwi Akontombra, Juaboso, Bia and Bibiani/Anhwiaso/Bekwai. Sefwi Wiawso is the seat of the paramouncy (traditional authority) and the seat of the district administration. The majority of services available in the district, such as hospitals and banks, are concentrated in Sefwi Wiawso (Figure 2.3). The main district markets takes place weekly in the adjacent town of Sefwi Dwenasi. The five districts share Sefwi as a common language that is closer to Anyi-Baulé than to the common Twi dialect. Sefwis belong to the Akan cultural group and form a matrilineal society with political offices being transmitted through matrilineal lines.

The Sefwi Wiawso district had a population of about 150,000 people in 2000 equivalent to a population density of 95.5 person/km^2. Mostly people are Akan (73.4%), followed by Mole/Dagbon (11.3%), Ga/Dagme (5.3%), Ewe (4.6%), Guan (1.5%). The district population is largely rural (76.6%) and few households have access to electricity and piped water (Table 2.2). The district has several hospitals, however, most are located in Sefwi Wiawso and small health posts serve the rural communities. Key indicators show that overall Sefwi Wiawso is comparable to other districts in the Western Region, however, it is likely to be at the poorer end of the range.

The Sefwi Wiawso district covers 2,397km^2 of which 733km^2 (30.6%) are forest reserves managed for timber production. The majority of the remaining landscape is farmland, estimated as 862km^2 covered by cocoa farms and 300km^2 covered by food crop farms (Boni *et al.*, 2004). Hence, the two main economic activities in the district are agriculture and forestry. About 75% of the population are employed in the agriculture sector, growing cocoa and food crops, with the economically most important food crops being plantain, cocoyam, cassava, maize, yam and rice.

2.8.1. Wansampo

This study was carried out in the village of Wansampobreampa (hereafter Wansampo) (6.06N, -2.73W, see Figure 2.3) in the Akontombra district (formerly Sefwi Wiawso district), Western Region, SW Ghana. The community is situated inside the Sui River Forest Reserve and ownership of the land on which the community is situated is vested in the Aboduam stool, which is under the Sefwi Wiawso paramount stool. A total of 58 farming areas existed when

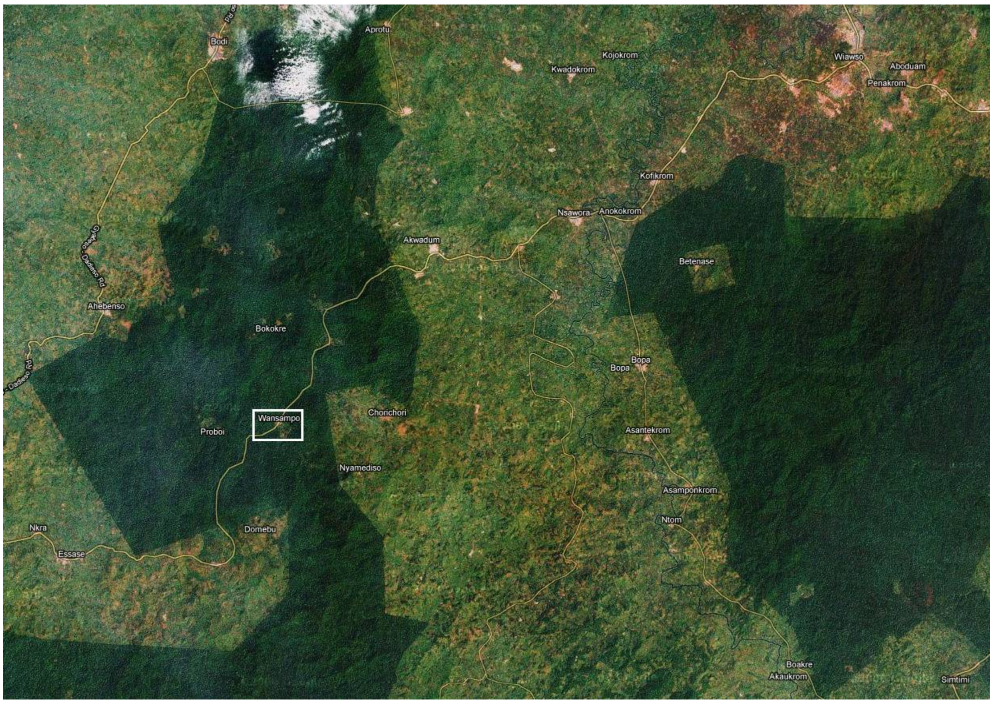

Figure 2.3.: The wider study area with the Sui Forest Reserve on left (Wansampo is highlighted), Suhuma Forest Reserve on the right and the district capital Sefwi Wiawso (Wiawso) in the top right corner. The landscape comprises continuous forests (dark green), farmland (bright green), settlements (brown) and roads (yellow). Source: Google Maps.

the Sui FR was gazetted. Wansampo has developed out of one of these farms and villagers have therefore the usufruct right to farm land adjacent to the community (Forestry Division, 1960). The size of the admitted farm is 2.5 hectares and the owner is stated as Kofi Yamoah (Asiamah, 1994).

Wansampo is bisected by a laterite road that connects two district capitals (Sefwi Wiawso and Akontombra) and is accessible all year. Frequent traffic of passenger cars facilitates transportation to district markets. The road developed out of a feeder road that was built by a timber company during the 1960s. The village has a governmental primary school (six years) with kindergarten attached (two years) that employs two trained teachers and four teaching assistants. There are three church buildings (Roman Catholic, Presbyterian and Musama Disco Christo Church), two drinking bars and three shops, as well as several people regularly trading by setting-up tables in front of their houses. Public buildings include two toilets and

Table 2.2.: Key summary statistics for the Sefwi Wiawso district and the Western Region, based on the 2000 population census (Source: Ghana Statistical Service, 2005a).

Indicator	Sefwi Wiawso	Western Region
Human population	148,950	1,924,577
Population density (pers./km^2)	95.5	80.5
Urbanisation (% of pop.)	23.4%	36.3%
Employment in agriculture[a]	73.8%	58.1%
Economically active[b]	55.7%	57.6%
Fertility rate (children/woman)	4.8	4.4
Population growth	n/a	3.2%
Literacy[b]	52.0%	58.2
Secondary education[c]	50.3%	50.0%
Electricity[d]	27.9%	43.1%
Piped water[e]	7.9%	23.9%

[a] Percentage of economically active population stating agriculture as their main job
[b] Percentage of people 15 years or older
[c] Percentage of population aged six years or older that completed Junior or Senior Secondary School, respective values for Sefwi Wiawso were 43.4% and 6.9%
[d] Percentage of households connected to the national electricity grid
[e] Percentage of dwellings with access to piped water inside or outside piped water or tanker supply. The remaining access water from wells and natural sources

a recently built bus stop. During district and national elections, the village acts as a polling station for neighbouring communities. The nearest settlement with electricity is about 20km away outside the Forest Reserve. The village is not covered by mobile phone networks. The nearest health post is located in Nsawora along the Sefwi Wiawso road about 20km away.

Four boreholes had been built with financial support from the Sefwi Wiawso district assembly, WaterAid (an NGO) and the Roman Catholic church in 2006. However, three boreholes stopped working within the first year. In 2008, villagers relied on the remaining borehole but frequently fetched water from a nearby stream when the water level in the borehole was low.

2.8.1.1. Sui Forest Reserve

The Sui FR was constituted under Sefwi Wiawso state bye-laws No.8 of 1929, which was subsequently replaced by the Sefwi Confederacy Native Authority Rules of 1951 (Asiamah, 1994). Adjacent to the Sui FR are the Santomang FR and Tano Ehuro FR, which together constitute Forest Management Unit 5 and are described in a joint forestry management plan (Asiamah, 1994). The total area of the Sui FR is 33,390ha, of which 32,538ha are used for timber production.

The Sui FR had been selectively logged by several timber companies for decades (Table 2.3). Some parts of the forest have been logged up to four times, resulting in an extensive networks of feeder roads criss-crossing the forest and substantial damage to the forest structure. Botanical surveys in the 1990s classed the the forest as partly degraded forest (*i.e.* showing obvious disturbance or degradation and usually patchy but good forest predominant; a maximum of 25% of the forest area exhibits serious scars and poor regeneration; while a maximum of 50% of the area is slightly disturbed with broken canopy) (Hawthorne & Abu-Juam, 1995).

Table 2.3.: Timber companies being granted logging concessions in the Sui Forest Reserve.

Company	Year granted	Size (ha)
Western Veneer and Lumber Company Ltd.	1945	124
Bibiani Logging and Lumber Company Ltd.	1957	11,150
Tropical Wood Supply	1967	2,468
Glicksten West Africa Ltd.	1982	19,637
Ghana Primewood Products Ltd.	1997	9,500
Suhuma Timber Co. Ltd.	1998	10,500

2.8.1.2. Farming

In the Wansampo community, a single household may own several ”farms“. A Wansampo farm is comparable to a field in which a single or multiple crops might be grown. Such farms might be adjacent to the community or within walking distance outside the forest reserve, or in a small number of cases even further afield. The farm surveys carried out over the course of this study (see Section 3.5.5) revealed that the mean number of farms owned/utilised per household was 5.0 (SD=2.6). Initial attempts to obtain estimates of farm size for each household were unsuccessful, because many interviewees were either reticent or uncertain about their farms' size. Further, confusion about farms owned and/or used by households could not be solved until late into the data collection by which time it was not practical to pursue this. A total of 94% of farms were within walking distance of the community. The remaining 6% of farms were commonly located near the owner's hometown within the Sefwi Wiawso district, or less frequently in more distant parts of the country (*e.g.* Brong Ahafo and Northern Region), and were managed by relatives who lived more locally.

About half of those farms within walking distance of the community (55%) were inside the forest reserve, while the other half were just outside its boundaries (Table 2.4). The latter were concentrated in two areas east and south of Wansampo and were within 1-2 hours walking distance (Figure 2.4). Farms inside the forest reserve were within 0.5-1 hour walking distance. A total of 18% of farms occurred within the clearing immediately surrounding the community, while a further 22% of farms were located in areas of Taungya, *i.e.* governmental agroforestry system. These could be further split into old Taungya (abandoned by government and converted into pure food crop farms) and new Taungya (active agroforestry system). Farmers did not have secure land tenure to farm land in the two Tunagya areas and were not allowed to plant perennial crops, such as cassava or cocoa. Neither of the two areas had substantial tree coverage inside the farm, but small trees (< 4 years) existed in the new Taungya and more were planted during the study period (for a summary of the Ghanaian Taungya system, see Agyeman *et al.* 2003).

The farmland around Wansampo was intensively cultivated, predominantly for cocoa production. Cocoa was planted on 59% of farms and it was the dominant crop on 45% of farms (Table 2.5). Of the farms with cocoa as the dominant crop, 44% had only mature

Table 2.4.: The location and number of farms within walking distance of Wansampo that were owned and/or used by 63 households participating in the survey. Households also owned 20 farms that were not within walking distance and consequently very rarely visited.

Area	Inside FR	No. farms
Wansampo	yes	128
Farm		*52*
New Taungya		*40*
Old Taungya		*23*
Garden		*11*
Forest		*2*
Fiepriso/Kwakuseikrom	yes	21
Asiamakrom	yes	3
Proboi	yes	10
Nyamediso	no	107
Domebo	no	24

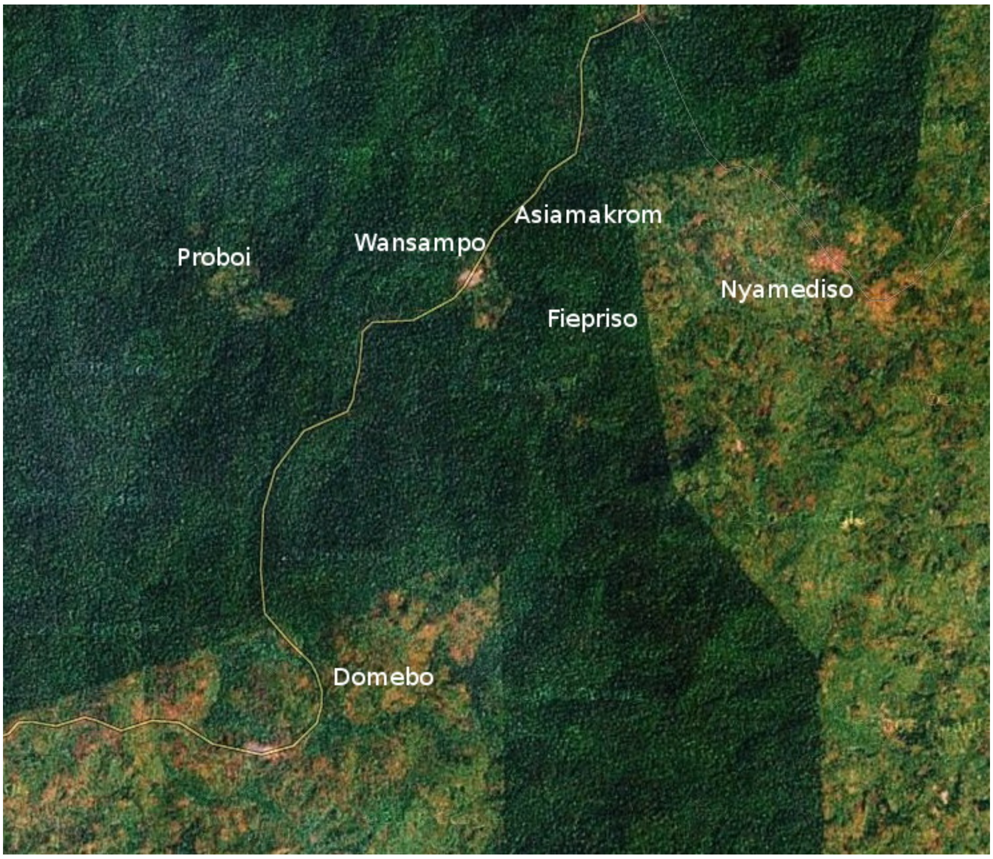

Figure 2.4.: Main areas where farms used by surveyed households were located. The landscape comprises continuous forests (dark green), farmland (bright green), settlements (brown) and roads (yellow). Source: Google Maps.

cocoa trees (>5 years), 29% had a combination of mature and young trees, and 27% had only young cocoa trees. The vast majority of cocoa farms (81%) were monocultures, with no food crops or very few crops planted under the cocoa trees. The remaining cocoa farms that still had a large amount of food crops were in the process of turning into monocultures.

Food crop farms were the second most common type of farm (36%) and comprised a variety of crop types. Cocoa was not planted on these farms. Farmers rarely used their own farmland for planting food crops, instead 55% of the food crop farms where located inside the Taungya areas. The Ghanaian government is advocating this system to regenerate degraded FRs and to provide communities with extra land for the cultivation of food crops, thereby reducing the pressure on existing forests (Agyeman *et al.*, 2003).

Traditional fallow rotation to regenerate soil productivity does not exist, since farmers aim to put all their land to productive use. However, 5% of farms were covered by forest or secondary regeneration. This was primarily due to labour being bound up in work on other farms. All households owning farmland covered by secondary vegetation stated that they would convert the land as soon as the labour was available. Of the productive farms 19% had some areas of secondary vegetation but this was primarily non-woody vegetation (*i.e.* weeds). Only 4% of farms had any forest remaining.

Table 2.5.: The crop composition of farms owned or used by surveyed households. Data was available for 272 farms within walking distance of Wansampo.

Farm type	Dominant crop	% of farms	% with weeds	% with forest
Cocoa	Cocoa	44.5	28.1	1.7
	Cocoa/food crop	14.7	22.5	2.5
Food crop	Food crops (mixed)	30.5	4.8	3.6
	Plantain	0.7	50.0	0.0
	Rice	1.1	0.0	0.0
	Oil palm	3.7	10.0	0.0
Non-productive	Nonwoody plants	4.4	100.0	0.0
	Forest	0.4	0.0	100.0

2.8.1.3. Demography

According to the household surveys conducted over the course of the study (Section 3.4.1), the community comprised a total of about 70 households and 400 community members. The composition of the community (in terms of the number of households and people living in Wansampo) varied over time; the following data are accurate for the 63 households participating in the study in June 2009 (the end of the study period).

The surveyed households comprised a total of 327 household members (Table 2.6). However, the population showed substantial temporal variation as household members frequently travelled to and from neighbouring settlements and nearby urban centres. Thus, only 281 people (86%) were present during the two days of the census (for details, see Section 3.4.1). Summing up the mean number of household members recorded consuming dinner in the community resulted in a total of 264 community members.

Male and female household members comprised 50% of the total population each (female=163; male=164). About a third of the population was under the age of eleven (38%) and about two thirds were under the age of 21 (61%). The age of the household head averaged 46.6 years±15.2 SD (Min=21, Max=84).

Table 2.6.: Number of male and female household members per age class in the surveyed households, based on census at end of data collection (reference year is 2009).

Age (years)	Female	Male	Sum (%)
0-5	30	40	70 (21.4%)
6-10	28	26	54 (16.5%)
11-20	33	41	74 (22.6%)
21-30	21	15	36 (11.0%)
31-40	21	19	40 (12.2%)
41-50	11	9	20 (6.1%)
51-60	7	7	14 (4.3%)
61-70	7	5	12 (3.7%)
>70	5	2	7 (2.1%)
Total	163	164	327 (100%)

At the household level, 19 (30%) were headed by a woman (*i.e.* a female-headed household, hereafter FHH) and 44 (70%) were headed by a man (*i.e.* a male-headed household, hereafter MHH). On average, households had 5.2 household members. This figure is very similar to the district average of 5.1 people per household (Ghana Statistical Service, 2005a). MHHs had a slightly higher number of household members (5.6) than FHHs (4.2) (Table 2.7). Female-headed households included male household members and six FHHs included active male household members. However, on average, FHHs included fewer active male household members than MHHs.

Table 2.7.: Demographic composition of studied households. The data are based on a census in June 2009 and do not reflect temporal fluctuations in household size.

Type	All HHs	MHH	FHH
	Mean±SD (Range)	Mean±SD (Range)	Mean±SD (Range)
All	5.2±2.5 (1-12)	5.6±2.6 (1-12)	4.2±1.8 (1-7)
Male	2.6±1.8 (0-7)	3.1±1.8 (1-7)	1.5±1.1 (0-3)
Female	2.6±1.4 (0-6)	2.5±1.5 (0-6)	2.7±1.2 (1-6)
Male active[1]	1.2±1.0 (0-5)	1.5±1.0 (1-5)	0.4±0.6 (0-2)
Male non-active	1.4±1.3 (0-5)	1.5±1.4 (0-5)	1.1±0.9 (0-3)
Female active	1.4±0.8 (0-4)	1.3±0.8 (0-4)	1.7±0.9 (0-4)
Female non-active	1.2±1.0 (0-4)	1.2±1.1 (0-4)	1.1±0.6 (0-2)

[a] Active household members ≥16 years (reference year is 2009, see Table 3.9 for more details)

Wansampo is a Sefwi community with the majority of household heads being Sefwi (83%) an ethnicity that is part of the matrilineal Akan, followed by Ashanti (6%), Akuapim (5%) and Ewe, Krobo, Kusaasi and Nzema each comprising 1.6%. About half the household heads were born in Wansampo (53%). In contrast to other cocoa farming communities, Wansampo had experienced little labour immigration of other ethnicities (Arhin, 1988), probably reflecting the limited availability of farm land adjacent to the village, resulting in migrants settling outside the forest reserve.

Chapter 3

General Methodology

3.1. Chapter overview

This chapter outlines the methods employed to collect the data presented in this thesis. Those methods that are common to more than one chapter are discussed here, whereas those that are specific to a given analysis are detailed in the appropriate chapter. This chapter starts by giving a brief overview of the field work (Section 3.2), followed by a justification for the choice of study community (Section 3.3), and an introduction to the use of households as the main sampling unit (Section 3.4). Subsequently, I describe the quantitative methods common to all chapters (Section 3.5), outline the main explanatory variables assessed (Section 3.6), and finally, provide a description of the statistical approach adopted (Section 3.7).

3.2. Field work overview

The field period for this Ph.D. lasted 22 months, of which 16 months were spent in the study community. Of the remaining six months, two were engaged in intensive language training and four were used for further preparations for the study (Table 3.1). Chronologically, the 22-month field period was split into two parts. The first part comprised a seven-month pilot study during which I made local contacts, recruited local assistants, received initial language training, piloted questionnaires in the forest community of Betenase for one month, selected a study site for the main data collection and initiated preliminary surveys in the study community.

The second part of my field period started with the two months of intensive language training in the Ghanaian city of Takoradi, followed by the consolidation of my relationships in the study community, finalising the main household questionnaire design and conducting the main data collection. During this second period, I spent all my time in the study village, except for brief visits to the town of Sefwi Wiawso for administrative work and to purchase supplies, and for two longer periods of absence - to participate in a statistics course (February 2009) and due to sick leave requiring medical evacuation from Ghana (March - April 2009).

Table 3.1.: Timetable of main events during Ph.D. Allowing for an authorised six-month dedicated period of language training, and a two-month period of illness, the Ph.D. was completed within the specified four-year time frame.

Period	Description
Oct. 2006 - March 2007	UK - literature review and development of field methods
April 2007 - Oct. 2007	Ghana - pilot study
Nov. 2007 - Jan. 2008	UK - upgrade and reappraisal of methods
Feb. 2008 - Mar. 2008	Ghana - language training
April 2008 - July 2009	Ghana - data collection
Aug. 2009 - May 2011	UK - data analysis and write-up

During the data collection, I was assisted by British and American volunteers. The British volunteer, Charlotte Whitham, who assisted me for ten weeks during the main socio-economic household survey period (May - July 2009), was an Imperial College Masters student who was also collecting data for her Masters thesis. The American volunteer, Laura Kurpiers, assisted me during a six months period (July - December 2008) until she became ill and had to be evacuated. In both cases, the volunteers were trained in social research methods and throughout their work supervised by me. They independently carried out household surveys, allowing me to increase number of interviews conducted and gain a more in-depth insight into the role of opportunistic hunting patterns (see Whitham 2009).

3.3. Selection of study community

The decision to conduct my research in Ghana was primarily driven by my focus on bushmeat hunting in a farm-forest mosaic landscape with depleted wildlife populations. The choice of Sefwi Wiawso district in particular followed my earlier involvement with a local conservation project of the Zoological Society of London (ZSL). Initially, there were also plans for my Ph.D. to collaborate with this project. The study village was chosen after extensive surveys of communities throughout the Sefwi Wiawso district during which the location, the approximate number of houses and the presence of schools and health centres (indications of settlement size) were recorded. Once a number of potential study sites had been identified, the following selection criteria were applied:

- a relatively small community of fewer than 100 households, to enable repeated sampling of a large proportion of all households
- accessible by road and good market integration, both to increase the chance of households having diversified livelihoods and for health-and-safety reasons
- villagers who have a positive attitude towards the research team and were happy to allow research to take place in their community
- no previous NGO presence to reduce the risk of early interviewee fatigue
- outside the reach of the ZSL conservation project activities to avoid interference with NTFP surveys
- a relatively homogeneous Sefwi community, to facilitate the analysis of land tenure systems (an objective later dropped)
- close proximity to a Forest Reserve to allow assessing the functioning and importance of Social Responsibility Payments in forest communities (objective later dropped)

Finally, the village of Wansampo was chosen because it fulfilled all the criteria. Confirmation of the criteria was sought during an initial visit to Wansampo and a community meeting during which the purpose of the study was explained and community members asked for permission to live and work in their community.

The principal reason for focusing the research on one community, rather than two or more, was to facilitate the development of a detailed understanding of local livelihoods, good relations with the interviewees and ultimately high data quality. This proved an important decision, as conflicts between “illegal” resource users in the village and government agencies/timber companies could have endangered the success of the data collection if the community had not trusted in my impartiality (for discussion of this subject, see Gavin *et al.* 2010).

The obvious drawback of this sampling design is the lack of wider representativeness. Access to markets and forests, size of the community, ethnic composition etc. are all important determinants of livelihood opportunities and decision-making (*e.g.* Ellis 2000; Barrett *et al.* 2001), and one single community cannot be representative of a range of diverse communities within an area. For this reason I interpret the wider applicability of my results cautiously, although it is hoped that many findings reported here will have relevance to comparable wildlife harvesting systems in agricultural communities elsewhere in the tropics.

3.3.1. Local assistants and relations

Two local field assistants were recruited upon my arrival in the community. They belonged to the two main matrilines present in the village. Both had been born in the village and lived there most of their lives, giving them a detailed knowledge of local livelihoods. This knowledge and their family relations enabled them to act as invaluable gatekeepers and informants throughout my time in the village (Hammersley & Atkinson, 2007). Both had received a basic education, were sufficiently literate and spoke good English. It could be argued that the assistants' family ties with community members had a negative influence on their work and biased the way in which they communicated information. While this is a valid concern and it is very hard to disproof, employing local assistants was found to be advantageous. First of all, two assistants from outside the village were introduced to the community at the very beginning of the field period and they found it difficult to facilitate access similar to as this was done by the local assistants. Secondly, employing local staff improved my status in the community, since people appreciated that family members were given the opportunity to earn money. Thirdly, information about certain households was commonly revealed by the assistant with the closer family ties. While acknowledging potential disadvantages, it was strongly felt that local assistants improved the quality of the research.

The assistants were trained from the beginning of my time in the community in interview methods. They received several days of training in interviewing theory and practice, (*e.g.* issues around leading questions), and basic socio-economics, before facilitating the first surveys during the pilot study. All interviews were discussed in detail with the local assistants. On the one hand, this was important to improve their understanding of the reasons for asking certain questions and to ensure that they were aware of their importance for the success of the research. On the other hand, it was a crucial part of the questionnaire development process. The assistants worked six days per week and received a monthly salary of US$100. This was equivalent to about twice the national minimum wage (see Table 2.1) and considered fair remuneration for work often seen as tedious.

While living and working in Wansampo, I rented a house in the community that served as accommodation and quiet retreat for me and my volunteers. Employing a community member to fetch water, purchase food crops and prepare food was also a convenient arrangement and crucial to free-up time for collecting data. While my presence for several months prior to the main data-collection period was important to build good relations and facilitate the interviews, conducting repeated interviews with the same households would still have been very difficult without informal rewards. The American Anthropological Association states, "while anthropologists may gain personally from their work, they must not exploit individuals, groups, animals, or cultural or biological materials. They should recognise their debt to the societies in which they work and their obligation to reciprocate with people studied in appropriate ways" (AAA, 1998). Early on, some interviewees raised the question about cash payments for participation in the survey, but for ethical and practical reasons (*e.g.* interviewees worrying that they may not get paid if they report no bushmeat harvest, and/or potentially influencing household consumption and expenditure patterns), I decided on non-monetary rewards. Consultation with women revealed that people were notoriously short of soap for washing clothes and it was decided that households received soap on a monthly basis. Every household received two bars of locally produced soap, purchased for about US$0.34 which was roughly the amount a labourer received for working one hour. In addition, households received photographs taken in the village, two parties and dinners for 300 people were organised, and finally a bus stop was constructed as a farewell present.

3.4. Survey period, households and sample size

It is difficult to define the exact period of data collection for this Ph.D. because many useful insights and data were gathered early on during my stay in the village. However, the main socio-economic household survey started on 12/07/2008 and finished on 26/06/2009, resulting in 11.5 months of data collection. During this time, 804 full socio-economic households surveys were conducted with 63 households. The average number of surveys per household was 12.8 (SD=2.3; Min=3; Max=17), *i.e.* each household was surveyed approximately once per month. The number of households surveyed was determined by the number of permanent households living in the village and whether they were willing to participate in the surveys: all households present and willing to participate were included. The primary reason for including all households in the survey was to capture the greatest possible socio-economic variation among households and have each group represented by the largest possible number of households.

A household can be defined as a group of people that live in the same place or under the same roof, share the same meals, and/or share decisions over the allocation of household assets (Ellis, 1993). Similarly, the Poverty Environment Network (PEN) of the Center for International Forestry Research (CIFOR) stresses the importance of resource pooling, *i.e.* labour and income, but notes that individual household members may nonetheless maintain separate economies (PEN, 2007), as is common between husband and wife in Ghana (Bukh, 1979). Households may include people who are not biological relatives of the family and further include (blood relatives or not) who do not live in the same house, such as permanent and seasonal urban migrants (Bigsten, 1996; Stoian, 2005), provided that they maintain strong links and engage in some form of economic dependence or support. Despite this apparent clarity of the household concept, difficulties exist with the allocation of people into different households, either because their degree of resource pooling is not easily observed and/or the same individual is ”claimed“ by different households.

3.4.1. Approaching the household

The composition of households was assessed repeatedly throughout the field period during each household survey (see below). Before the man socio-economic household survey began, however, households were identified using two different censuses. The first census of the whole village was conducted during the early stages of the pilot study (August 2007) to provide a first assessment of the number of households present in the village, the identity of the household heads, and a preliminary indication of household composition, demography, level of education and main sources of income. Based on these census data, every person recorded received a unique personal ID that remained unchanged throughout the study period. Although the research team had gained experience in conducting censuses during a pilot study in Betenase, there was little knowledge about the structure and composition of the Wansampo community and the relationships between households, and there had been limited time to train newly recruited local assistants and ensure that they informed interviewers when potentially inaccurate information was gathered. Hence this census was considered ”uninformed“.

After the first census, the team spent four months in the community during which direct observations, the development of a preliminary genealogical tree of the community[1] and

[1]The development of a genealogical tree was facilitated by the fact that most household heads or spouse could be linked either through biological or perceived ancestry, or marriage to a common ancestor (Nana Kwaku Amoahene from Aboduam). Genealogical data were managed in the software Family Tree Maker (MyHeritage, 2007)

surveys eliciting the houses in which people ate and slept, provided a more in-depth understanding of the delineation and composition of households, and the relationships both among household members and between households. This was followed by a second census of the whole community in April 2008, during which data from the first census were revised. For some households, this second census revealed substantially smaller household sizes, as people who had been claimed as households members were now judged independent, *e.g.* married with children and living in neighbouring village and only visiting a family member in the household once a week. In light of the evidence that appeared during the course of the following data collection, the quality of this census was judged as "relatively informed".

Two criteria were used to identify households, namely the sharing of food (Hanson, 2004) and the economic independence of the household (CIFOR, 2007b). For household members to share food, the household required both (1) access to a cooking place, whether this was a building designed as a kitchen or a fireplace outside sleeping quarters, and (2) access to farmland, from which to harvest food crops for own consumption. This definition is in line with previous observations that cocoa farmers' households in Sefwi Wiawso are both production and consumption units (Boni, 1993) and that household members rely on household production for consumption purposes (Hanson, 2004). While household members commonly ate together, there was also frequent sharing of food between households in the form of prepared meals being sent to relatives or neighbours.

Two further household characteristics were used to support decisions about household delineation and composition: a household had to be economically independent from other households, and household members had to be depended at least partly on economic resources controlled by the household head. While it is difficult to assess economic independence, especially when households experience strong seasonal income shortages and may depend on loans and gifts during part of the year (see Chapter 7), the preliminary income data obtained during the census - in combination with consultation of key informants

- was sufficient to obtain an overall picture. This was verified during subsequent income surveys preceding the main data collection.

With the start of the main data collection, people judged by interviewees as household members, plus those who had consumed dinner (the main daily meal) the day before at the household's premises, were recorded for every interview. The latter were included to facilitate detailed analysis of consumption and gift exchange patterns between household members and visitors. Such individuals were not deemed household members, but their close connection to the household and their occasional use of household resources was deemed important. Indeed, this approach provided a much richer and more detailed understanding of the presence of - and interaction between - community members and therefore of household composition. This method was particularly important because of frequent fluctuations in household composition. These high-resolution data showed substantial temporal variation in household composition, beyond those to migration and death, mainly due to time spent in other settlements (some household members had cottages in farms where they stayed at times in order to reduce travelling times). Hence, these data were used during those analyses requiring a temporally flexible measure of household composition, to improve analyses sensitive to household composition, *e.g.* on meat consumption.

Following the initial censuses, and the main socio-economic household survey, a third and final census was carried out (June 2009). This census benefited from a large body of data, long-established relationships with the study households, and a more detailed understanding of genealogical relationships. This census was considered ”informed“, and its data were used as the basis for estimating household parameters used as control variables during analyses.

3.5. Quantitative household surveys

3.5.1. General notes on the questionnaire

Interviews were conducted in the form of semi-structured questionnaires that elicited all monetary and non-monetary household incomes and expenditures within the 24-hours prior to the interview. This relatively short recall-period facilitated the reconstruction of incomes and expenditures by the interviewees and direct observation by researchers. To improve the recording of infrequent large income or expenditures, two-week recalls were also included.

3.5.1.1. Developing the questionnaire

The questionnaire was developed over a one-year period in the field, starting with the initial translation, piloting and adaptation of a questionnaire used by the CIFOR Poverty Environment Network (PEN) (see CIFOR 2007a for the questionnaire and CIFOR 2007b for the guidelines). The PEN questionnaire was tested in villages near Sefwi Wiawso and subsequently piloted during a one-month study in the forest community Betenase. This pilot study showed that the questionnaire did not fit the purpose of this study, necessitating substantial changes to its overall structure. These changes were carried out during the first months in Wansampo, and insights from basic income and expenditure surveys conducted during this period in Wansampo integrated into the questionnaire design. The final draft version of the questionnaire was trialled during 60 interviews in Wansampo (not included in this analysis), leading to minor changes and the final questionnaire used during this study (Appendix A.7).

3.5.1.2. Conducting interviews

Household interviews were conducted daily during the afternoon/evening, commencing around 15:30 when people had returned from their farms. People commonly left for their farms early in the morning and were busy with preparing for departure or organising breakfast before then, preventing interviews earlier in the day. Each household was interviewed approximately every three to four weeks. Initial attempts to sample households systematically on consecutive weekdays failed, since interviewees were not always willing to be interviewed on this schedule and frequently stated that they had just returned from the farm and were tired, and that we should come back the next day. Arranging interviews in advance did not improve the success rate substantially, because people would often forget and either still be on the farm or busy preparing dinner at the arranged time. While this was not always the case, logistically it seemed more efficient to adopt an opportunistic approach and select a household for interview that had not been sampled on the same weekday during the last two rounds of interviews. For this purpose, each interviewer carried a list of possible households for the day, based on the time since last interview and the weekdays already sampled, and approached people opportunistically. This increased the rate of interviews conducted and improved relations with interviewees, since it was then easier for them to decline an interview if it was inconvenient.

Efforts were made to include all household members in the interview to avoid under-reporting of income and expenditures (Fisher *et al.*, 2010). In case an adult household member was not present or could not participate in the interview, information on that person's activities were sought from the other household members present. If these individuals suggested that incomes may have been received or expenditures made that had not already been stated, interviewers continued the interview with the respective person later during the day. Children were often not present during the interview, which may have caused some underestimation of their incomes and expenditures, although this is unlikely to have been a significant effect since children in the community very rarely earned money.

All incomes and expenditures were recorded as an interaction between two people, and their respective personal IDs were recorded. For example, if a household had purchased a food item, we would ask whose money was spent and from whom the item was bought. Each survey team carried a list that included the personal IDs for all community members, plus first and second names, relationship with household head and year born for verification. In those cases where individuals from outside the community were concerned, these were recorded as: friends, family member or stranger.

All interviews were conducted in Twi/Sefwi either by myself or by volunteers from the UK or USA, with assistance from local assistants. The exceptions were brief periods towards the end of data collection when both myself and the volunteer were on sick leave and two local assistants carried out the interviews independently. In-depth discussions with the two assistants and interviewees subsequently verified that the interviews were conducted according to high standards.

3.5.2. Measuring household income

Estimates of gross daily household incomes were obtained through a series of questions referring to different types of household income. For the purposes of the data collection, household income was broadly divided into household production, trade, labour and gifts. I discuss each of these in turn below. While households were well-integrated into the cash economy, a large part of their livelihood activities were subsistence-based and/or involved the exchange of resources, requiring the assessment of both monetary and non-monetary incomes in these areas. For consistency, and to acknowledge the importance of subsistence activities, I refer to both monetary and non-monetary flows entering the household as income earned.

All items were valued by interviewees in local village sales prices and recorded in Cedis (see 3.5.6 for conversion rates). Most products were traded in Wansampo and interviewees were familiar with local prices. Whenever possible, items were counted and weights recorded.

Household production referred to the non-monetary income obtained from the harvest/gathering of farm products and/or NTFPs[2] within the last 24hrs, that were destined for either household consumption or for sale/gift but where no transaction had yet taken place yet. For each harvest we recorded the personal ID of the harvester. In case the harvester was not a household member, interviewees were further questioned as to whether it was a gift or the household had received help in harvesting its own product.

Part of the socio-economic household survey was a detailed bushmeat survey. In accordance with Milner-Gulland *et al.* (2003), bushmeat or wild meat was defined as any "meat products derived from wild animals for human consumption". Bushmeat therefore encompasses wild fish, crustaceans and molluscs, as well as (non-domesticated) terrestrial mammals, birds, reptiles and amphibians harvested for food, as suggested by Nasi *et al.* (2008). Interviewees were asked whether household members had harvested, or made any attempt to harvest, bushmeat within either the last 24 hours or previous two weeks. If bushmeat had been harvested in either period, the species, number of animals, hunting technique, location, habitat, time of day (morning, afternoon, evening and night), local sales price and use (*i.e.* own consumption, gift or sale), were recorded. Harvested animals were weighed to the nearest 25g using mechanical fishing scales (Salter Brecknell Super Samson: model 5kg), whenever this was possible. However, due to small sample sizes for most species, body mass estimates in this analysis largely rely on literature estimates (see Table A.2).

Cash income earned by household members from trading included all sales of items within the last 24hrs that had been produced, purchased or received as a gift at any time. This

[2] Note that the term NTFP is ambiguous and there is substantial confusion about the type of products included (see Belcher, 2003, for a review of the terminology and discussion in the literature). The definition used here includes all wild products, including firewood and woody construction material, harvested from forest, modified forest, or forest-derived land

method resulted in two potential problems for the double counting of incomes. First, the recording of production or gift incomes in addition to income from the sale of the same item where both incidents occurred within the last 24hrs. This problem was dealt with by carefully checking when and how the sold item entered the household and recording such items only under the trade income category. A second source of double counting arose where income from production or gifts were recorded during an earlier interview and recorded again as sale income during a subsequent interview. While it was not possible to completely exclude the possibility of double counting in this case, it was an unlikely event as most traded items were perishable and could not be sold three to four weeks after the harvest (the approximate time between interviews). The exception was rice, of which large quantities were harvested by three households and stored for several months before selling. In this special case, no production income was recorded but only the income from the sale. This approach was likely to underestimate the value of rice, as the households also consumed part of it, but the amount consumed was generally negligible compared to the amount sold.

Labour income was recorded if a household member had received money or non-cash payment, *e.g.* food crops, within the last 24 hours for labour conducted at any time. For households receiving income from salaried employment of one of its members, the monthly salary was recorded and converted into the daily equivalent, regardless of whether income had been received during the last 24hrs or not. This was necessary, because monthly salary payments were infrequent events and limiting the recording of salaries to occasions where payments had been received within the last 24hrs would have underestimated this income source. Care was taken to avoid recording salaries where these had not been paid, as was the case for a number of school teachers in the village.

Gift income occurred in the form of farm produce, labour, meals or money received by household members. For each gift received the monetary price equivalent was recorded.

Two-week recalls elicited incomes from transactions exceeding US$ 4.22 (50,000 Cedis). Such transactions referred to single events: if a given type of income was received several times during the preceding two weeks and only cumulatively exceeded US$ 4.22 it was not recorded. Two-week recall incomes were divided by 14 to estimate daily income. This monetary threshold was judged appropriate for large infrequent incomes and was confirmed as such by informants. The method was prone to the double counting of household incomes and care was taken to avoid this. If an interviewee reported earning the same type of income within the last 24 hours and the preceding two weeks, we inquired about the average daily income from this income source and how often in the last two weeks this income was earned. Based on this a mean daily income was estimated. All incomes recorded were gross incomes, excluding any expenditure.

3.5.3. Reliability of price estimates

To elicit monetary and non-monetary incomes and expenditure all transactions were recorded in the equivalent local sales/purchase price. Interviewees frequently purchased and sold agricultural produce and animal products, and were familiar with local sales prices. When interviewees stated unrealistic sales values, this commonly led to discussions among household members, after which a consensus was formed and the revised value recorded. The prices recorded for harvested food crops, showed greater variation around the mean than was recorded for crop sales, but overall the prices were comparable, indicating that the price estimates for harvested produce was reliable and reflected sales prices (Table 3.2).

Table 3.2.: Summary statistics for prices (US$/kg) stated for harvested and sold farm products during interviews (includes only records where item could be weighed during interviews).

	Harvest				Sale			
Crop	Mean±SD	Min	Max	N	Mean±SD	Min	Max	N
Cassava	0.14±0.11	0.05	0.79	47	0.12±0.03	0.07	0.19	20
Cocoyam	0.35±0.24	0.04	1.41	40	0.33±0.04	0.26	0.36	13
Gardenegg	0.48±0.23	0.26	1.12	12	0.54±0.24	0.22	0.94	10
Plantain	0.22±0.18	0.05	1.47	89	0.16±0.05	0.08	0.30	23
Tomato	0.52±0.26	0.17	0.96	17	0.96±0.48	0.12	1.69	14
White yam	0.25±0.13	0.05	0.51	13	0.26±0.05	0.19	0.31	4

3.5.4. Measuring household expenditure

Interviewees were asked to state all household expenditures during the last 24 hours. Expenditures occurred in the form of monetary expenditures for purchases and monetary and non-monetary gift expenditures. The most common monetary expenditure was the purchase of perishable food items bought on a daily basis, mostly from vendors in the village.

Where a household had given a non-monetary gift to a non-household member, interviewees were asked to value the gift in the local sales price. While people were familiar with agricultural produce and the cost of labour, estimating the value of food crops used to prepare a meal that was given as a gift was more difficult. The most common meal exchange involved fufu (a starch staple made from cassava and plantain) and interviewees stated the gift value as the local sales price of the meal. To estimate the production value of the ingredients, 29 independent fufu surveys were conducted in which both the value of the food crops used as ingredients and the local sales price of the resulting meal were recorded. The ingredient-meal value coefficient (*i.e.* the amount by which the value of the food crops was multiplied to obtain the value of the meal) was estimated as 2.25 (SD=0.81) and all fufu gift expenditures subsequently divided by 2.25. Apart from fufu, all other types of meals, including cooked meat, were reported in their raw production value and did not require transformation.

3.5.5. Farm surveys

Farm surveys were conducted with all households participating in the survey. The survey elicited detailed data on: location of the farm, farm owner, year when the farm was obtain, name of previous owner, mode of title transfer (gift, inherited, purchased or contract farming), and crop composition. The interviews were conducted with the household head and spouse plus other household members if these were the farm owner/user. Since it proved difficult to obtain reliable information about farm ownership and the crops grown on farms from a single interview, the interviews were conducted repeatedly (up to eight times for some households) and non-household members that were familiar with the household's farms were consulted. Data quality was further improved by team members frequently accompanying household members to their farm, thereby allowing them to verify the existence, location and crop composition of the farm. Where possible, the location of a farm was recorded using a GPS.

3.5.6. Currency

A currency redenomination took place in Ghana in 2007 that replaced "old" Ghana Cedi with a "new" Ghana Cedi at a rate of 10,000 "old" Ghana Cedis = 1 "new" Ghana Cedi. However, few people were able to express prices in the new currency and all prices were recorded in the "old" Cedi. The mean exchange rate from "old" Ghana Cedi to US$ between June 2008 and June 2009 was US$1.0 = 11,862 Cedis (http://www.oanda.com/).

3.6. Explanatory variables

3.6.1. Household wealth

Wealth is a major determinant of a household's livelihood strategy. It also strongly influences bushmeat harvest and use patterns, and the relative importance of bushmeat in livelihoods (*e.g.* Woldenhanna & Oskam 2001; de Merode *et al.* 2004). Yet both wealth and poverty are multidimensional concepts (Alkire & Santos, 2010a), encompassing a range of interacting tangible and intangible assets - or lack thereof - as diverse as authority, social capital and access to health and education. A holistic definition has been proposed by Ellis (2000) that includes all aspects of human well-being, which in turn are strongly influenced by human capabilities. This complex construct of wealth hampers quantitative assessments and is frequently simplified by equating wealth with income or consumption per capita. However, Chambers (1995) notes that this narrow technical definition focuses on only one dimension of deprivation or lack thereof, and ignores a multitude of other crucial dimensions. Due to these difficulties with quantifying multidimensional household characteristics, participatory methods have been widely used to group households into wealth categories (Takasaki *et al.*, 2000; Ambrose-Oji, 2003; Carter *et al.*, 1993).

3.6.1.1. Participatory wealth ranking

Participatory wealth ranking (PWR) is a non-intrusive approach based on a participatory assessment and rating of households into wealth categories defined by local informants (Chambers, 1995). The validity of PWR has been confirmed by comparison with independent wealth proxies (*e.g.* Adams *et al.* 1997; Takasaki *et al.* 2000). The ranking of households is a measure of relative wealth distribution among households rather than a measure of absolute wealth, such as the figure of US$1.25/person/day used by the World Bank as a criterion for extreme poverty (World Bank, 2008). Households categorised as wealthy in a community may therefore still be poor in absolute terms. However, understanding variation in relative poverty and its implications for rural livelihoods has been identified as an important step in reducing absolute poverty (Lok-Dessallien, 1998).

Wealth ranking exercises were conducted with seven individuals, all of whom were long-standing community members of different genders, socio-economic backgrounds and community neighbourhoods, following the methods outlined in Grandin (1988). As the community comprised only 70 households and most participants felt confident in ranking each household, it was not necessary to conduct separate ranking exercises for different neighbourhoods (as may be required for larger communities). Only two participants stated that they could not rank two or three households because they "did not know their farms".

When this happened, the cards were put aside and no wealth rank was recorded for those respective households during that particular exercise. Qualitative data on the local meaning of wealth (locally referred to as "ahonjadeϵ"), and the criteria used by the participants for ranking, were collected both before and after the exercises. The cards used during the ranking had the names of the household head and his/her spouse (in English and local names) written at the top, and were read to participants. If participants were not sure who was meant, due to a variety of local names being used, pointing towards the household's house or stating another local name was sufficient for unambiguous identification.

Participants independently grouped households and decided on the number of wealth groups during the exercise. Most participants decided on a large number of groups (mean=8.33±2.58 SD). This made it difficult for the informants to identify distinct characteristics for each wealth groups, and also led to some groups containing very few households. However, when the participants were asked whether they would like to combine wealth categories they insisted on keeping their original number of wealth ranks.

For this study, all households were grouped into four wealth categories based on their mean participatory wealth score (Table 3.3). To calculate mean wealth scores every household received a value for every ranking exercise, depending on the group it was allocated to and on the total number of wealth groups chosen during that exercise, *i.e.* a household placed in the wealthiest pile out of a total of four piles, received a value of 0.25. This was repeated for every exercise and the mean estimated across exercises. The cut-off points between wealth groups (see horizontal red lines in Figure 3.1) were calculated by subtracting the highest mean wealth score obtained by any household from the mean lowest score obtained and dividing the result by three. This provides three cut-off points to obtain four wealth groups (following Grandin, 1988). Four wealth categories were used, instead of the five (quintiles) that are common in the economics literature, to ensure a sufficient number of households in the wealthiest and poorest categories (Table 3.3). In general, there was least disagreement among the informants about the households in the wealthiest and poorest categories, and the criteria used for distinguishing households in the two middle wealth groups were generally less distinct (for similar observations, see Carter *et al.* 1993).

Table 3.3.: Number of surveyed households with male or female household head across four wealth categories.

	Gender of household head		
Wealth Group	Female	Male	Total (% of total)
wealthiest - 1	0	8	8 (12.7%)
2	8	12	20 (31.7%)
3	7	14	21 (33.3%)
poorest - 4	4	10	14 (22.2%)

In the words of one informant, wealth meant: ”to own big cocoa farms, a house, a car, clothes, funeral cloth, furniture, and have many children because they can go to school and get better work“ (Table 3.4). Overall, wealth was defined in a materialistic way and strongly depended on income from the sale of cocoa beans that could be used to purchase property or invest in the education of children. When asking informants about the single most-important factor that differentiated households in different wealth categories, the unanimous response was ”cocoa“. In the words of one interviewee, “our business is cocoa, so I compare cocoa farms“, which meant the number of cocoa farms owned, the size of the farms, whether the cocoa trees were mature yet or still young and not bearing fruits, and whether the trees were healthy or infested with diseases. Two people said that they could not rank a particular household and gave as the reason: ”I have not seen his farm“.

Poor households were described as having fewer assets and being unable to send their children to private schools that demand high fees (Table 3.4). Often, the poorest households were newly established and had not yet had time to develop their cocoa farms; they were described as ”boys in the village“. On the other hand, a person’s attitude was also reported to be important. To have a vision, to work hard on the farm, and to not waste money were attributes strongly associated with wealth, while the lack thereof was linked to poverty. Income seasonality also appeared to be a problem across wealth categories: ”regardless of wealth, if you don’t take care of your money you don’t have money outside the cocoa season“.

One informant highlighted the low level of opportunities and social mobility associated with poor households: ”[the poorest] cannot do anything, do not have anything and your wife has to give you food [through her matrilineal links]. They have no income except gifts“.

Children had a special role in the way a household was perceived. Some households were considered wealthy but grouped with less wealthy households, because they did not have children. The justification given by one person was: ”if you give birth, you move up. If you don't give birth you vanish[3] but with children you can pass things". Hence, children were considered an asset that was developed through school education and considered a safety net that provided security when the household head was not able to fend for his needs.

Table 3.4.: Criteria commonly used by informants during participatory wealth ranking exercises.

Category	Signs of Wealth	Signs of lack of wealth
Cocoa farm	Own large cocoa farms with mature cocoa trees	Own no cocoa farm or small cocoa farm with young cocoa
House	Have own house; property in town counts even more	Rent house in village
Food crops	Surplus food crop production is sold: ”They have more than they need“	Required to buy food crops
Money	Have lots of money & savings	Have little or no money, especially no savings ”have to borrow money when sick“
Labour	Employ farm labourers	Not employing farm labourers
Children	Many	Few or none
School fees	Pay expensive school fees for private school education	Pay low school fees for government school education
Work attitude/ability	Work hard, have vision and use money well	Do not work hard because of attitude or disability, waste money

[3]The notion of "vanishing" was repeatedly stated and was linked to losing land tenure rights. A person may not own a plot of land but s/he owns the cocoa trees on it and the longevity of cocoa trees means that land tenure is secured for decades and can be passed on to children. They can take care of you when you are in trouble or old.

3.6.1.2. Verifying participatory wealth measures

Plotting the mean wealth score and corresponding standard deviation for each household indicated some level of variation in the wealth assessment by different PWR informants (Figure 3.1). To assess the validity of PWR results, these were compared with independent quantitative wealth proxies, as follows (household income is not discussed here but a high level of correlation with wealth is shown in Chapter 7).

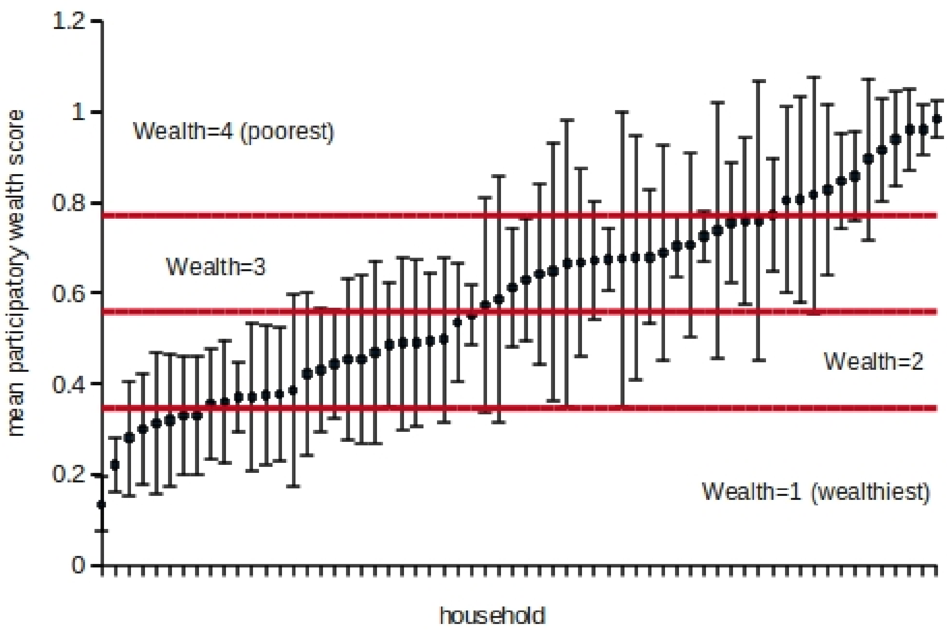

Figure 3.1.: Results of participatory wealth ranking expressed as mean participatory wealth score. Horizontal lines show limits of wealth groups. Standard deviations are shown.

Roof value

Houses are an essential shelter during tropical rains. They are generally the second major asset after farmland for households in rural areas of developing countries (Appleton, 1996), they serve as a status symbol, and they are commonly been used as a proxy for wealth (Ghirotti, 1992). In single-storey buildings the size of a roof is proportional to the living area of a house and therefore likely to be positively related to the cost of construction. The size of a house used for sleeping together with the roofing material were prominent criteria during participatory wealth ranking.

All houses in the community[4] were measured using a tape measure (to the nearest 10cm) and their roofing material recorded. The roof value of houses used for sleeping was estimated by multiplying the mean number of iron or raffia palm sheets per square meter with the size of the house (in m^2) and the cost of purchasing one raffia or iron sheet. Raffia sheets were either produced by household members or bought in Wansampo for US$ 0.17/sheet. Iron sheets were bought in packs of 20 sheets for US$ 118.02 in Sefwi Dwenasi and had to be transported to Wansampo in a car for which a fee of US$ 8.43 had to be paid. Since it was not certain whether all iron sheets were transported in one car or transported on different days, requiring several cargo payments, a one-off transportation fee was included in the price of iron sheets regardless of the number of iron sheets used for the building (Table 3.5).

Table 3.5.: Number of iron and rafia sheets per m^2 of sleeping space and the respective price.

Roof material	Mean sheets/m^2 (SD)	Cost/m^2	N
Iron	1.09 (0.24)	US$ 6.43	9
Rafia	7.89 (3.43)	US$ 1.34	9

On this basis, the value of the roof of a household's sleeping area increased significantly with wealth (Figure 3.2, Kruskal-Wallis: $\chi^2 = 29.4523$, df = 3, p-value<0.001), providing evidence for the reliability of the PWR results.

Household expenditure

Household expenditure is generally considered a better proxy for household wealth than household income, because expenditure is related to consumption and consumption choices are influenced by a household's long-term income (Friedman, 1957).

[4]For practical reasons this analysis is limited to houses owned by survey participants in Wansampo and does not include cottages on farms or houses owned in different places. As most households owned a cottage and only one household in the wealthiest category had a large house in town, the effect on the outcome of the analysis is negligible

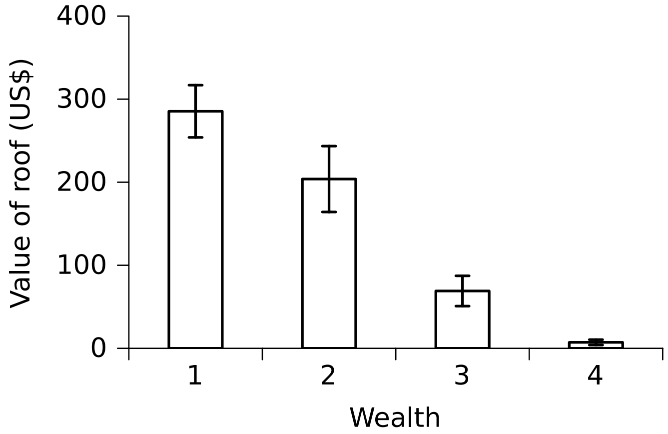

Figure 3.2.: Value of roof covering the sleeping area across wealth categories. Standard errors are shown.

Average daily expenditure was estimated for each household based on their respective mean expenditure incurred over 24 hour and two-week periods (the latter divided by 14) before an interview (see Section 3.5.4). Similar to the roof value, the mean daily household expenditure increased with wealth, providing further evidence for the reliability of PWR results (Figure 3.3; One-way Anova: F-value=15.373, df=3, $p<0.001$; Shapiro test: p-value>0.05).

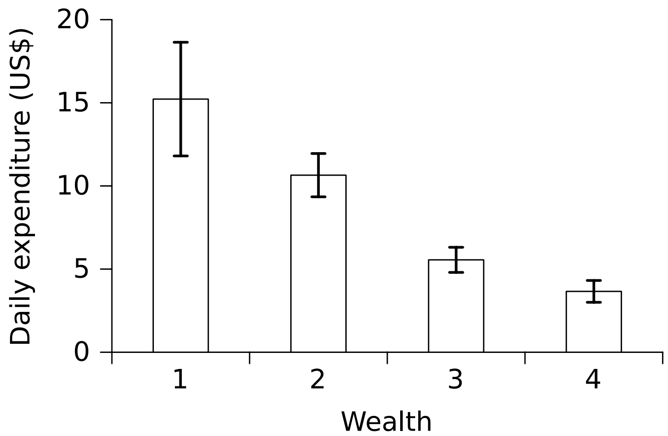

Figure 3.3.: Value of daily household cash expenditure across wealth categories. Standard errors are shown.

In summary, both independent wealth measures suggested real differences among PWR categories: an increase in both the value of a household's roof and household expenditure in households of higher wealth rank. These findings provide strong evidence in support of the PWR results.

3.6.2. Seasonality

Seasonality in tropical agricultural systems is broadly grouped into the ”planting season” when little food and income is available, hence often called the “lean” or “hunger” season, and the “harvesting season“. Within a cocoa farming system with perennial crops as the main source of livelihoods, the equivalent of the planting season is the "off-season" (hereafter lean season) when relatively little cocoa is harvested and the "cocoa season" when most cocoa is harvested and sold. This seasonal variation in the sale of cocoa beans can be expected to result in marked seasonal variation in household incomes (Barrientos & Asenso-Okyere, 2008). For the purpose of this thesis, the twelve months data-collection period was divided into three seasons, based on household cocoa income. The three seasons were: (1) before the cocoa harvest (July 2008 to September 2008); (2) during the cocoa harvest (October 2008 to January 2009); and (3) after the cocoa harvest: February 2009 to June 2009. These three seasons strongly correlated with cocoa sales patterns, both with respect to the frequency of cocoa sales (Table 3.6) and the value of cocoa sales (Table 3.7). Cocoa sales occurred most frequently (Figure 3.4a) and were of the highest value (Figure 3.4b) during the cocoa season. Cocoa sales were least frequent and of lowest value before the cocoa season. An intermediate pattern was observed after the cocoa season, when cocoa sales were more likely than before the cocoa season but less likely than during the cocoa season. The value of cocoa sales after the cocoa season was substantially lower than during the cocoa season but similar to before the cocoa season. Hence the lean season encompasses both the before and after periods, but the severity of the stress is more likely to be higher before than afterwards. Overall, 20% of all cocoa income was earned before the cocoa season, 52% during the cocoa season and 28% afterwards.

The grouping of months into the three seasons employed in this study resembles that described by Dei (1989) as the harvest season (Oct.-Dec.), post harvest season (Jan. - March) and lean season (April-Sept.) in his study of food crop farmers in SE Ghana. Similarly, cocoa processors and manufacturers distinguish between a mid-crop (June - October) and main-crop (October - May) (Barrientos & Asenso-Okyere, 2008).

Table 3.6.: Results of binomial GLMM analysis testing the effects of seasonality on cocoa sales.

Model	ΔAIC_i	Akaike weight
season	0	>0.99
null	72.17	<0.01

Table 3.7.: Results of GLMM analysis testing the effects of seasonality on cocoa sales.

Model	ΔAIC_i	Akaike weight
season	0	>0.99
null	70.53	<0.01

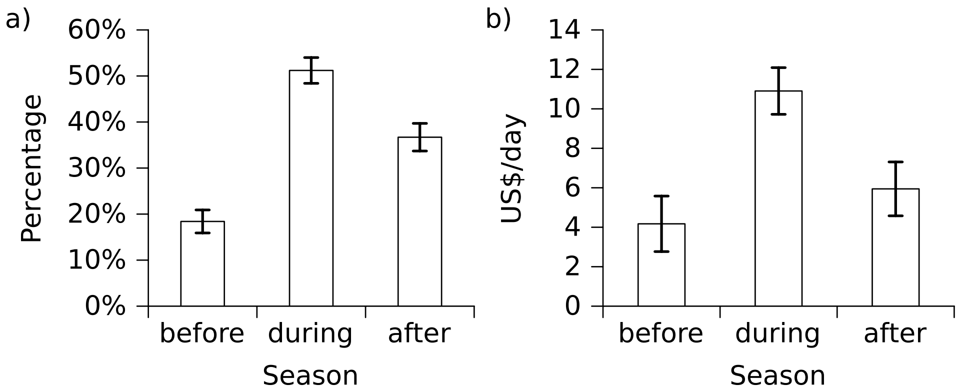

Figure 3.4.: Seasonality of cocoa sales: a) percentage of interviews recording cocoa sales per season; b) mean daily value of cocoa sales per season (for interviews recording cocoa sales).

3.6.3. Gender of the household head

The head of each household was identified by household members during the community censuses (see above) and verified through discussions with local research assistants. Out of a total of 63 survey households, 44 have a male household head (MHH) and 19 a female household head (FHH) (see Table 3.3). The most senior household member was commonly stated as the household head, except in two cases where elderly mothers were staying with their sons and the sons were in charge of the household's resources. If the most senior people in the household were a couple, the husband was identified as the household head and the household categorised as male-headed household.

Problems with the identification of the gender of the household head have been recognised where female headship is a transitory phenomenon in the life cycle of a household (**?**). This is most likely a problem in longitudinal studies spanning several years, but was less problematic in this study. The marriage of one female household head towards the end of the survey period probably would have required changing the household from FHH to MHH status, but as the woman and her children left the community and moved to her husband's hometown no further interviews were conducted and all previous interviews were considered under the FHH category.

Some studies distinguish between those households headed by women whose husbands are temporarily absent (de facto FHH) versus those where households are headed by a widow (de jure FHH). However, except in one case where the female household head was married to a polygamous man who lived with his second wife in a different village, and only occasionally came to Wansampo (in which case, the households was identified as FHH), this distinction was of no importance and is not considered further.

3.7. Statistical analysis

All statistical analyses were performed in the R environment, version 2.9.2 (**?**). To explore the relationship between a response variable and independent variables, Linear Mixed Models and Generalized Linear Mixed Effect Models (GLMM) were used ('lme4' package, version 0.999375-32; Bates & Maechler 2009). GLMMs allow for the analysis of non-normally distributed data and the specification of a random effect to account for the non-independence of repeated measures, in this case repeated surveys of the same households. Hence, all models included household ID as a random effect.

As is common in household surveys with short recall periods, zero counts occurred frequently. To accommodate this data structure the data were modelled using a two-step approach that first assessed a binary distribution of the response variable (*i.e.* the likelihood of an event occurring) and subsequently focused on those interviews where values > 0 had been recorded (*i.e.* the scale of positive responses) (Martin *et al.*, 2005). Assessments of likelihoods using binary data were modelled using a binomial error distribution and logit-link function. To facilitate model fitting, non-binary data were log-transformed, or in the case of proportion data, square-root transformed to approximate a normal distribution.

According to Pinheiro & Bates (2000), the distributional assumptions of GLMM's are that:

1. the within-group errors are independent and identically normally distributed, with mean zero and variance σ^2, and are independent of the random effects.

2. the random effects are normally distributed, with mean zero and covariance matrix ψ (not depending on the group) and are independent for different groups

For each model run, the validity of the above assumptions was tested qualitatively by plotting within-group residuals that provide a good surrogate for within-group errors. Similarly, model fit was visually inspected using fitted versus residual plots (Zuur *et al.*, 2009).

For each analysis undertaken for a dependent variable of interest, a set of GLMMs were carried out. Each GLMM in the set included household ID as a random effect, and four ”control“ variables as fixed effects (described in Table 3.9). The latter are household characteristics that might potentially confound the analyses of interest if they were not included in each model at the outset. The first model in the set, the ”null“ model, contained no other variables except this random effect and four fixed effects, as predictors of the dependent variable. The remaining models encompassed the range of all possible combinations of the predictor variables. For example, an analysis that explored the effects of predictor variables A and B would involve three further models: variable A only, variable B only, and the interaction between A and B. The results of each model in the set are then tabulated in the main text, unless the tested variables showed no substantial effect on the dependent variable, in which case the GLMM results are presented in the Appendix. On these tables, a ”+“ indicates an additive effect between two variables (*i.e.* both had an independent effect on the dependent variable), while ”:“ indicates an interaction effect between two variables. When both interaction and additive effects were present, *e.g.* ”var1+var2+var1:var2”, the abbreviation “var1*var2” was used (following Pinheiro & Bates 2000).

Rather than using traditional null-hypothesis testing procedures for variable selection, an information-theoretic approach was used (Burnham & Anderson, 2002). The advantages of this approach are that it allows us to (a) evaluate multiple non-nested models relative to each other, (b) quantify the relative support for multiple models simultaneously, and (c) assess model uncertainty using model averaging. For a discussion of the advantages and disadvantages of the information-theoretic approach see Anderson *et al.* (2000); Stephens *et al.* (2005); Lukacs *et al.* (2007), and Stephens *et al.* (2007).

The information-theoretic approach using Akaike’s Information Criterion (AIC), values provides criteria that allow for an objective assessment of the trade-off between model bias and model precision. AIC is defined as

$$AIC = 2k - 2ln(L), \tag{3.7.1}$$

where k is the number of parameters in the model and L is the value of the maximised log-likelihood of the model (Burnham & Anderson, 2002). A model with a low AIC is more parsimonious than a model with a high AIC. AIC values contain arbitrary constants and are affected by sample size, and therefore must not be understood as an absolute reference of a model's performance but have to be viewed in relation to a set of alternative models, each testing a relevant hypothesis (Burnham & Anderson, 2002).

The interpretation of GLMM results was based on two criteria. First, a model's relative support was evaluated in reference to the model with the lowest AIC value (ΔAIC_i = AIC of respective model - AIC of best model). Models with $\Delta AIC_i \leq 2$ were considered to receive substantial support, models with ΔAIC_i between 4 and 7 to have considerably less support, and models with $\Delta AIC_i \geq 10$ to have essentially no support (Burnham & Anderson, 2004). Secondly, the ΔAIC_i of the null model itself (hereafter ΔAIC_N) provided a measure of the relative confidence in the interpretation of the results. If support for ΔAIC_N was high (≤2) or even moderately high (4 - 7), then confidence in the alternative models was low, even if the ΔAIC_i scores were ≤2. All interpretations of relative support for individual variables were further triangulated by assessing the respective effect sizes and standard errors and the ΔAIC_i of the univariate model.

Akaike weights were estimated to normalise model likelihood across the set of alternative models and provide a ”weight of evidence”. Akaike weights are defined as

$$w_i = \frac{exp(-\Delta_i/2)}{\sum_{r=1}^{R} exp(-\Delta_r/2)} \tag{3.7.2}$$

where Δ is the difference between two AIC values, *i.e.* the lowest AIC value among the models and the AIC value of the model referred to.

3.7.1. Variables

The main independent variables assessed in this thesis are threefold: household participatory wealth rank (wealth), income seasonality (season) and gender of the household head (hhsex)

(Table 3.8). Each variable is analysed as a categorical variable. As noted above, model inference is based on a set of all possible combinations of the three variables, including interaction effects between household participatory wealth and season, and gender of the household head and season. The interaction effect between gender of the household head and household wealth could not be assessed, since FHHs were not represented in the wealthiest category, preventing the estimation of fixed-effect estimates and resulting in model failure.

Table 3.8.: Main independent variables assessed during analyses.

Variable	Explained
Wealth	A household's wealth status, categorised in four factor levels (1=wealthiest to 4=poorest)
Season	Seasonality categorised in three factor levels (before-, during, and after-cocoa season)
Hhsex	Gender of the household head, categorised in two factor levels (female- and male-headed household)

Four fixed effects were included in all the GLMMs as "control" variables (Table 3.9), unless otherwise stated. Household composition (the number of active males, and the dependence ratio) and the personal characteristics of the household head (age and education) have important ramifications for the outcome of livelihood analyses (Appleton, 1996; Abdulai & CroleRees, 2001; Perz *et al.*, 2006). The control variables were chosen because they have been shown to influence hunting pattern (Walker *et al.*, 2002; Kumpel *et al.*, 2009; Coad *et al.*, 2010) and were independent from each other (Spearman rank: N=63, $\rho<0.65$, $p>0.05$). For details of correlation between variables used in models see Table A.4.

Table 3.9.: Variables controlled for and used as constant fixed effects during GLMM analyses.

Variable	Explained
Active male[a,b]	Number of active male household members: active male were ≥16 years and ≤65 years (continuous variable; range: 0 to 4).
Dependence ratio[a,c]	Household dependence ratio: number of dependent/total number of household members (range: 0-0.75) categorised in four factor level (≤0.2; >0.2 to ≤0.4; >0.4 to ≤0.6; >0.6). A dependent household member was ≤ 15 years.
Age[b]	Age of household head (range: 21-84 years) categorised in six factor levels (≤30; >30 to ≤40; >40 to ≤50; >50 to ≤60; >60 to ≤70; >70).
Education	Number of years a household head had spent in formal education (primary to tertiary education; range: 0-12 years): categorised in five factor levels (0; >0 to ≤3; >3 to ≤6; >6 to ≤9; >9).

[a] Based on a census conducted in June 2009 and do not take into account temporal fluctuations of household composition during the survey period.
[b] 2009 was the reference year for age calculations.
[c] No maximum age was used for identifying dependent household members because all elderly people participated in farm work. Some people worked more than others but everybody contributed. Only children were truly dependent and even this was not true for all. Variation in activity levels is controlled for through the number of active male household members.

Chapter 4

Wildlife depletion in a West African farm-forest mosaic and the implications for hunting patterns across the landscape

4.1. Summary

(1) Wildlife depletion due to unsustainable hunting is a threat to both conservation and rural livelihoods. To reduce the pressure on forest-dependent species sensitive to hunting, it has been suggested that agricultural habitats may provide an alternative source of sustainable bushmeat.

(2) In order to explore the potential for human-modified landscapes to support rural communities and thereby reduce hunting pressure on forest species, this study asked the following questions: (a) what is the level of wildlife depletion in an intensively managed mosaic of farmland and timber production forest; (b) what is the relative importance of bushmeat hunting in farmland compared to forest; and (c) how do hunters integrate hunting activities with agricultural livelihoods in a wildlife-depleted landscape?

(3) To answer these questions, repeated hunting surveys were conducted among 63 households over a period of twelve months (N = 791 interviews) in a Ghanaian cocoa farming community situated in a forest reserve. The bushmeat harvest and hunting patterns in both the community farm land and surrounding forest were assessed.

(4) The level of wildlife depletion in the forest-farm mosaic was high, with evidence for the local extinction of the largest species across all taxonomic groups. The loss of species was higher in farmland than forest, presumably reflecting the effects of habitat modification as well as hunting. Most hunting occurred in forests, reflecting that forests covered a larger area and contained more species. However, bushmeat harvest from farmland was disproportionately high relative to its coverage, apparently because most hunting was opportunistic and integrated with agricultural activities.

(5) The high level of wildlife depletion and low bushmeat harvest in farmland suggest that intensively used farmland may not provide an alternative to hunting in forests. However,

agriculture in this system was intensive, and further research is required to ascertain the generality of these findings in less intensively managed landscapes.

4.2. Introduction

The depletion of wild animals through an unsustainable bushmeat harvest poses a problem for both conservation efforts and the livelihoods of resource users (Milner-Gulland *et al.*, 2003). Bushmeat is an important source of animal protein and cash income throughout rural sub-Saharan Africa. This is especially the case where income generating opportunities are scarce and alternative sources of animal protein are either not available or too expensive (Fa *et al.*, 2003; Kumpel *et al.*, 2010b).

A combination of increasing human populations in rural areas, increasing bushmeat demand from urban populations and improved hunting technologies have resulted in unsustainable hunting pressure and the widespread decline and local extinction of prey populations (Elliott, 2002). Indeed, hunting can locally extirpate large-bodied animals even where human population densities are low (Alvard, 1993; Noss, 1998b; Peres, 2000a).

This is bad news for conservation efforts and leaves bushmeat-dependent communities with an impoverished resource base and potentially less secure livelihoods. Recent management suggestions from a conservation point of view have focused on reducing urban demand through taxation and increasing the cost to hunters through better law enforcement (Wilkie & Godoy, 2001). While these strategies may be successful in reducing bushmeat offtake and achieving conservation objectives, they do not take into account that impoverished rural populations can depend on bushmeat and that policies restricting their access to the resource may result in less secure livelihoods. This raises the question as to how the detrimental effect of bushmeat hunting on threatened species can be reduced while at the same time providing for the needs of bushmeat-dependent rural communities.

Recently, it has been suggested that both objectives could be achieved by focusing the hunting effort on non-threatened wildlife species in farmland and thereby reduce the pressure on threatened forest-dependent species (Robinson & Bennett, 2004). Wildlife productivity in forests is relatively low compared to secondary habitats, such as logged forest and farmland, suggesting that the level of sustainable offtake could be higher in disturbed habitats.

According to this argument, the disturbance or conversion of primary forests has a negative effect on the abundance of forest-dependent species with low ecological flexibility (*e.g.* specialised diet or adaptation to arboreal lifestyle), thus shifting the composition of wildlife communities towards species more resilient to habitat disturbance. These species are often of smaller body size than specialised forest-dependent species (Fimbel, 1994; Lopes & Ferrari, 2000). This shift in species composition may result in an overall decline in total biomass, but because small-bodied animals exhibit higher intrinsic rates of natural increase than large-bodied animals (Hennemann, 1983; Robinson & Redford, 1986), biomass production may increase, allowing for a higher levels of sustainable offtake (Robinson & Bennett, 2004; Wilkie & Lee, 2004).

Support for this argument from field studies in the Neotropics is equivocal. Comparison of wildlife abundance in a Mexican farm-forest mosaic with varying levels of disturbance showed that wildlife was more abundant in disturbed than less disturbed habitats (Escamilla *et al.*, 2003). On the other hand, Demmer *et al.* (2002) reported higher abundance of mammals in old-growth forests than in human disturbed secondary forest. Similarly, evidence from a Brazilian primary-secondary forest mosaic showed higher wildlife production in primary than secondary forest due to the local extinction of some species in the secondary forest (Parry *et al.*, 2009b). However, Parry *et al.* also showed that the production of some resilient species was higher in secondary forest than primary forest. Despite the disagreement about wildlife abundances in secondary versus primary habitats, all of these studies recorded substantial wildlife populations in secondary habitat, especially of small-bodied animals, that could provide resource-dependent households with an alternative to hunting of less resilient large-bodied forest animals.

Despite this potential benefit of human-modified habitats for both conservation purposes and household consumption/income needs, little is known about how hunters utilise different habitats within the landscape and particularly how the bushmeat harvest from human modified habitats compares to that from less disturbed habitats. Existing studies are largely limited to the Neotropics and indicate that hunters harvest substantial amounts of bushmeat from disturbed habitats, yet less disturbed habitats remain the most important source of bushmeat (Smith, 2005; Gavin, 2007; Parry *et al.*, 2009a). These findings may, however, reflect relatively healthy populations still residing in the less disturbed habitats in these particular localities - indicated by the presence of species sensitive to hunting, *e.g. Tapirus terrestris/bairdii*, in all three studies. Indeed, one would expect the relative importance of undisturbed forest and modified secondary habitats to be contingent not only upon their relative productivities but also their respective histories of hunting, such that the harvest of resilient species from secondary habitats will become more important as the level of wildlife depletion in forests increases.

4.3. Research questions

To explore the potential for human-modified landscapes to support rural communities and thereby reduce hunting pressure on forest habitat, the study investigated patterns of wildlife depletion and bushmeat hunting by farmer-hunters (hereafter hunters) from a farm-forest landscape. The three main questions were:

1. What is the level of wildlife depletion in an intensively managed mosaic of farmland and timber production forest?

2. What is the relative importance of bushmeat hunting in farmland compared to forest?

3. How do hunters integrate hunting activities with agricultural livelihoods in a wildlife-depleted landscape?

4.4. Methods

4.4.1. Bushmeat harvest

Bushmeat hunting and harvest data were collected using 24hr and two-week recall periods as part of a general socio-economic household survey (for details see Section 3.5). For each bushmeat harvest the recorded data included: personal ID of the hunter, species harvested, harvest method, number of animals harvested, location and habitat type (forest or farm) where the harvest occurred, and the time of day of the harvest (morning, afternoon, evening or night). If no animal had been killed, the interviewee was asked whether traps had been checked or a household member had been on a gun hunt (attempted harvest). To assess the level of "opportunistic" bushmeat harvests, we recorded for every harvest or attempted harvest whether the hunt was independent from other activities. For example, a hunt that followed or preceded farm work, was rated as opportunistic (since the hunt would take place at or around the farm, or near the path travelled). On the other hand, a "non-opportunistic" harvest occurred, for example, when a hunter walked from the village to check his traps and returned to the village without conducting any farm work.

The biomass of harvested wildlife was estimated by multiplying the number of animals per species harvested with the respective body mass estimate. Mean weight estimates were obtained from this study and where not available, mean values from Kingdon (1997) were used (see Table A.2 for details). Attempts were made to view all animals and identify them to species level. However, often the animals had already been smoked, cooked or sold and species identification relied on information obtained from hunters. The identification of non-mammalian species was generally limited to the genus or family level. Very few interviewees reported discarding rotten animals, instead parts of the animals not yet rotten were commonly consumed. Discarded parts were not included in the analysis.

A comparison of the bushmeat harvest value recorded using 24hr and the two-week recall periods showed that the two-week recall data was 34% lower than would have been expected from 24hr-recall data. The 24hr-recall data were considered the more accurate of the two records, since the reported hunting events occurred closer in time to the interview and there was a higher chance of interviewees remembering the harvest (Beaman *et al.*, 2005). Similarly, Lund *et al.* (2008) recorded threefold higher income estimates for one-month than three-months recall periods. Direct observations of animals harvested within the 24hrs preceding the interview allowed for verification of interviewee information. Hence, two-week recall data were only used for the analysis of presence/absence of a species in hunters' bags but not for detailed harvest estimates.

4.4.2. Assessing the level of wildlife depletion

To assess the level of mammal species depletion in the forest surrounding the village, we compared the species profile of hunters' bags from Wansampo with the species profile of two nearby protected areas. The protected areas were the Ankasa Conservation Area, *i.e.* the Nini-Suhien National Park and the Ankasa Resource Reserve (hereafter Ankasa), and the Bia Conservation Area, *i.e.* Bia National Park and the Bia Resource Reserve (hereafter Bia). Both areas are within a radius of 100km of Wansampo (Ankasa = 90km; Bia = 60km) and were part of the same continuous forest block before these were separated through deforestation during the 19th and 20th century. In the absence of baseline data for Wansampo (*i.e.* a species inventory before human land-use initiated), this comparison makes two important assumptions: (1) species present in the nearby protected areas should also be present in

Wansampo, and (2) all species present in Wansampo were harvested during the twelve months data collection period. From this follows that a species not harvested is absent, which, given the preceding assumption, means that it must have gone extinct locally.

The wildlife data for Ankasa and Bia were obtained from Gatti (2009) and are based on 529 surveys in Ankasa (about 2,000 hours survey time) and 204 surveys in Bia (about 900 hours survey time).

4.4.3. Habitats and farm surveys

Interviewees did not differentiate between different forest types, such as secondary forest and high forest but referred to it collectively as "bush". This may have been a result of high levels of structural damage to the forest caused by decades of industrial logging activity with some parts of the forest having been selectively logged up to four times (Section 2.8.1.1). On the other hand, interviewees distinguished between cocoa and food crop plants, but due to small sample sizes, these were grouped into one category (farmland) and not analysed separately.

To assess the level of crop damage, we first conducted comprehensive farm surveys to establish the type and number of farms owned/managed per households. The interviews were conducted with the household head and spouse plus other household members if they owned/used farms. Since it proved difficult to obtain reliable information about farm ownership and the crops grown on farms from a single interview, the interviews were conducted repeatedly (up to eight times for some households) and non-household members that were familiar with the household's farms were consulted. During a subsequent survey, the crop damage on farms was assessed by asking interviewees to rate the level of crop damage for each farm on a scale from 0 (none) to 3 (heavy). The level of crop damage could not be verified through quantitative surveys and relied on the subjective perceptions of farm owners. In the case where farms were managed by labourers or they were beyond walking distance and infrequently visited no data on crop damage was collected. A total of 48 out of 63 households provided information about crop damage on their farms, resulting in a total of 189 out of 315 farms being rated.

Wildlife harvested along the farm-forest boundary represented an ambiguous case in terms of habitat allocation due to the location and uncertain origin of the animals. For consistency, the definition used here followed peoples' perception that traps along the farm-forest boundary were located in farmland. The harvest of bushmeat from river traps was categorised as forest or farm habitat, depending on the surrounding habitat.

4.4.4. Trap surveys

Hunters frequently moved traps between areas and habitats, and during this process groups of traps may have been dismantled for some time before being set up again. Unfortunately, it was not possible to track the exact number of active traps throughout the survey period. Instead a survey of all traps active during a three-day period in July 2009 was conducted by Charlotte Whitham under the supervision of BSH (see Whitham 2009). Each household was asked about the number of traps used at the time, the approximate location and the land type (forest or farm) in which they were positioned. To obtain an approximate hunting area for the community as a whole, the locations mentioned by hunters were related to previous farm and hunter surveys that recorded locations using a GPS unit. Based on these data, it was estimated that traps were positioned within a radius of 4.7km from the centre of the village. "Hunter follows" (*i.e.* accompanying a hunter on a hunt) indicated an average walking distance per hunt of 3.8km, suggesting that a hunting radius of 4.7km radius was a realistic estimate of the hunting area (C. Whitham, unpublished data). The proportion of the hunting area comprising forest and farmland was calculated in GoogleEarth Professional.

4.4.5. History of wildlife depletion

Informal discussions with village elders and hunters about the historical context of wildlife depletion in the area aimed to establish a sequence in which successive species had become rare or locally extinct. However, few people could reliably distinguish different species of primate and ungulate, and it was not clear whether they had never seen the species or had rather forgotten about it due to the long time since they last saw one. To simplify the approach, discussions focused on three easily identifiable species, namely bongo (*Tragelaphus euryceros*), black-and-white colobus (*Colobus vellerosus*) and red river hog (*Potamochoerus porcus*), and information was sought as to which decade they had either last hunted each of the species themselves and/or seen another person in the community harvest these species.

4.4.6. Data analysis

Interviews with incomplete hunting data were excluded from the analysis, resulting in a sample of 791 interviews (from 63 households) used for this analysis. The analysis was primarily descriptive but GLMMs were used to assess the effect of the habitat type (forest/farmland) on the relative profitability of hunting, defined as harvest value (in US$)/household/day. To assess the underlying reason for differences in profitability, we also assessed the effect of the habitat type on the a) sales price (in US$)/kg body mass harvest and b) body mass (kg)/household/day. Habitat type was the only variable tested (fixed effect) and household ID acted as random effect. Model evaluation was based on AIC values, as described in Section 3.7.

4.5. Results

4.5.1. What is the extent of wildlife depletion?

The community has a long history of hunting bushmeat primarily for subsistence use. Oral tradition reports that the first settlement was established around the beginning of the 20th century as a hunting camp. The settlers had left their home town and migrated 40km to the site of the current village, because of already depleted wildlife populations around their home town. The village became well known for its abundant wildlife and is still associated with “cheap and plenty meat” among people in nearby towns.

Yet contemporary hunters’ bags showed strong evidence of heavily depleted wildlife populations in the area around the village. To differentiate between the effects of hunting and habitat conversion/hunting this study will first compare the species profiles of the protected areas (Ankasa/Bia) with the Sui FR (effect of hunting), followed by a comparison of the Sui FR with farmland inside or adjacent to the Sui FR (effect of habitat conversion/hunting).

The harvest of bushmeat in the Sui FR was limited to 15 mammal species, indicating that 55% or 56%[1] of mammalian forest species present in nearby protected areas were locally extinct in the study area (Table 4.1). The high level of wildlife depletion was consistent across taxonomic groups (Table 4.2). Within each group the species with the highest body mass was absent in the Sui FR. The level of local extinction was especially high for primates and ungulates of which 70% and 63% of species, respectively, were absent, with only the smallest species still present. The bushmeat harvest was dominated by small-bodied species, consistent with high levels of wildlife depletion. Only one out of ten large-bodied species (>10kg) was present in the forest reserve (*Tragelaphus scriptus*), and this species may be on the brink of local extinction given its low harvest frequency (two animals in 18 months).

[1] depending on whether *Herpestes sanguinea* is included

Comparing wildlife species harvested from the Sui FR and adjacent farmland showed that 80% of the species present in the forest were absent in the farmland. The only species present in farmland but not in forest was *Thryonomys swinderianus*, a farmland species that was also not recorded in the protected areas. Of the four mammal species present in farmland, three were rodents and one (*Neotragus pygmaeus*) was an ungulate. None of the other taxonomic groups were present in farmland. Overall, these findings suggest a high level of wildlife depletion in the forests (primarily due to hunting) and an even higher impact of hunting/habitat modification on mammals in farmland.

A low harvest volume and the strongly skewed prey profile of the hunters' bags were further indications of highly depleted wildlife populations. The bushmeat harvest recorded over 791-recall days from both forest and farm comprised 208kg of biomass with a total sales value of US$308 (Table 4.3). Mammals were the most important prey group, comprising 82% of harvest value and 71% of biomass. However, nearly half the harvested mammal biomass was from the giant pouched rat (*Cricetomys emini*) alone. Overall, this species comprised 37% of total harvest value and 35% of harvested biomass and it was also the most commonly harvested species. This was followed by a number of medium- and small-bodied species that each contributed between 5-8% to the harvest value, *e.g.* African civet (*Civettictis civetta*), Maxwell's duiker (*Cephalophus maxwelli*) and molluscs. With the exception of molluscs, these species were very rarely harvested and their disproportionate contribution to the total harvest value was due to their relatively high body mass and consequently high sales prices.

Mammals were a more important prey group in forest than farmland (Table 4.3). Of a total of 18 taxa harvested across the landscape, 17 (94%) were harvested in forest and only nine (50%) in farmland. Further, mammals comprised 71% of all taxa harvested in forest, but only 33% of the taxa harvested in farmland. Perhaps not surprisingly, mammals comprised a larger share of total biomass harvested in forest (74%) than in farmland (61%).

Informal interviews with village elders and young hunters revealed that wildlife populations had been depleted for decades. Few people remembered seeing *Tragelaphus euryceros*, *Colobus vellerosus* or *Potamochoerus porcus* at all. Of those who did remember seeing these species, the last sightings occurred between ten and twenty years ago at which time these species were already considered rare. Among the younger generation of hunters, few had seen large-bodied mammals since their childhood.

Table 4.1.: Mammal species harvested in forest/farmland in Wansampo (WSP) and recorded during wildlife surveys in forest habitat in Ankasa and Bia (Source: Gatti 2009). Presence of species confirmed (C); presence of species possible according to unconfirmed sightings (P); species not recorded (–). Species ordered by descending body mass (according to Kingdon 1997).

English name	Latin name	Ankasa	Bia	WSP Forest	WSP Farm	Mass (kg)
Elephant	*Loxodonta africana*	C	C	–	–	2200.0
Bongo	*Tragelaphus euryceros*	C	C	–	–	322.5
Red river hog	*Potamochoerus porcus*	C	C	–	–	80.0
Yellow-backed duiker	*Cephalophus sylvicultor*	C	C	–	–	62.5
Leopard	*Panthera pardus*	C	–	–	–	55.0
Bushbuck	*Tragelaphus scriptus*	C	C	C	–	55.0
Western chimpanzee	*Pan troglodytes verus*	C	C	–	–	32.5
Black duiker	*Cephalophus niger*	C	C	–	–	20.0
Crested porcupine	*Hystrix cristata*	C	–	–	–	19.5
Bay duiker	*Cephalophus dorsalis*	C	C	–	–	19.5
Black-and-white colobus	*Colobus vellerosus*	P	P	–	–	11.5
White-naped mangabey	*Cercocebus atys lunulatus*	C	–	–	–	8.3
Maxwell's duiker	*Cephalophus maxwelli*	C	C	C	–	8.0
Grasscutter[a]	*Thryonomys swinderianus*	–	–	–	C	6.7
African civet	*Civettictis civetta*	C	C	C	–	6.0
Roloway monkey	*Cercopithecus diana roloway*	P	–	–	–	5.5
Lowe's monkey	*Cercopithecus lowei*	C	C	–	–	4.4
Olive colobus	*Procolobus verus*	C	C	–	–	4.4
Marsh mongoose	*Atilax paludinosus*	C	C	–	–	3.6
Lesser spot-nosed monkey	*Cercopithecus p. petaurista*	C	C	C	–	3.3
Tree hyrax	*Dendrohyrax dorsalis*	C	C	C	–	3.0
Brush-tailed porcupine	*Atherurus africanus*	C	C	C	–	2.8
Long-tailed pangolin	*Uromanis tetradactyla*	C	C	–	–	2.7
African palm civet	*Nandinia binotata*	C	C	–	–	2.6
Tree pangolin	*Phataginus tricuspis*	C	C	C	–	2.4
Royal antelope	*Neotragus pygmaeus*	C	C	C	C	2.3
Pel's anomalure[b]	*Anomalurus peli*	C	C	C	–	1.6
Common cusimanse	*Crossarchus obscurus*	C	C	C	–	1.3
Bosman's Potto	*Perodicticus potto*	C	C	C	–	1.2
Giant pouched rat[b]	*Cricetomys emini*	C	C	C	C	1.1
Giant squirrel[b]	*Protoxerus stangeri*	C	C	C	–	0.8
Beecroft's anomalure[a]	*Anomalurus beecrofti*	C	C	–	–	0.7
Slender mongoose[c]	*Herpestes sanguinea*	?	?	C	–	0.6
Squirrel[d]	various	C	C	C	C	0.3
Demidoff's galago	*Galagoides demidovii*	C	C	–	–	0.1

[a] A farmland species not commonly occurring in forests
[b] Presence confirmed by Sylvain Gatti during personal communication
[c] Likely present in the protected areas but could not be identified from tracks (Sylvain Gatti, personal communication)
[d] Treated as one species when estimating the level of local extinctions due to lack of detailed data

Table 4.2.: Mammal species harvested in forest/farmland in Wansampo (WSP) and recorded during wildlife surveys in forest habitat in Ankasa and Bia (Source: Gatti 2009). Presence of species confirmed (C); presence of species possible according to unconfirmed sightings (P); species not recorded (–). Species ordered by taxonomic group and descending body mass (according to Kingdon 1997).

Taxa	English name	Ankasa	Bia	WSP Forest	WSP Farm	Mass (kg)
Rodents	Crested porcupine	C	–	–	–	19.5
	Grasscutter	–	–	–	C	6.7
	Brush-tailed porcupine	C	C	C	–	2.8
	Pel's anomalure	C	C	C	–	1.6
	Giant pouched rat	C	C	C	C	1.1
	Giant squirrel	C	C	C	–	0.8
	Beecroft's anomalure	C	C	–	–	0.6
	Squirrel (various)	C	C	C	C	0.3
Carnivores	Leopard	C	–	–	–	55.0
	African civet	C	C	C	–	6.0
	Marsh mongoose	C	C	–	–	3.6
	African palm civet	C	C	–	–	2.6
	Common cusimanse	C	C	C	–	1.3
	Slender mongoose	?	?	C	–	0.6
Pholidotes	Long-tailed pangolin	C	C	–	–	2.7
	Tree pangolin	C	C	C	–	2.4
Afrotheria	Elephant	C	C	–	–	2200.0
	Tree hyrax	C	C	C	–	3.0
Ungulates	Bongo	C	C	–	–	322.5
	Red river hog	C	C	–	–	80.0
	Yellow-backed duiker	C	C	–	–	62.5
	Bushbuck	C	C	C	–	55.0
	Black duiker	C	C	–	–	20.0
	Bay duiker	C	C	–	–	19.5
	Maxwell's duiker	C	C	C	–	8.0
	Royal antelope	C	C	C	C	2.3
Primates	Western chimpanzee	C	C	–	–	32.5
	Black-and-white colobus	P	P	–	–	11.5
	White-naped mangabey	C	–	–	–	8.3
	Roloway monkey	P	–	–	–	5.5
	Lowe's Monkey	C	C	–	–	4.4
	Olive colobus	C	C	–	–	4.4
	Lesser spot-nosed monkey	C	C	C	–	3.3
	Bosman's potto	C	C	C	–	1.2
	Demidoff's galago	C	C	–	–	0.1

Table 4.3.: Bushmeat harvest recorded in 791 interviews using 24 hour recall period (percentages are per habitat).

Species	Forest				Farmland			
	No. interview (method)[a]	No. animals	Value in US$ (% of total)	Mass in kg (% of total)	No. interview (method)[a]	No. animals	Value in US$ (% of total)	Mass in kg (% of total)
Giant pouched rat	26 (g/d/t/h)	50	85.3 (34.2%)	55 (35.8%)	12 (t/h/d)	17	30 (50.4%)	18.7 (34.4%)
African civet	1 (g)	1	25.3 (10.2%)	6 (3.9%)	0	0	0 (0%)	0 (0%)
Tree pangolin	7 (t/h)	6.5	21.5 (8.6%)	15.6 (10.1%)	0	0	0 (0%)	0 (0%)
Maxwell's duiker	1 (t)	1	21.1 (8.5%)	8 (5.2%)	0	0	0 (0%)	0 (0%)
Snail	15 (h)	110	16.4 (6.6%)	22 (14.3%)	8 (h)	18	2.9 (4.8%)	3.6 (6.6%)
Pel's anomalure	5 (g)	6	16.9 (6.8%)	9.6 (6.2%)	0	0	0 (0%)	0 (0%)
Tree hyrax	4 (g/h/t)	3.5	16.9 (6.8%)	10.5 (6.8%)	0	0	0 (0%)	0 (0%)
Tortoise	11 (h/t)	12	12.5 (5.0%)	9.6 (6.2%)	2 (t)	2	2.5 (4.3%)	1.6 (2.9%)
Crab	5 (rt)	91	7.3 (2.9%)	4.6 (3.0%)	8 (rt)	77	6.5 (10.8%)	3.9 (7.1%)
Brush-tailed porcupine	1 (t)	1	10.1 (4.1%)	2.8 (1.8%)	0	0	0 (0%)	0 (0%)
Grasscutter	0	0	0 (0%)	0 (0%)	2	2	9.3 (15.6%)	13.4 (24.6%)
Fish	3 (rt)	14	1.1 (0.4%)	2.8 (1.8%)	3 (line/rt)	57	5.9 (9.9%)	11.4 (21.0%)
Squirrel	3 (t)	3	3.4 (1.4%)	0.9 (0.6%)	2 (t/h)	3	1.8 (3.0%)	0.9 (1.7%)
Slender mongoose	2 (t)	2	4.2 (1.7%)	1.2 (0.8%)	0	0	0 (0%)	0 (0%)
Lesser spot-nosed monkey	1 (g)	1	4.2 (1.7%)	3.3 (2.1%)	0	0	0 (0%)	0 (0%)
Bosman's potto	1 (g)	1	1.7 (0.7%)	1.2 (0.8%)	0	0	0 (0%)	0 (0%)
Crayfish	2 (rt)	6	0.6 (0.2%)	0.5 (0.4%)	1 (rt)	8	0.7 (1.1%)	0.7 (1.3%)
Bird	1 (t)	1	0.8 (0.3%)	0.2 (0.1%)	1 (h)	1	0.1 (0.1%)	0.2 (0.4%)
Attempted	8	n/a	n/a	n/a	22	n/a	n/a	n/a

[a] harvest methods recorded: t=terrestrial trap, rt=river trap, d=dog, h=hand, g=gun, line=fishing rod

4.5.2. How important are farms for bushmeat hunting?

The bushmeat harvest from farmland was substantial but the forest was the main source of bushmeat. Of the total bushmeat offtake, 19% of the harvest value and 26% of the biomass was derived from farmland while the remainder came from forest (Table 4.3). No bushmeat was harvested from residential areas.

There were two likely factors behind the low importance of bushmeat from farmland. First, farmland comprised a smaller part of the hunting area than forest, 20% and 80% respectively. However, this representation of habitats did not take into account differences in access rights. Hunting in forest was not regulated and access restrictions did not exist. On the other hand, hunting in farmland required the usufruct right to the land and as parts of the farmland within the hunting area were owned by neighbouring communities, the effective farmland area available to the surveyed households was less than the farmland cover figure of 20%. Thus, while the greater cover of forest in the hunting area may contribute to its greater importance in the bushmeat harvest, it also appears that the bushmeat harvest per unit area may have been disproportionately higher in farmland. Secondly, the profitability of hunting was substantially lower in farmland (US$1.9/ household/day±0.3 SE) than in forests (US$4.0/household/day±0.6 SE) (ΔAIC_N=7.2, N=94). Surprisingly, there was limited statistical support to show whether the difference in profitability was due to a higher sales price:biomass ratio or higher biomass harvest/day in forests than farmland ($\Delta AIC_N \leq 2.5$ in both cases), despite summary statistics indicating about 30% higher sales price:biomass ratio and biomass harvest/day in forest than farmland

In summary, the greater extent of forest cover appears to be the primary reason for the greater contribution of forest to bushmeat sales, but a higher sales:mass ratio and harvest/day may also apply to hunting in forest. While the data are suggestive (and consistent with the higher mammalian species richness of forests) the statistical models do not allow us to confirm that this is the case.

Yet despite the easier access and some indication for higher profitability of hunting in forests, hunting in farmland was common (33% of all harvest events) with a high level of participation among households (50% of hunting households harvested bushmeat in farmland) (Table 4.4). To understand this apparently irrational behaviour it is useful to consider the wider agricultural setting of bushmeat hunting in Wansampo.

Table 4.4.: Total bushmeat harvested, the number of harvest events and the number of households (HHs) harvesting bushmeat across habitats and methods.

	Farm			Forest		
Method	Mass (%)	Events	HHs	Mass (%)	Events	HHs
Land						
Trap	47.4	11	8	41.5	30	18
Hand	11.2	11	9	22.6	20	14
Dog	7.1	2	2	19.3	11	6
Gun	0	0	0	15.7	8	5
River						
Trap	12.9	8	4	0.8	1	1
Fishing line	21.5	1	1	0	0	0
Total	100.0	31	19	100.0	63	30

4.5.3. How are hunting activities integrated into agricultural livelihoods?

This study took place in an agrarian society among hunters who were primarily farmers and spent most of the time working on their farms. Farm work took place on six days a week and Sundays were used for resting and attending church services. During a working day, farmers started walking to their farms around 8am and returned between 2pm and 4pm. Access to forests during such days was limited. Although a farmer might travel through forest to reach his/her farm, this would involve no more than one hour walking through forest and another hour back, and often it would be considerably less.

In this context it may be no surprise that 90% of bushmeat harvest events in farmland were opportunistic and occurred in conjunction with farm work. Examples of such harvest activities included checking farm traps during breaks, gathering snails encountered during farm work or collecting animals flushed out of hiding and killed by the hunter's dog.

In accordance with farming hours, the vast majority of harvest events took place in the morning or afternoon, with little difference in the timing of harvests between farmland and forests (Table 4.5). Notably, very few hunts occurred during the night and these were limited to forests.

Table 4.5.: The percentage of bushmeat harvest events in farmland and forest taking place at different times of the day.

	Habitat	
Time of day	Farm	Forest
Morning	35%	52%
Afternoon	45%	38%
Evening	20%	8%
Night	0%	2%

In terms of hunting techniques used, trapping was the single most important method for harvesting bushmeat, in both farmland and in forests, (47% and 42% of biomass offtake per habitat respectively) (Table 4.4). In forests, gathering of animals, and dog and gun hunting were also important but the harvest of bushmeat from rivers was negligible. Interestingly, river trapping and fishing were important methods of harvesting bushmeat in farmland, although the importance of fishing was strongly influenced by a single large catch. Gathering of animals was also a common harvest method in farmland but dog hunts were rare in farmland compared to more frequent occurrence in forests.

Overall, the evidence suggests an integration of farm work and bushmeat hunting that was aimed at effort minimisation, making it an efficient complementary activity with minimal opportunity cost. Non-opportunistic bushmeat harvesting in farmland (10% of events) was generally limited to farms and gardens within the vicinity of the village that required little effort to reach. In contrast, the majority (69%) of bushmeat harvesting in forests occurred during explicit hunting trips that were not linked to other activities. Opportunistic harvests in forests (27% of events) took place on the way to or from the farm when encountering animals in low hanging branches, *e.g. Phataginus tricuspis*, or along the forest edge, *e.g. Kinixys belliana*. A further 4% of opportunistic bushmeat harvests in forests happened when the main purpose for the trip was to collect raffia leaves or mushrooms.

Trapping was the single most important hunting method in farmland, yet traps in farmland were restricted to 6% of farms and the vast majority of traps in farmland (88%) were positioned along the farm-forest boundary rather than inside the farm. While this shows that few traps were set inside farms and hunters had a preference for setting traps along the boundary, we do not have detailed enough data to conclusively say whether the high level of boundary trapping reflected the spatial distribution of farms, *i.e.* high percentage of farms were adjacent to the forest, or whether it was disproportionate.

Crop damage was not an important incentive for setting traps in farmland or along the farm-forest boundary. Hunters questioned about their motives for trapping in farmland were unanimous in their response that they wanted to "get meat". No hunter stated that traps were set to prevent crop damage. Instead, where crop damage was of concern, people would use poisoned baits to kill crop pests, the most common pests being squirrel and giant pouched rat. Further, the low number of farms with traps strongly contrasted with the high level of reported damage. Crop damage was common and reported for 77% of farms for which data were available (Table 4.6). A total of 79% of households perceived heavy damage to their crops from wildlife in at least one of their farms. Overall, heavy crop damage was reported in 76 farms, corresponding to four times the total number of farms in which traps were set.

Another way in which hunting was integrated into farming activities was the harvest of crustaceans and fish from small streams flowing through farms. This source of bushmeat was available during the rainy season when rivers that had dried out during the dry season filled with water and provided a reliable source of crabs, crayfish and fish. This harvest could easily

Table 4.6.: Perceived level of crop damage in farms as stated by farm owners (N=48 households and 189 farms).

Crop damage	No. farm (%)	No. households (%)
none	43 (23%)	26 (54%)
weak	53 (28%)	28 (58%)
medium	17 (9%)	12 (25%)
heavy	76 (40%)	38 (79%)

be integrated into normal farm work, as traps could be checked at any time during the day. It was also a reliable source of bushmeat yielding some harvest most days. While aggregate statistics indicate that fishing was more important than using river traps (Table 4.4), this was due to a single harvest of several kg of fish and is likely an over-representation of this method's importance to households.

4.6. Discussion

High levels of wildlife depletion were found in this farm-forest mosaic, with evidence for the local extinction of the largest species across all taxonomic groups. The loss of species was found to be more marked on farmland than forest, presumably reflecting the effects of habitat modification as well as hunting. Unsurprisingly, given that forests covered a larger area and contained more species, most hunting occurred in forests. However, bushmeat harvest from farmland was higher than expected, apparently because most hunting was opportunistic and integrated with agricultural activities. Contrary to common perception, there was no evidence that such farmland hunting was carried out to control crop raiding. The following discussion focuses on three points: methodological issues in the assessment of wildlife depletion, the integration of hunting with agricultural activities, and the conservation value of cocoa farms.

4.6.1. Wildlife depletion

Overall, this study confirmed earlier wildlife surveys in Ghana's forest zone that indicated a high level of depletion of large-bodied mammals (Holbech, 1996; Barrie & Aalangdong, 2005) and primates in particular (Struhsaker & Oates, 1995; Whitesides & Oates, 1995; Abedi-Lartey, 1998; White & Berry, 2000), suggesting that the density of large-bodied mammals in Ghana may be among the lowest within the Upper-Guinean forest region (Barrie & Aalangdong, 2005).

However, one could argue that the high level of depletion recorded in this study was due to the use of hunters' bags as an indication of species' presence instead of wildlife surveys. While it is possible that not all mammalian species actually harvested by hunters were recorded and not all species present in the area may have been harvested these are unlikely to be causes for concern, for two reasons.

First, the accumulative species curve levelled off quickly (87% of species were recorded after the first 17% of interviews), suggesting that most harvested species were recorded in the interviews (see Figure A.1). There were no taboos prohibiting the harvest of certain species. The only existing bushmeat related taboo disallowed fathers' of twins to consume *Cricetomys emini* but this only applied to one household and the species was in fact the most commonly hunted bushmeat in the village.

Secondly, participatory monitoring methods are a common tool in conservation research, and hunter surveys are considered a reliable method for assessing species presence and even relative abundance (see Danielsen *et al.*, 2005, and studies in the same volume). The sales prices of large-bodied animals, such as *Tragelaphus scriptus* - exceeding US$100 in the village and US$300 in towns (Lars Holbech, personal communication 2011) - served as a strong incentive for local hunters to pursue rare animals despite the low chances of a successful harvest. Hunters penetrated deep into the forest when checking traps and gathering snails or other NTFPs and it was unlikely that large-bodied ground-dwelling species would have gone undetected. Several hunters stated that they set foot traps in an area as soon as they saw tracks of a large ungulate, suggesting that these species would have been harvested had they still been present. However, this is not to say that hunter surveys will have provided a perfect assessment of all wildlife species in the area. In particular, arboreal species are more problematic, since they cannot be identified from tracks and they may alter their behaviour towards a more elusive and cryptic anti-predator behaviour in order to evade hunters (see Watanabe 1981 and review in Cowlishaw & Dunbar 2000). Hence, it is possible that some primate species were not recorded, although the assessment of primate depletion closely matched results from an earlier wildlife survey in nearby unprotected areas (Holbech, 1996).

A further complication with assessing the level of wildlife depletion arises through the choice of baseline. Ideally, the effects of human land-use on wildlife are assessed by a comparison of wildlife abundance before and after the changes in land-use occur. Yet, longitudinal data are rarely available, requiring the use of contemporary snapshot data for both the human-modified landscape under investigation (in this case the Sui FR) and a corresponding landscape without human impacts as a “pristine“ control (in this case the protected areas). The problem inherent to this approach is that of ”unquantified shifting baselines“ in the control landscape, whereby the control site itself has been modified by human land-use resulting in the underestimation of the impacts of human activities on wildlife populations in the area under investigation (Gardner *et al.*, 2009). In fact, both protected areas used in this study experienced some level of hunting, resulting in the absence of *Procolobus badius waldroni* and possible two further species (*Colobus vellerosus* and *Cercopithecus diana roloway*), and a generally low abundance of most other mammals. While this highlights the difficulty of identifying appropriate controls and baselines, the comparison of presence/absence data carried out in this study should, at least, be more robust than comparisons involving abundance estimates (*e.g.* Parry *et al.* 2009b), given the relatively lower error rate in presence/absence data than in abundance data (Larson *et al.*, 2008). Nevertheless, due to the absence of a truly pristine control site, the local extinction of 55% of mammalian forest species will have been an underestimation of human land-use impacts in the Sui FR.

On a final methodological note, it may not be hunting alone that explains the observed differences in wildlife presence between the Sui FR and the two protected areas. The Sui FR had been logged on an industrial scale for several decades prior to the study and was still being logged when this study took place. Intensive and prolonged logging can have negative effect on wildlife abundance (Meijaard *et al.*, 2005). The species-specific response may vary with life-history traits (*e.g.* folivores may benefit from increased leaf production in logged forests and frugivores experience reduced food availability) with some species declining in density under intensive logging, but there is little evidence that even intensive logging alone, *i.e.* in the absence of hunting, results in local extinctions (see reviews on primates (Plumptre & Grieser Johns 2001) and ungulates (Davies *et al.* 2001)). While there is some uncertainty to the exact cause and effect relationships between human land-use and local extinctions in the Sui FR and there is a strong likelihood for synergistic effects of habitat disturbance/conversion and hunting, it is likely that high hunting pressure was the main driver of local extinctions among mammals in this study, as was also concluded by Plumptre (1996), Rumiz *et al.* (2001) and Wilkie *et al.* (2001).

4.6.2. Integrating hunting with agriculture

The Sui FR was the main source of bushmeat for hunters in Wansampo, reflecting the greater availability of forest habitat in the area and higher harvest value/day from forest than farmland. Yet hunting in farmland was common and bushmeat offtake in farmland appeared to be disproportionate to the size of the habitat available. This study suggests that farmers have efficiently integrated hunting in farmland in their agricultural activities by focusing on opportunistic trapping as the most important hunting method. While the importance of trapping in farmland is similar to forest, most harvest events in farmland were opportunistic and this strongly contrasts hunting patterns in forest, which were predominantly non-opportunistic. Similarly, opportunistic harvests are common among farmers in Central America. Among Mexican farmers, for example, opportunistic harvests comprised a third of all bushmeat harvested (Jorgenson, 1995; Leon & Montiel, 2008) and agriculturalists in Panama even harvested 66% of all bushmeat during opportunistic encounters in anthropogenic habitat (Smith, 2005). Trapping in farmland has been widely reported as a response among African forest farmers to offset the costs of crop losses due to wildlife (Caspary, 1999; Davies *et al.*, 2007). In this study, however, crop damage did not appear to be an important factor for hunting in farms. Instead, farm hunting seemed to be driven by an interest in harvesting bushmeat for household consumption and/or sale, and hunters used a passive form of hunting (trapping) rather than active forms of hunting (with guns or dogs) in order to integrate hunting activities with day-to-day farm work.

The question that arises is whether the observed hunting pattern is the result of an agricultural livelihood and/or an adaptation to high level of wildlife depletion. Oral history recalls that the community started as a hunting camp and people farmed food crops and bushmeat primarily for subsistence. Yet with the onset of cocoa farming and increasing market integration, facilitated by the road development in the 1960s, villagers realised that they could earn "more money" from the sale of cash crops than bushmeat and started to embrace an agricultural lifestyle. These days, cocoa is the main source of cash income (Chapter 7) and cocoa farms are a highly valued status symbol that enables economic development, provides secure land tenure and a heritage to pass on to the next generation (see Section 3.6.1 and Knudsen 2007). In contrast, bushmeat hunting is considered a low status activity that is associated with "small boys" and "sleeping in the bush". There is evidence that hunting in Ghana's forest zone can provide substantial incomes to ambitious hunters (Ntiamoa-Baidu, 1998) but this was not in line with the aspirations of people in this village whose livelihood was farming and who used bushmeat primarily as a safety net (Chapter 5). Hence, it appears that the efficient integration of hunting into agricultural activities, is primarily driven by the adoption of intensive and time consuming cocoa farming, rather than a result of high levels of wildlife depletion.

4.6.3. Low wildlife production in farmland

Overall, this study failed to support the ideas that a) bushmeat harvest in farmland can be more important than wildlife harvest from forests, and b) the relative importance of bushmeat harvest in farmland increases as the level of wildlife depletion increases. Instead this study confirms earlier studies conducted in habitat mosaics with abundant wildlife, which concluded that forest was the main source of bushmeat (Gavin, 2007; Parry *et al.*, 2009a).

Why is this the case? The hypothesis that the predominance of small-bodied animals in farmland results in higher wildlife production in farmland than forest (Robinson & Bennett, 2004) is based on the assumption of structurally diverse farmland that provides ample food supply to wild animals. In the study community, however, farmland is intensively managed with 45% of all farms being monoculture cocoa plantations (Table 2.5) that do not contain food crops and very little undergrowth for animals to hide and reproduce. Cocoa is a perennial crop and the trees may live for 50 years during which the farmer receives income from cocoa bean sales and the land does not revert to fallow. A further 36% of farms were allocated for food crop production that may provide better habitat for wildlife, however, most of the food crop farms were inside an agroforestry area (taungya) that was distant from other farms. Since the cultivation of food crops is the responsibility of women, men rarely ventured to the taungya and setting traps there would have been extra effort that few men were willing make. Only five percent of farms had extensive coverage of forest or secondary regeneration and this was primarily due to labour shortage. As such the findings of this study may differ from other areas of purely shifting cultivation, due to the permanence of the cocoa fields.

Cocoa agroforests can harbour a rich fauna of birds (Van Bael *et al.*, 2007; Harvey & Gonzalez, 2007; Faria *et al.*, 2007), bats (Faria *et al.*, 2007; Harvey & Gonzalez, 2007), insects (Delabie *et al.*, 2007) and amphibians (Faria *et al.*, 2007). However, not all cocoa farms are grown using agroforestry techniques and the extent to which forest fauna can survive in the cocoa farm is likely to be strongly dependent on the structural diversity of the cocoa farms and the associated food resources available to wildlife (Cassano *et al.*, 2008; Tscharntke *et al.*, 2011). Cocoa farms can be roughly divided into two categories; (a) “shaded“ cocoa farms with a high level of structural diversity and food availability in a traditional cocoa agroforest, and (b) ”un-shaded“ cocoa farms that are intensively managed monoculture cocoa plantations where forest trees have been removed and cocoa trees form the only canopy. ’Shaded’ cocoa farms were largely absent in the study area (personal observation) and are uncommon in Ghana’s Western Region as a whole. This region has the highest level of cocoa farms receiving zero-to-light shade (79% of farms compared to 50% in other parts of the country (Gockowski

& Sonwa 2008)) and as such resembled the intensively managed cocoa landscapes in south-east Asia and neighbouring Côte d'Ivoire, which are known to harbour little biodiversity (Ruf & Schroth, 2004). Indeed, intensively managed cocoa plantations with low structural diversity within the canopy, low abundance of food resources, and a scarcity of understorey vegetation for animals to hide in have been shown to provide poor habitat for wildlife (Siebert, 2002).

Chapter 5

The importance of bushmeat in the livelihoods of West African cash-crop farmers living in a faunally-depleted landscape

5.1. Summary

(1) Bushmeat is an important resource in the livelihoods of rural communities in sub-Saharan Africa and may be a crucial safety-net for the most vulnerable households, especially during times of economic hardship.

(2) To explore this possibility, this study tested the hypotheses that: (a) vulnerable households harvest more bushmeat; (b) bushmeat contributes a greater proportion to household production in vulnerable households; (c) bushmeat is more important for cash income than consumption in vulnerable households; and (d) bushmeat sales are more important for vulnerable households.

(3) The study took place over a twelve-month period among 63 households with diversified livelihoods living in a Ghanaian cocoa-farming community in a wildlife depleted landscape. Repeated socio-economic questionnaires (N=787) elicited household production, including bushmeat harvest and use thereof, monetary expenditures and meat/fish consumption using a combination of 24h- and two-week-recall periods. GLMMs were used for statistical analyses, interpreted using an information theoretic approach.

(4) The bushmeat harvest value averaged less than US$ 1.0 per day for 89% of households and comprised less than 7% of household production value. Household wealth and gender of the household head had little effect on the importance of bushmeat. However, bushmeat harvest and sales were highest during the agricultural lean season. Overall, most harvested bushmeat was consumed (64%) and enabled households to spend 30% less on meat/fish purchases.

(5) These findings suggests that, despite wildlife depletion, bushmeat can continue to have an important role in rural livelihoods by acting as a safety net for income smoothing and reducing household expenditure during times of economic hardship.

5.2. Introduction

There is growing awareness of the importance of ecosystem services such as the harvest of non-timber forest products (NTFP) for rural communities in developing countries (Cavendish, 1999a; Campbell *et al.*, 2002; TEEB, 2010). An estimated 1.6 billion people depend partly or fully on forest products to sustain their livelihoods (World Bank, 2004). Where income-generating livelihood options are scarce, the sale of NTFPs is often the only means to earn a cash income (Arnold & Ruiz-Perez, 1998). This suggests a link between NTFP harvest and poverty alleviation, which has recently gained increasing attention in conservation, development and policy circles (*e.g.* Roe 2010) and funding bodies (NERC, 2006).

Bushmeat is an important NTFP throughout sub-Saharan Africa, worth millions of dollars in trade (Milner-Gulland *et al.*, 2003). It has many properties favourable to commercialisation, such as high price-to-volume ratio and flexible allocation of labour inputs (Brown & Williams, 2003; Milner-Gulland *et al.*, 2003). Hunters supplying bushmeat to traders may exert strong bargaining power within the rural-urban commodity chain (Cowlishaw *et al.*, 2005a) and can gain incomes comparable to or higher than average local wages (Anadu *et al.*, 1988; Noss, 1997; Ntiamoa-Baidu, 1998; Tieguhong & Zwolinski, 2009). This suggests a potential role for bushmeat in poverty alleviation.

However, the importance of bushmeat for poverty alleviation is questionable for two reasons. Firstly, current bushmeat harvest levels are unsustainable and wildlife populations are declining throughout the tropics (Fa *et al.*, 2002; Corlett, 2007; Peres & Palacios, 2007). Estimated sustainable offtake levels are pegged far below current harvest levels in African forests (Fa *et al.*, 2002) and it is not clear whether a sustainable harvest would generate sufficient income to lift people out of poverty (Brown, 2007).

Secondly, evidence about the importance of bushmeat in rural livelihoods is primarily derived from studies conducted in environments with abundant wildlife and with few alternative opportunities for earning income. For example, a recent study in rural Equatorial Guinea showed that bushmeat is the only source of cash income for 59% of men in the village (Kumpel *et al.*, 2010b). This predominance of a single income source contrasts strongly with other sub-Saharan livelihoods studies, which show that income diversification is widespread, and that the importance of farm income and nonfarm income, of which bushmeat is a part, varies greatly across localities (Reardon, 1997). Hence wildlife depletion and increasing opportunity costs of bushmeat hunting due to a household's engagement in alternative income generating activities (Smith, 2005), may reduce the importance of bushmeat as a source of cash income and consequently its contribution to poverty alleviation.

On the other hand, the open access nature of bushmeat harvesting systems, the relatively low entry costs compared to other activities, and the flexible timing of hunting effort allocation, mean that bushmeat may be important to disadvantaged households, such as the rural poor or FHHs (Ambrose-Oji, 2003; Coomes *et al.*, 2004; Starkey, 2004; Brooks *et al.*, 2008), and to a wider cross-section of households during the agricultural lean season. The seasonality of tropical farming systems results in temporal fluctuations in income and production flows, thereby exposing households to income and consumption shortages (Upton, 1996). This is especially the case for poor and FHHs that hold limited capital assets and are restricted in their options for diversifying income and production sources (Ellis, 2000). Bushmeat has been shown to be of pivotal importance at times of acute shortage in the livelihoods of the most vulnerable by helping to overcome shortages of food consumption (Dei, 1989) and income (Falconer, 1990; de Merode *et al.*, 2004).

Few bushmeat studies have been conducted among diversified farming households living within a faunally-depleted environment (Bowen-Jones *et al.*, 2002) and their conclusiveness regarding the importance of bushmeat, especially for vulnerable households, is hampered by small sample sizes and/or short data collection periods, as well as a lack of focus on household vulnerability.

For example, Dei's (1989) study of cash-crop farmers living in a wildlife-depleted environment in Ghana was limited to 20 households. At the time, he concluded that bushmeat was important for consumption, especially for poor households during the lean season, although it was not an important source of income. Another study conducted recently in a nearby area by Crookes *et al.* (2007) sampled a larger number of households (388) during a brief period of two months during the lean season, and concluded that bushmeat was a major source of household income, providing 35% of total village income, compared to 25% from farming. In contrast, Bennett (2002) citing a number of southeast Asian studies, reported that households living in wildlife depleted forests did not depend on bushmeat for consumption, "because the resource is simply not there any more".

While it is difficult to draw conclusions from studies that vary in their depth of data collection and have been conducted at sites with varying degrees of wildlife depletion and access to alternative income sources, and at different times over the last few decades it nevertheless appears that depleted wildlife populations continue to support rural livelihoods, albeit to a lesser extent than where wildlife populations are abundant (Nielsen, 2006). Where attempts have been made to record socio-economic household characteristics (*e.g.* Dei 1989), it seems that the importance of bushmeat continues to be positively related to household vulnerability, *e.g.* chronically poor households, and in households with temporarily low income. However, overall the existing information about the importance of bushmeat to vulnerable households and particularly during the agricultural lean season is limited. This hampers the development of policy and management interventions to support rural livelihoods and conservation (Takasaki *et al.*, 2001).

To improve our understanding of the potential of bushmeat harvested from depleted wildlife populations to support vulnerable households (*i.e.* poor households and female-headed households), especially at times of economic hardship, this case study was based among

Ghanaian cocoa farmers with access to a diverse range of income and production sources, and living within a forest-farm landscape with impoverished wildlife. The study investigated the effects of vulnerability on the importance of bushmeat in households, hypothesising that (1) vulnerable households harvest more bushmeat; (2) bushmeat contributes a greater proportion to household production of vulnerable households; (3) bushmeat is more important for cash income than consumption in vulnerable households; and (4) bushmeat sales are more important for vulnerable households.

Table 5.1.: Hypotheses (H) and predictions (P) examining the importance of bushmeat harvested from depleted wildlife populations to cocoa farming households with diversified livelihoods

Hypothesis & predictions[a]	
H1: Bushmeat harvest increases with vulnerability. Bushmeat harvest is[b]	
P1.1	higher in the lean season
P1.2	higher in poorer households, (P1.21) especially in the lean season
P1.3	higher in FHHs, (P1.31) especially in the lean season
H2: Importance of bushmeat in household production increases with vulnerability[c]	
P2.1	higher in the lean season
P2.2	higher in poorer households
P2.3	higher in FHHs, (P2.31) especially in the lean season
H3: Bushmeat consumption decreases with vulnerability[b]	
P3.1	lower in the lean season
P3.2	lower in poorer households, (P3.21) especially in the lean season
P3.3	lower in FHHs, (P3.31) especially in the lean season
P3.4	Consumption of harvested bushmeat reduces consumption of purchased meat/fish
H4: Bushmeat sales increase with vulnerability[d]	
P4.1	higher in the lean season
P4.2	higher in poorer households, (P4.21) especially in the lean season
P4.3	higher in female headed households, (P4.31) especially in the lean season

[a] It was not possible to test for interaction between household wealth and seasonality, because GLMM failed to estimate fixed effect estimates as a result of perfect separation of 0s and 1s in some cells, *i.e.* wealthiest households always consumed all harvested bushmeat and households from all wealth categories except the poorest always consumed all harvested bushmeat during the cocoa season

[b] Predictions 1.1-1.3 and 3.1-3.3 were tested using a two-step approach that first assessed the likelihood of an event occurring (suffix ’a’) and then the scale of positive responses (suffix ’b’)

[c] Predictions 2.1-2.3 were only tested for the scale of the response (suffix ’b’), because assessing the likelihood of bushmeat contributing to household production would have repeated our analysis of the likelihood of bushmeat harvest

[d] Predictions 4.1-4.3 were only tested for the likelihood of an event occurring (suffix ’a’) because it was expected that the binary responses about bushmeat sales were more accurate than the exact value due to the two-week recall period used during this analysis

5.3. Methods

5.3.1. Assessing bushmeat harvest and use

Information on bushmeat harvest and use pattern was collected as part of a general socio-economic household survey using semi-structured interviews. All hunting data were collected using 24hr and two-week recalls. Bushmeat was defined broadly, including wild animals such as mammals, birds, decapodes, pulmonates and testudines. During each interview bushmeat harvest and use of the harvest were elicited. If a harvest event had taken place, the recorded data included the hunter ID (person who harvested animal), species harvested, number of animals harvested and sale price in the village. Interviewees were used to buying and selling agricultural products and bushmeat in the village and were familiar with local prices. For each harvest event, interviewees were further questioned as to whether the harvest was for consumption by household members, sale to non-household members or a gift to non-household member. We did not differentiate between past and planned use, *e.g.* whether an animal harvested within the last 24 hours had already been consumed or would be consumed. On the other hand, bushmeat used during the recall period but harvested more than 24 hours prior to an interview was not recorded in this category. For each use category the respective value was recorded. If no animal had been killed within the last 24 hours, the interviewee was asked whether a harvest had been attempted, *i.e.* traps checked or a gun hunt performed.

5.3.2. Assessing household production

Estimates of the value of household production harvested within 24 hours prior to an interview were obtained by eliciting (a) farm production (farm produce that arrived at the house); (b) farm consumption (own production consumed in farm); (c) items produced within last 24 hours and already sold; and (d) items produced within the last 24 hours and already given away as a gift. All produce was valued by interviewees in local sales prices (for an assessment of price estimates see Section 3.5.3). To avoid underestimation of infrequent cocoa harvests, these were recorded using two-week recalls and the value divided by 14 to obtain daily production estimates.

5.3.3. Assessing household expenditure

Interviewees were asked to state all monetary expenditures incurred within the last 24 hours. To elicit infrequent large expenditures two-week recalls were employed on single event expenditures, *i.e.* not accumulative over the period, exceeding US$ 4.22 (50,000 Cedis). The threshold was judged appropriate for large infrequent expenditures and was confirmed as such by informants. For all expenditures the proportion of value used for consumption, sale and gifts was recorded.

5.3.4. Assessing meat/fish consumption

Meat consumption surveys started by asking interviewees about the type and monetary value of meat consumed by household members for dinner, breakfast and lunch within the last 24 hours. While recording the specific value for each meat type and meal, these data were then cross-checked with data on wildlife harvest and household meat expenditure for the same period. Subsequently, recorded values were checked against gift exchange data for the same period and consumption estimates were discussed with interviewees if mismatches were observed. For every record of meat consumed by household members it was also recorded whether it entered the household through purchase, own production, *e.g.* harvest of bushmeat, or as a gift. The majority of purchased meat consumed, was bought from traders in the village on a daily basis, which aided the data collection.

5.3.5. Data analysis

The analysis was based on a total of 787 interviews from 63 households with complete data for the variables assessed. The analysis focused on five household response variables: the bushmeat harvest, the contribution of bushmeat to household production, the consumption and sale of harvested bushmeat and the consumption of meat/fish (Table 5.2).

The independent variables assessed during the analyses were household wealth, agricultural seasonality, gender of the household head and consumption of harvested bushmeat (Table 5.3). To control for the confounding effects of household demographics and composition, four additional variables were included as fixed effects in the models (Table 3.9).

To assess the effect of bushmeat harvest on meat/fish expenditures, consumption of harvested bushmeat was used as a proxy. This was necessary because a) bushmeat harvest within the last 24 hours commonly occurred during the same day as the interview, but b) most interviews were conducted before dinner time and therefore collected data on the previous night's dinner. Therefore it was not possible to assess the effect of bushmeat harvest on meat expenditure pattern directly but only to examine the effect of the consumption of harvested bushmeat, *i.e.* more than 24 hours prior to an interview, on the consumption of purchased meat, *i.e.* purchased more than 24 hours prior to an interview, during previous night's dinner.

Table 5.2.: Response variables used during GLMM analyses

Variable	Explained[a]
Bushmeat harvest	(1) bushmeat was harvested in last 24 hours (yes/no); (2) monetary value of bushmeat harvested in last 24 hours (continuous variable)
Proportion of production value	(1) proportion of the total household production value obtained in last 24 hours derived from bushmeat harvest (continuous variable)
Bushmeat consumption	(1) all or part of bushmeat harvested within last 24 hours was intended (or already used) for consumption by household members (yes/no); (2) monetary value of bushmeat harvested within last 24 hours intended (or already used) for consumption (continuous variable)
Bushmeat sales	(1) all or part of bushmeat harvested within the last two weeks was sold (yes/no)[b]
Meat consumption	(1) purchased meat/fish was consumed by household members at the last dinner (yes/no); (2) monetary value of purchased meat/fish consumed by household members at last dinner (continuous variable)

[a] All analyses were conducted using 24hr recall data except the analyses of bushmeat sales pattern which were based on two-week recall data. This was necessary because bushmeat sales were rare events preventing meaningful analysis of 24hr recalls
[b] No interviewee stated that he had not used bushmeat harvested within the last two weeks

Table 5.3.: Independent variables used during GLMM analyses

Variable	Explained
Household wealth	four factor levels (1=wealthiest to 4=poorest)
Season	three factor levels (before-, during-, and after-cocoa season)
Gender of household head	two factor levels (female & male)
Bushmeat consumption	bushmeat harvested by a household member was consumed at previous night's dinner: two factor levels (yes/no)

5.4. Results

On days when bushmeat was harvested, the average value was US$3.2/household/day (±US$4.1 SD), ranging from US$0.04/household/day for a single crab or snail to US$25.3/household/day for the harvest of a highly prized large African civet (see also Table A.10). However, across the whole survey period, harvest value averaged US$0.4/household/day (±US$1.75 SD). Only 5% of households harvested bushmeat with a mean daily value higher than the national minimum salary (US$2.24/day) and a further 5% of households harvested bushmeat worth more than half the minimum salary. Hence, 90% of households harvested bushmeat worth less than half the minimum salary.

5.4.1. Bushmeat harvest

To assess the relationship between vulnerability and bushmeat harvest, the evidence for an effect of income seasonality, household wealth and gender of the household head on the likelihood of harvesting bushmeat (Table 5.5) and the value of the bushmeat harvest (Table A.5) were examined.

Overall there was good support for an effect of income seasonality and gender of the household head but not household wealth on the likelihood of bushmeat harvest (Table 5.5). However, there was no evidence to suggest that any of the three variables affected the value of bushmeat harvested per day (Table A.5). First, income seasonality had a strong effect on the likelihood of a household harvesting bushmeat but no effect on the value harvested (rejecting Prediction 1.1b, ΔAIC_N=0, see Table A.5). Bushmeat harvest was most likely before and after the cocoa season and least likely during the cocoa season, confirming Prediction 1.1a (Figure 5.1).

Table 5.4.: Bushmeat harvest recorded over 9870 sampled days (705 interviews conducted using 14-days recall)

		Male households			Female households		
Species name	Scientific name	# interviews	# animals	Value (US$)	# interviews	# animals	Value (US$)
Giant pouched rat	*Cricetomys emini*	150	532	881.2 (40.8%)	20	55	92.6 (45.5%)
Tortoise	various	53	155	182.8 (8.5%)	5	8	13.9 (6.8%)
Maxwell's duiker	*Cephalophus maxwelli*	5	7	181.3 (8.4%)	0	0	0 (0%)
Flying squirrel	*Anomalurus pelii*	10	38	142.1 (6.6%)	1	1	3.8 (1.9%)
Tree pangolin	*Phataginus tricuspis*	32	36	139.1 (6.4%)	5	4.5	14.8 (7.2%)
Tree hyrax	*Dendrohyrax dorsalis*	27	32	121.8 (5.6%)	3	7	27.8 (13.7%)
Brush-tailed porcupine	*Atherurus africanus*	14	15	108.8 (5.0%)	2	2	16.9 (8.3%)
Crab	various	23	1154	79.3 (3.7%)	1	15	1.3 (0.6%)
Grasscutter	*Thryonomys swinderianus*	8	8	52.3 (2.4%)	1	1	2.5 (1.2%)
Snail	*Archachatina spp*	48	485	42.6 (2.0%)	16	187	21.9 (10.8%)
Lesser spot-nosed monkey	*Cercopithecus petaurista*	3	3	42.2 (2.0%)	0	0	0 (0%)
African civet	*Civettictis civetta*	2	2	42.2 (2.0%)	0	0	0 (0%)
Potto	*Perodicticus potto*	5	10	27.8 (1.3%)	0	0	0 (0%)
Squirrel	various	21	26	24.8 (1.1%)	2	2	1.7 (0.8%)
Monitor lizard	*Varanus niloticus*	5	5	21.9 (1.0%)	0	0	0 (0%)
Royal antelope	*Neotragus pygmaeus*	3	3	20.2 (0.9%)	0	0	0 (0%)
Bird	various	6	7	18.5 (0.9%)	2	71	2.3 (1.1%)
Common cusimanse	*Crossarchus obscurus*	3	7	14.8 (0.7%)	0	0	0 (0%)
Slender mongoose	*Herpestes sanguinea*	3	4	8.4 (0.4%)	0	0	0 (0%)
Fish	various	7	32	6.3 (0.3%)	1	50	4.2 (2.1%)
Giant squirrel	*Protoxerus stangeri*	2	2	2.6 (0.1%)	0	0	0 (0%)
Crayfish	various	2	6	0.6 (0%)	0	0	0 (0%)

Table 5.5.: Results of binomial GLMM analysis testing the effects of household wealth, seasonality and gender of the household head on the likelihood of a household harvesting bushmeat within 24 hours prior to an interview (N=787; No. households=63). ΔAIC_i and Akaike weight are shown for all alternative models tested. The model controlled for the effects of household characteristics listed in Table 5.3.

Model	ΔAIC_i	Akaike weight
season+hhsex	0	0.46
hhsex	0.8	0.31
season*hhsex	3.2	0.09
wealth+season+hhsex	3.8	0.07
wealth+hhsex	4.6	0.05
wealth+season*hhsex	7.1	0.01
wealth*season+hhsex	9.9	<0.01
season	11.2	<0.01
null	12.1	<0.01
wealth*season+hhsex*season	13.3	<0.01
wealth+season	16.5	<0.01
wealth	17.4	<0.01
wealth*season	22.4	<0.01

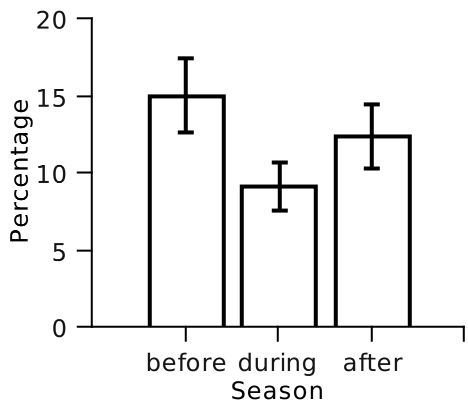

Figure 5.1.: Percentage of interviews recording bushmeat harvest within the last 24 hours across seasons (GLMM results in Table 5.5). Means and errors across households are shown.

Secondly, a household's likelihood of harvesting bushmeat was strongly dependent on whether the household head was male or female but the harvest scale was consistent across genders. Male-headed households were on average three times more likely to harvest bushmeat than the more vulnerable FHHs, rejecting Prediction 1.3a (Figure 5.2). Furthermore, while FHHs showed no discernible difference in their bushmeat harvest likelihood among seasons, thereby rejecting Prediction 1.31a, male-headed households were less likely to harvest bushmeat during the cocoa season than during the lean season (Figure 5.2). This demonstrated that the seasonal pattern that confirmed Prediction 1.1a was mainly due to the seasonal harvest pattern of male-headed households.

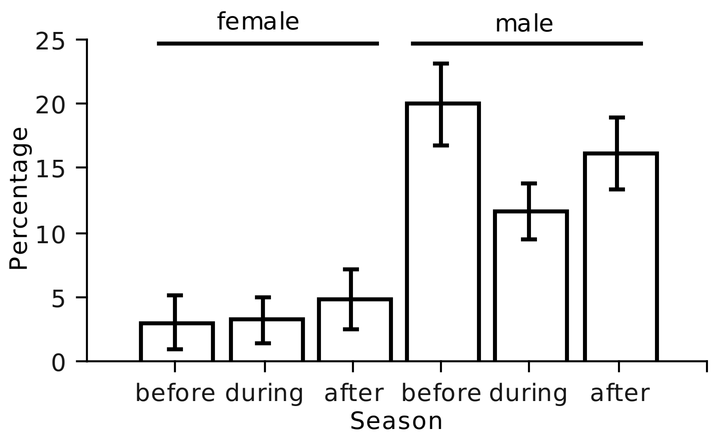

Figure 5.2.: Percentage of interviews recording bushmeat harvest within 24 hours prior to interviews for female- and male-headed households (GLMM results in Table 5.5). Means and errors across households are shown.

In contrast to Prediction 1.2, wealth had basically no effect on the likelihood of a household harvesting bushmeat, nor were poor households more likely to harvest bushmeat than wealthier households during the lean season, rejecting Prediction 1.21a.

5.4.2. Importance of bushmeat in household production

On days when bushmeat was harvested, it comprised 44% of household production value (median=34%; range=0.5% - 100%) but due to the relatively low frequency of harvesting, bushmeat only comprised 7% of total household production (median=0%; range=0% - 100%) across the year. Perhaps unsurprisingly, given this relatively low contribution to total household production and the lack of a seasonal pattern in the scale of bushmeat harvest, there was only marginal evidence for bushmeat to contribute more to household production during the lean season than during the cocoa season, and basically no evidence that bushmeat comprised a larger proportion of household production to poor households or FHHs (Predictions 2.1b - 2.3b), nor was bushmeat more important to FHHs during the lean season (Prediction 2.31b) (ΔAIC_N=1.78; N=97, see Table A.6).

5.4.3. Use of harvested bushmeat

Most harvested bushmeat was consumed within the hunter's household. Interviewees who harvested bushmeat within 24 hours prior to an interview reported the consumption of all or part of the harvest in 93% of interviews, sale in 19% of interviews and gift in 13% of interviews, suggesting that when bushmeat was sold or given away as gift, most households kept some for their own consumption. Of the total bushmeat value harvested 64% was consumed, 25% was sold and 10% was given away as gifts.

Considering the high prevalence of bushmeat consumption, it is perhaps not surprising that neither seasonality nor household wealth or gender of the household head affected the likelihood of consuming harvested bushmeat, rejecting Predictions 3.1a - 3.3a (ΔAIC_N=0, N=97, Table A.7). Similarly, there was no evidence for an effect on the scale of bushmeat consumption, *i.e.* the value of consumed bushmeat for days with positive bushmeat harvest, rejecting Predictions 3.1b - 3.3b (ΔAIC_N=0; N=86, Table A.8).

As harvested bushmeat was mainly consumed and there was no evidence for bushmeat consumption being more important for poor households or FHHs or during the lean season, it was hypothesised that the consumption of harvested bushmeat reduced household meat expenditure. Households consumed meat on a nearly daily basis (92% of interviews) and spent on average US$ 0.92/day (SD=1.41) on buying meat. This was equivalent to 42% of daily food expenditure and 29% of daily total household expenditure. Dinner was the main meal during the day and of the total meat value consumed, 91% was consumed during dinner.

The consumption of harvested bushmeat reduced the value of consumed purchased meat/fish (Table 5.6), suggesting that bushmeat harvest resulted in savings to the household, confirming Prediction 3.4a. When households consumed harvested bushmeat, only 31% of interviews recorded additional consumption of purchased meat/fish (Figure 5.3a). In contrast, 74% of households consumed purchased meat/fish for dinner in the absence of harvested bushmeat, with the remaining 26% consuming meat/fish gifts. Furthermore, on days when purchased meat/fish was consumed, additional consumption of harvested bushmeat reduced the value of meat/fish consumed by about 30%, confirming Prediction 3.4b (Figure 5.3b).

Table 5.6.: Results of binomial GLMM analysis testing the support for an effect of consumption of harvested bushmeat on the consumption of purchased meat/fish at previous night's dinner (N=694; No. households=63). ΔAIC_i and Akaike weight are shown for all alternative models tested. In addition to controlling for the effects of household characteristics listed in Table 5.3 the model also controlled for the effects of household wealth, seasonality and gender of the household head.

Model	ΔAIC_i	Akaike weight
bushmeat consumption	0	>0.99
null	63.83	<0.01

Table 5.7.: Results of GLMM analysis testing the support for an effect of consuming harvested bushmeat on the value of purchased meat/fish consumed at previous night's dinner (N=468; No. households=62). ΔAIC_i and Akaike weight are shown for all alternative models tested. In addition to controlling for the effects of household characteristics listed in Table 5.3 the model also controlled for the effects of household wealth, seasonality and gender of the household head.

Model	ΔAIC_i	Akaike weight
bushmeat consumption	0	0.97
null	6.95	0.03

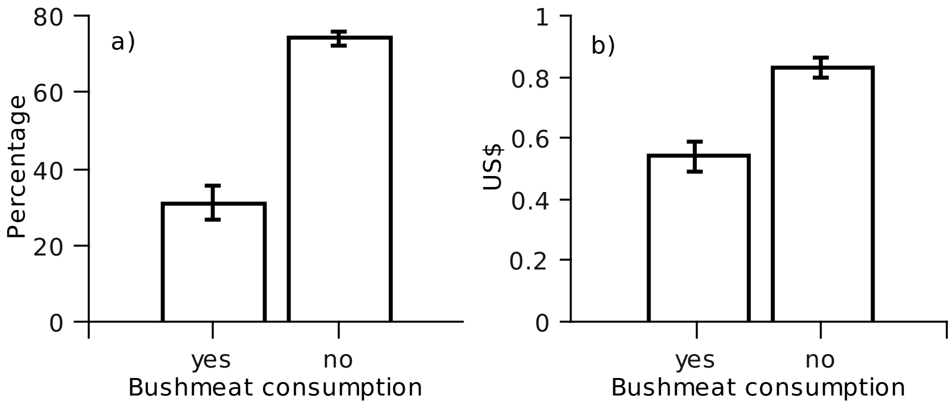

Figure 5.3.: Consumption of purchased meat/fish by household members at previous night's dinner in relation to whether harvested bushmeat was consumed: a) percentage of interviews reporting the consumption of purchased meat/fish (GLMM result in Table 5.6); b) value of purchased meat/fish (GLMM result in Table 5.7). Standard errors are shown.

In addition to bushmeat consumption reducing household expenditure, harvested bushmeat was more likely to be sold at the end of the lean season (when cocoa income was lowest) than during the cocoa season, with 41.8% of interviews reporting the sale of harvested bushmeat before the cocoa season, compared to 18.3% and 21.6% during and after the cocoa season respectively, confirming Prediction 4.1a (Table 5.8; Figure 5.4). However, there was no substantial evidence for bushmeat sales being more important for vulnerable FHHs or poor households than MHHs or wealthy households in general and particularly during the lean season, rejecting Predictions 4.2a - 4.3a.

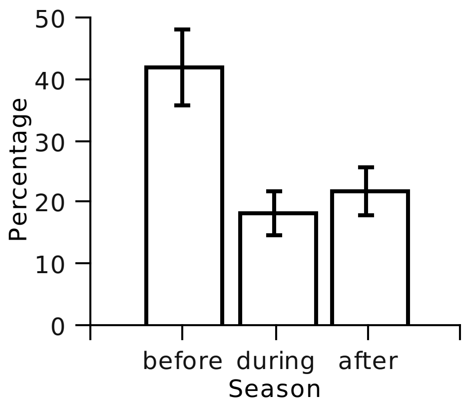

Figure 5.4.: Percentage of interviews recording sale (part or whole harvest) of bushmeat harvested in the last 24 hours (GLMM result in Table 5.8). Means and errors across households are shown.

Table 5.8.: Results of binomial GLMM analysis testing the support for an effect of household wealth, seasonality and household gender on the likelihood of a household selling all or part of bushmeat harvested within last two weeks (including all interviews recording bushmeat harvest in last two weeks: N=293; No. households=50). ΔAIC_i and Akaike weight are shown for all alternative models tested. The model controlled for the effects of household characteristics listed in Table 5.3.

Model	ΔAIC_i	Akaike weight
season	0	0.58
season+hhsex	1.9	0.23
wealth+season	3.6	0.10
wealth+season+hhsex	5.3	0.04
season*hhsex	5.6	0.04
wealth+season*hhsex	8.9	0.01
wealth*season	9.8	<0.01
wealth*season+hhsex	11.5	<0.01
null	13.1	<0.01
wealth*season+hhsex*season	15.0	<0.01
hhsex	15.0	<0.01
wealth	16.4	<0.01
wealth+hhsex	18.1	<0.01

5.5. Discussion

The analyses indicate that among cocoa farmers in a faunally-depleted environment, the value of harvested bushmeat is relatively low and contributes little to household production, yet there is evidence that bushmeat is important during the agricultural lean season and that it enables households to save money.

The vast majority (89%) of households harvested bushmeat worth less than US$1.0/day, which is substantially less than has been reported from sites with abundant wildlife. For example, rural Gabonese hunters earned US$2.61/AME/day and 72% of total income from bushmeat (Starkey, 2004) and trappers in the Central African Republic had average daily incomes between US$1.3 and 1.9/hunter (Noss, 1998a). But this study's estimates are comparable to depleted environments in Côte d'Ivoire where hunters gained US$195 per annum (Bassett, 2005), suggesting that the underlying reason for the low harvest and lack of overall importance in cocoa farmers production is wildlife depletion.

However, this conclusion is challenged by other studies conducted in Ghana that reported substantially higher incomes from bushmeat sales. Ntiamoa-Baidu (1998) interviewed hunters living in Ghana's forest and savannah zone during a one week period of the agricultural lean season and derived a national average income from bushmeat sales of US$3.2/hunter/day. Possible reasons for the divergent results between Ntiamoa-Baidu's study and the present study are that: a) wildlife populations have declined in the ten years between her study and this study; b) the short duration of her study during the agricultural lean season led to an unrepresentative estimation of seasonal bushmeat harvest; and c) a focus on hunters who expended higher effort than was the case for hunters in this study (see Whitham, 2009, for estimates of hunting effort in Wansampo).

The importance of hunting effort is highlighted by a recent study of a Ghanaian bushmeat market. Professional hunters who invest the time to transport bushmeat from rural areas to town were shown to earn up to US$6/day by selling a single grasscutter (*Thryonomys swinderianus*) (Cowlishaw *et al.*, 2005a), showing that bushmeat hunting within a landscape depleted of wildlife can be profitable provided hunters invest sufficient effort. In contrast, this study recorded bushmeat harvest and attempted harvest in only 20% of interviews and when an animal was killed, this was often the result of an opportunistic harvest, *e.g.* checking farm traps only when they were on the farm (see Chapter 4 and Whitham (2009)).

So why was the bushmeat harvest so low in Wansampo? Ghanaian cocoa farmers have long been known as rational peasants (Hill, 1956), who adjust their livelihood activities depending on their opportunity cost and relative profitability. For example, Gyimah-Brempong (1993), using longitudinal data to assess the supply-response function of Ghanaian cocoa production in relation to changes in the producer price of cocoa and net income from cocoa sales relative to food crop production, concluded that farmers' production decisions depended both on the price of cocoa and the profitability of food crop production relative to cocoa production. Unfortunately, this study did not collect detailed time budgets to assess the time available to cocoa farmers for hunting and the relative profitability of different livelihood activities.

However, it is likely that the low bushmeat harvest was due to both wildlife depletion, possibly most noticeable by the lack of a seasonal pattern in the value of bushmeat harvested, and by the high opportunity costs of bushmeat hunting due to high labour demands on cocoa farms that affects the frequency or likelihood of a bushmeat harvest.

However, despite severe wildlife depletion and the low value of bushmeat harvests, this study found a positive relationship between income seasonality and bushmeat offtake and use. Households harvested bushmeat more frequently during the lean season, when households earned least cash income (see Chapter 7), suggesting that bushmeat may provide a buffer against the effects of income shortage. Similar responses to seasonal income shortages have been reported among hunters (de Merode *et al.*, 2004; Perla & Salvador, 2008), fishers (Brooks *et al.*, 2008) and NTFP gatherers in general (Falconer, 1990).

It could be argued that seasonal variation in bushmeat harvest was due to the timing of the planting season and farmers wanting to protect their newly planted food plants from crop damage (*e.g.* Davies *et al.* 2007). This is a possibility but unlikely to be an important reason in Wansampo, as most bushmeat was killed in forest rather than farmland (Whitham, 2009, and Chapter 4). Some farmers have been shown to increase hunting effort during periods of low labour requirements and one could argue that cocoa farmers are busiest during the cocoa season, resulting in low bushmeat harvest at this time. However, previous research in Ghana has shown that for cocoa farmers the opposite patterns prevails, as they spend more days per month in their farms during the lean season than the cocoa season due to high labour demand for weeding (Okali, 1975). Similarly, recent evidence from a large scale cocoa farmer survey in Ghana reported that the busiest months each year are August to November (before and during the cocoa season in this study) and the least busy months are January to May (during and after the cocoa season) (Hainmueller *et al.*, 2011). Hence, there is no strong evidence to suggest that seasonal variation in bushmeat harvest was due to variation in farm labour requirements.

The safety net function of bushmeat is further emphasised by showing that consuming harvested bushmeat reduces household expenditure on meat/fish purchases. Increasing the bushmeat harvest frequency during the lean season enables households to consume bushmeat more often during this period of income shortage (see Chapter 6) and thereby save money when cash income is lowest. Similarly, Coad *et al.* (2010) recorded that rural hunters in Gabon spent less money on buying food as their bushmeat harvest increased, thereby freeing up money to buy other items. Reducing cash expenditure is especially important during the agricultural lean season, to provide money for essential services, such as hospital bills.

The value of harvested bushmeat per day (with positive bushmeat harvest) was constant across seasons, however, the sale of part or the whole bushmeat harvest was most likely during the lean season (see also de Merode *et al.* 2003), thereby providing income during a time of cocoa income shortage and helping households to smoothen seasonal income fluctuations. This confirms previous studies assessing bushmeat hunting and NTFP harvest in general in relation to income shortage (Falconer, 1990; de Merode *et al.*, 2004; Brooks *et al.*, 2008; Perla & Salvador, 2008). Hunters commonly sell more of their catch as their harvest increases (Coad *et al.*, 2010; Kumpel *et al.*, 2010b), but this selling of a surplus does not seem to be the case in this study. While it was not possible to test for a seasonal pattern in the value of bushmeat sales due to data limitations, the fact that on the one hand daily harvest value was constant across seasons but on the other hand the likelihood of selling and consuming (see Chapter 6) harvested bushmeat was highest during the lean season, strongly suggests that during the lean season hunters sold part of the already small catch, while during the cocoa season they were more likely to consume the whole catch, as they had income from cocoa sales.

Overall, these findings substantiate earlier studies that bushmeat is an important safety net, whose primary importance lies more in timing than magnitude of use (Arnold & Ruiz-

Perez, 1998). The seasonal safety net function of bushmeat therefore appears to be resilient to reductions in the abundance of wildlife and availability of high value large-bodied animals.

While this study highlights a safety net function of bushmeat during the lean season, it also shows that poor households do not depend more on bushmeat than wealthier households. In fact, there was no evidence for any wealth differentiation related to patterns of bushmeat harvest and use. This contrasts strongly with a number of studies which concluded that wealth had a strong effect on bushmeat harvest whereby the wealthiest (*e.g.* Coomes *et al.* 2004) or medium-wealth households harvested most (Ambrose-Oji, 2003) and that bushmeat and NTFPs in general comprise the largest share of total income/production among the poorest households in a community (Scoones *et al.*, 1992).

What might explain this paradox? Failure to detect a difference between households of different wealth could have been caused by low variation in wealth among wealth categories (Godoy *et al.*, 2009). However, there was little indication that this might have been the case in Wansampo as the wealthiest households gained ten times higher mean daily cocoa income than the poorest.

One explanation for the absence of a wealth effect on the bushmeat harvest in Wansampo might be found in the wider economic context. Cocoa farmers in Wansampo have relatively high incomes (US$3.2/capita/day in purchasing power parity, see Chapter 7) compared to other bushmeat studies conducted in more remote locations where there are few alternative income sources to bushmeat. Even the poorest households have access to alternative cash incomes and earn more than US$0.6/capita/day (in purchasing power parity). Further, communities showing wealth differentiation in harvest patterns usually have access to an abundant wildlife resources (Starkey, 2004; Coad *et al.*, 2010), while in this study, wildlife resources are so limited that it restricts opportunities for major wealth related differences in hunting behaviour to arise between households. Gun hunting, frequently cited as a more efficient hunting technique and giving rise to high hunting incomes (Coomes *et al.*, 2004; Kumpel *et al.*, 2009), was of minor importance in Wansampo and most animals were trapped or collected by hand (Chapter 4 and Whitham 2009). Firstly, this indicates that wealth-related access restrictions may only apply to communities where wildlife is abundant enough to make the expensive technologies worthwhile. Secondly, our results support a number of NTFP studies conducted among farming communities with diversified livelihoods that found no relationship between natural resource harvest and household wealth (*e.g.* Wickramasinghe *et al.* 1996; Chenevix-Trench 1997), suggesting that poor households are not necessarily the most resource dependent within communities and that socio-economic determinants of resource use are likely to be more complex, particularly once households gain access to a wider range of livelihood opportunities.

Although FHHs are generally perceived as more vulnerable than others (IFAD, 2001), there was no evidence that they showed a greater reliance on bushmeat. Female-headed households harvested bushmeat but to a lesser extent than male-headed households despite controlling for the confounding effects of household composition. Women were not prohibited from checking traps and were recorded harvesting bushmeat from traps in farms that were set by their spouse. They also gathered snails and small mammals that were encountered in farms and along forest roads. However, cultural norms prevented women from setting traps themselves and checking traps in forests where most bushmeat was harvested. Hence, their role must be seen as a helper similar to that reported among Central African net hunters, where women cooperate with men in group hunts by driving animals into nets held by men (Turnbull, 1968; Noss, 1997).

Gathering snails is an important livelihood activity during the rainy season and women feature prominently in this activity (Falconer, 1994). However, the rainy season in Ghana (March to early July) only partly overlaps with the lean season (June to September) and few snails were available during the present study (for an example of annual variation in snail consumption, see Hodasi, 1995). For a FHH to overcome the limitations of the seasonal snail harvest, and gain access to trapped bushmeat that is available throughout the year, depends upon having at least one active male household member, which most FHHs did not have.

This suggests that labour limitations known to apply to FHHs (Haddad, 1991) extend to the harvest of bushmeat, thereby limiting the potential of vulnerable female households to take full advantage of bushmeat's safety net function.

Chapter 6

Does wildlife depletion lead to protein insecurity among Ghanaian cocoa farmers living in a cash economy?

6.1. Summary

(1) The effect of wildlife depletion on the protein security of rural forest communities - and especially the most vulnerable households - is poorly understood but it is critical for the sustainable rural development and appropriate conservation management.

(2) This study investigates protein consumption and security in a West African cash-crop farming community living in a wildlife depleted farm-forest landscape. Three hypotheses were tested: (a) vulnerable households are less protein secure; (b) vulnerable households depend on plant protein to cover their protein needs; and (c) animal protein consumption is limited by household cash income.

(3) The research was conducted over a twelve-month period among 63 households. The consumption of animal and plant protein, and household cash income, was estimated from repeated household surveys using a combination of 24hr- and two-week recall periods. Protein security was assessed by comparing protein consumption against a threshold of recommended daily allowance (RDA). GLMMs were employed for statistical analysis, using an information theoretic approach.

(4) Between 14% and 60% of households consumed less than the recommended daily allowance (RDA) for protein (depending on the conversion factor used) but neither protein consumption nor security co-varied with vulnerability. Plants were a major source of protein (>50%) and protein security was strongly dependent on the level of plant protein consumption. The importance of bushmeat consumption was highest during the lean season; but otherwise household vulnerability had little effect on the relative importance of different protein sources. Finally, few households had sufficient income to cover their protein needs through animal protein purchases. The extent of this income shortage was highest during the lean season and among poorer households.

(5) These findings suggest that income shortages among cash-crop farmers are sufficient to cause protein malnutrition, and bushmeat remains an important source of animal protein during the lean season in spite of wildlife depletion.

6.2. Introduction

Unsustainable hunting of wild animals for consumption (bushmeat) is a threat to animal prey populations and the plant species that depend on them for seed dispersal across the humid tropics (Wright *et al.*, 2000; Baillie, 2004). Wildlife depletion resulting from unsustainable harvest also endangers the protein security of rural forest communities that depend on bushmeat hunting, because of a lack of access to alternative protein sources (Bennett, 2002; Fa *et al.*, 2003). This is particularly the case in Africa, where levels of wildlife harvest are especially high and offtake may exceed production by a factor of 2.4 (Fa *et al.*, 2002). Consequently, understanding the linkages between wildlife depletion and protein security and the ability of consumers to substitute bushmeat with domesticated meat or fish is important for both conservation and food security.

Bushmeat is widely consumed in both urban and rural areas of sub-Saharan Africa. However, the per capita consumption of bushmeat as well as the relative importance of bushmeat within the diet is generally higher in rural than urban areas (Starkey, 2004). Urban consumers have access to a wide range of meat/fish types and bushmeat is part of a diverse meat diet that includes fish and livestock (Fa *et al.*, 2009). Due to the high price commanded for bushmeat in urban areas, it is usually considered a luxury item and the amount of bushmeat consumed is influenced by the price of bushmeat relative to the price of its substitutes, *i.e.* the cross-price elasticity of demand (Wilkie *et al.*, 2005).

In contrast, rural consumers have less choice than urban consumers for two main reasons. Firstly this is because of the lower availability of bushmeat substitutes in rural than in urban areas, due to high transport costs arising from long travelling distance and poor road conditions. Secondly, while the prices for bushmeat substitutes increase with distance from town, cash income is generally lower in rural communities, making alternative protein sources less affordable (Elliott, 2002). Market integration is an important prerequisite for reducing bushmeat dependence as has been shown for rural communities along a gradient of market access in Gabon: the relative importance of bushmeat in household consumption increased with distance from market ranging from 13% of total household consumption value in a village near town to 25% in a remote community (Starkey, 2004). Similarly, for rural Equatorial Guinea, Allebone-Webb (2008) showed that bushmeat consumption contributed 43% to total protein consumption in a village with poor transport links but only 18% in a village with good connections. In remote Cameroonian communities with few opportunities for purchasing alternative protein sources, bushmeat comprised 80 to 98% of animal protein consumption (Muchaal & Ngandjui, 1999).

While this demonstrates substantial variation in bushmeat dependence across villages in relation to market integration, there is also variation within communities. Growing evidence suggests that the bushmeat harvest is highest among the wealthiest or middle-wealth households (de Merode *et al.*, 2003; Coomes *et al.*, 2004; Starkey, 2004; Kumpel *et al.*, 2010b), but it appears that the relative importance of bushmeat in diets is highest among the poorest households (Starkey, 2004). This suggests that bushmeat may act as a safety net for the poor, who can least afford purchasing bushmeat substitutes. Among agricultural communities, this effect is often strengthened during the lean season when household cash income is low and food prices are highest (Dei, 1989; de Merode *et al.*, 2003), although seasonal variations in the importance of bushmeat may not exist in those communities that practice little agriculture and are heavily dependent on bushmeat (Kumpel *et al.*, 2010b).

The consequences of declining wildlife populations for rural communities in sub-Saharan Africa, especially for those households utilising bushmeat as a safety net, is largely unknown. Observations from wildlife depleted areas in south-east Asia, suggest that rural communities can make the dietary 'switch' from bushmeat to domesticated meat or fish, provided that (1) households have access to cash income generating activities other than bushmeat hunting, and (2) income levels are sufficient to cover protein needs through purchasing meat/fish (Bennett & Rao, 2002). However, it is uncertain whether the same applies to forest communities in Africa due to both the lower availability of fish in inland communities and the impacts of diseases on livestock production (Delgado *et al.*, 1999).

Hence, the question of whether forest communities in tropical Africa can adapt to depleted wildlife populations, or whether they will face protein malnutrition, remains unanswered. To address this question, this study was conducted in a rural Ghanaian community of cocoa farmers who were well integrated into the cash economy and were living in a forest-farm landscape with impoverished wildlife populations. In particular, this study tests the hypothesis that protein security decreases with household vulnerability, defined as a low cash income during the lean season, a low participatory wealth rank, and/or a female head of household. The effects were expected to be aggravated for those households showing a combination of these characteristics, especially those with low participatory wealth rank during the lean season and female-headed households during the lean season. This study hypothesises that:

(H1) vulnerable households consume less meat/fish (including bushmeat) and consequently show lower protein security;

(H2) the relative importance of animal protein consumption is lower, and the relative importance of plant protein is higher, in vulnerable households; and

(H3) the extent of animal protein consumption is limited by household cash income.

6.3. Methods

6.3.1. Estimating protein consumption

6.3.1.1. Animal protein

Animal protein consumption was defined as any meat, fish or other animal product consumed by household members during the 24 hours prior to an interview. Unless individual animal protein types are explicitly stated, meat/fish refers collectively to bushmeat, fish, crustaceans and livestock.

Meat/fish consumption surveys were part of a comprehensive socio-economic household survey that also collected detailed information on monetary and non-monetary incomes and expenditures. This allowed the use of a multi-step cross-checking process (triangulation) to improve the data quality of notoriously difficult consumption surveys (Gibson & Kim, 2007). We started by asking interviewees about the type and monetary value (recorded in Cedis) of meat/fish consumed by household members at any time during the last 24 hours and grouped these into breakfast, lunch and dinner, depending on the time of consumption. By recording the specific value consumed for each meat/fish type and meal, these data could then be cross-checked with data on wildlife harvest and household meat expenditure for the same period. Subsequently, the recorded values were also checked against gift exchange data for the same period and discussed consumption estimates with interviewees if mismatches were observed. Gift exchange surveys frequently recorded meat/fish that was prepared by the household but then sent to family members living in other households and these were subtracted from the household's own consumption. Finally, the data were compared with information from dinner participant surveys, in which the identity of household members consuming dinner at and/or outside the household, and non-household members consuming dinner at the household were recorded. The value of meat/fish consumed by household members outside the household was added to the household consumption and the value of meat/fish consumed by non-household members at the household was subtracted from the meat/fish available to household members. The meat/fish consumption surveys were facilitated by the fact that people rarely stored meat and most purchased or produced meat was consumed on the same day. Also, most meat/fish was purchased from traders in the community and prices were readily available.

Meat consumption in Cedi/household/day was converted into protein consumption in gram/household/day. This was done using species specific estimates of the price/kg body weight, derived from estimates of the monetary value per animal recorded during surveys in combination with body weight estimates from this study and the literature (Kingdon, 1997). Where no species specific price per kg was available, the mean value of the next higher taxonomic group was used, *e.g.* for an unidentified fish species the mean value across different fish taxa was used. Livestock data were based on local prices for animals of different age classes and mean weights obtained from Armbruster & Peters (1993). Dressed meat weights were estimated as 65% of the original weight for bushmeat and livestock, and 100% for fish and crustaceans, as none of the animal was discarded. Following Albrechtsen *et al.* (2005) protein weight was calculated by multiplying the dressed weight with the respective protein content, which was 25% for livestock, 28% for bushmeat; and 19% for fish. The protein content for dried fish was 47% (FAO, 1997) (for more details see Table A.2 and Table A.3).

6.3.1.2. Plant protein

Estimates of plant protein available for consumption were derived from data on food crop production, purchases and gift exchange rather than from consumption surveys. Six food crops comprised 78.1% of total vegetable, tuber and fruit harvest, namely plantain (*Musa paradisiaca*), cassava (*Manihot esculenta*), cocoyam (*Colocasia esculenta*), white yam (*Dioscorea alata*), yam (*Dioscorea* spp.) and okra (*Abelmoschus esculentus*). These are widely stated as the most important types of plant protein consumed in rural communities in SW Ghana (*e.g.* Nti *et al.* 2002). The harvest of food crops with high protein content, such as beans (various spp.) and groundnuts (*Arachis hypogaea*) was rarely recorded (<0.5% of harvest value) but they were frequently purchased, especially groundnut paste. For each of the food crop types the value harvested, purchased and received as a gift within the last 24 hours was estimated and converted into protein gram/household/24hr using the conversion rates listed in Table A.3.

A total of 31 surveys were conducted in which the weight of the raw plant and the plant weight that went into the pot were recorded. This was done for cassava (mean percentage discarded=33%; SD=12%, N=16), plantain (mean percentage discarded=43%; SD=5%, N=11) and cocoyam (mean percentage discarded=45%; SD=21%, N=4) showing that on average around 40% of the raw weight was discarded. The dressed weight of food crops was therefore defined as the raw weight minus 40%.

Food crops were grouped into two categories based on their protein content (low/high). Literature estimates of protein contents vary strongly: "low-protein" food crops vary between 0.5% and 4.0% of wet weight with most estimates lying between 1% and 2% (Table A.9). Both estimates, *i.e.* 1% and 2%, were used throughout the analysis as a lower and upper limit. Utilising a range of estimates aimed to control for the variation in protein content caused both by ripening processes, reported to be a difference of 50% for unripe and ripe plantain (Giami & Alu, 1994), and by the effects of different preparation methods that can alter protein content to varying degrees (Ayankunbi *et al.*, 1991). The level of variation in estimates of protein content of "high-protein" food crops was substantially lower. Their protein contents were approximated as 22% and 25% for beans and groundnuts/groundnut butter, respectively (Table A.3).

The two most common forms in which plant protein was consumed was as "ampesi" (boiled cocoyam or plantain) and "fufu" (a staple made of cassava and plantain). The sales price stated for "ampesi" corresponded to the value of the ingredients and could easily be converted into the protein weight equivalent. However, the value of fufu stated was higher than the cost of the ingredients and corresponded to prices in a local chop bar. This reflected the hard manual labour (pounding) involved in preparing fufu. To determine the conversion factor from fufu to protein weight 29 "fufu surveys" were conducted. These recorded the value of plantain and cassava used as ingredients and the local sales price of the resulting meal. The estimated conversion factors were 0.19 for plantain (19% of the sales price was the price of raw plantain) and 0.26 for cassava (26% of the sales price was the price of raw plantain), hence the mark-up was slightly more than two-fold. There was no difference in the price for raw and cooked meat.

Interviews were conducted after people had returned from their farm, which meant that farm produce was often still present during the interviews and could be weighed. Where crop weight data were available these were used instead of estimates of the harvest value. Plant protein destined for sale or gift was excluded from the analysis.

It is important to note that the estimates of animal and plant protein consumption reported here did not control for intra-household variation in protein consumption, which can be strongly skewed towards adult males (Gomna & Rana, 2007), but instead refer to the total amount of animal protein consumed by, and the amount of plant protein available to, the household as a whole.

6.3.2. Assessing protein security

Protein security was assessed by comparison of total protein consumption rates (animal and plant protein) against a threshold of 0.75g per kg human body weight per day, which has been proposed as the recommended daily allowance (RDA) of protein consumption (FAO/WHO, 1985). For an adult male or female (these are not distinguished) with an average body weight of 70kg this means a protein consumption of 52.5g/day. The threshold has been widely used in the bushmeat and food security literature (Fa *et al.*, 2003; Albrechtsen *et al.*, 2005;

Allebone-Webb, 2008; Blaney *et al.*, 2009). For criticism of applying such a threshold, and anthropological perspectives on protein security generally, see Messer (1984) and Carpenter (1986).

To obtain protein consumption per adult male equivalent (AME) and to compare this to the threshold value of protein security, household composition was assessed for each interview and per capita estimates converted into an AME value. This non-static approach to household composition was necessary, because cocoa farmers' households are dynamic production and consumption units that exhibit strong temporal variation in household composition (Boni, 1993; Hanson, 2004). Hence, during each interview a dinner survey was conducted in which household members who were present in the community within the last 24 hours and consumed dinner either at the household or elsewhere in the community were recorded using unique personal IDs. Demographic data were then used to calculate an estimate of household composition in AME units for every interview. The average household comprised 3.11 AMEs (SD = 1.54; range = 0.79 - 8.16). Besides allowing for long-term changes in household composition, this method of estimating household composition also gave more sensible estimates of meat/fish consumption per AME when few household members had participated in meals and households may have adjusted their meat provisioning strategies, *i.e.* bought less meat as fewer people had to be fed.

The conversion factors used to estimate AME value (RD, see Table 6.1) were obtained from Pedersen & Lockwood (2001) and were based on estimates of the recommended dietary allowances of male and females of different age classes (see references in Pedersen & Lockwood 2001). To assess the consistency of analyses using different conversion factors, analyses were repeated using three different sets of conversion factors (Consumption Units, Reference Adult and Adult Equivalent Unit, see Table 6.1 and Sellen 2003 for details). All analyses showed the same patterns with similar statistical results. Therefore only those findings based on RD are presented here. For comparison with studies using per capita estimates, note that household size expressed in AME are on average 26% lower than per capita estimates and consequently mean protein consumption estimates per AME are higher than consumption estimates per capita.

Table 6.1.: Four alternative methods for calculating household sizes in AME were compared. Conversion factors based on "recommended dietary allowances" (RD) were taken from Pedersen & Lockwood (2001), consumption unit (CU), reference adult (RA) and adult equivalent units (AU) were taken from Sellen (2003). The respective gender and age classes and the conversion factors are shown (m=male; f=female).

Sex	Age	RD	Sex	Age	CU	Sex	Age	RA	Sex	Age	AU
m/f	0-0.5	0.22	m/f	0-3	0.38	m/f	0-5	0.52	m/f	0-6	0.25
m/f	0.5-1	0.29	m	4-15	0.72	m/f	6-10	0.85	m/f	7-14	0.67
m/f	1-3	0.45	m	15+	1	m/f	11-15	0.96	m/f	15-60	1
m/f	4-6	0.62	f	4-15	0.69	f	15+	0.86	m/f	60+	0.67
m/f	7-10	0.69	f	15+	0.76	m	15+	1			
m	11-14	0.83									
m	15-18	0.98									
m	19-50	1									
m	51+	0.79									
f	11-14	0.72									
f	15-18	0.74									
f	19-50	0.76									
f	51+	0.66									

6.3.3. Estimating household cash income

Monetary incomes were infrequent events, especially in the case of large incomes such as cocoa sales, requiring a combination of 24hr and two-week recall. All monetary household incomes obtained within 24 hours prior to an interview from a diverse range of sources, *e.g.* farm labour, gifts, trade in provisions and farm produce, were recorded. Interviewees earning a regular income from employment were asked about their monthly salary and this was divided by 30 to obtain the mean daily income. Two-week recall elicited single event incomes, *i.e.* not accumulative over the period, exceeding US$ 4.22 (50,000 Cedis) and were divided by 14 to estimate daily income. This threshold was judged appropriate for large infrequent incomes and was confirmed as such by informants.

This method is prone to double counting of household incomes and care was taken to avoid this. If an interviewee reported earning the same type of income within the last 24 hours and two weeks, the average daily income from this income source and how often in the last two weeks this income was earned were inquired. Based on this a mean daily income was estimated. All incomes used in this analysis are gross incomes as these were the best approximation of the money available to a household at the time of an interview.

6.3.4. Data analysis

All analyses were based on aggregated means per household per season. The total sample size was 185, as not all households were interviewed in all seasons. With the exception of bushmeat consumption, aggregated values contained few zeros and did not require a two-step analyses. All statistical analyses were conducted using GLMMs.

6.4. Results

6.4.1. Importance of different protein sources

Protein derived from food crops and animals were of similar importance contributing 53% and 47% of total protein consumption, respectively (Table 6.2). Protein sources included a variety of meat and fish types and food crops, yet the majority of protein was derived from three sources: dried fish, plantain and cassava were the most frequently consumed protein sources and comprised 60% of total protein consumed.

The consumption of meat/fish averaged 103g/AME/day in dressed weight and 32g/AME/day in protein weight. The most frequently consumed animal protein was fish (75% of interviews) of which dried fish was the most prominent, recorded in 63% of all interviews. Fish was also the most important source of animal protein, comprising 58% of animal protein and 27% of total protein consumed. Bushmeat was the second most important source of animal protein. Bushmeat consumption was recorded in 32% of interviews and averaged 39g/AME/day in dressed meat weight and 10g/AME/day in protein weight, corresponding to 31% of animal protein and 14% of total protein consumed. Livestock was a minor source of protein supply (6% of animal protein and 3% of total protein) and mainly consumed during celebrations such as Christmas or when a child had been born.

The consumption of food crops was substantially higher than the consumption of meat/fish, averaging 1.7kg/AME/day dressed weight. The two most important sources of plant protein, *i.e.* plantain and cassava, alone averaged 1.3kg/AME/day (71% of plant protein and 39% of total protein). Hence, despite their low protein content, consumption of a large amount enabled people to derive a a substantial proportion of their total protein consumption from these crops.

Plantain and cassava were the main ingredients in the preparation of "fufu" - a traditional meal that formed an essential aspect of household consumption. Fufu was consumed for dinner on a daily basis and a common saying was "if you have not eaten fufu, you have not eaten that day". Small quantities of meat/fish were occasionally consumed for breakfast (without fufu) but the bulk of animal protein was served for dinner (with fufu). In fact, daily meat/fish consumption was perceived as a necessity in the majority of interviews (93% interviews) where respondents opinions were asked, "without meat or fish you cannot eat fufu“, which meant not eating at all that day.

Crops with high protein content such as beans and groundnuts, were of marginal importance for protein consumption (2% and 3% of total protein consumed, respectively). Groundnuts were not farmed by households in the village, instead small quantities were purchased to prepare soup to be served with fufu. Alternative soups were a light vegetable soup and palm oil soup. While groundnuts were used relatively frequently (recorded in 19% of interviews), they were used in small quantities mainly to flavour soups rather than as a source of protein or a substitute to animal protein. Beans were not a traditional crop planted in the area. Few households utilised the crop and beans could not be bought in the community, thus requiring purchases at the district market.

Table 6.2.: Meat/fish and food crop consumption in the village (N=185).

		Dressed g/AME/day[a]		Protein g/AME/day	
Type	%[b]	Mean	Median (range)	Mean	Median (range)
Meat/fish	*93.3%*	*103*	*86 (0-376)*	*32*	*27 (0-116)*
Fish	**74.6%**	**50**	**39 (0-319)**	**19**	**16 (0-71)**
Fish (dried)	62.6%	32	25 (0-131)	15	12 (0-61)
Fish (fresh)	14.0%	16	0 (0-277)	3	0 (0-52)
Fish (tinned)	3.3%	2	0 (0-47)	<1	0 (0-9)
Bushmeat	**32.3%**	**39**	**26 (0-256)**	**10**	**7 (0-71)**
Mammals	24.6%	29	15 (0-256)	8	7 (0-71)
Snails	3.0%	2	0 (0-49)	<1	0 (0-5)
Other	7.3%	7	0 (0-107)	2	0 (0-30)
Livestock	**14.2%**	**13**	**0 (0-265)**	**2**	**0 (0-48)**
Beef	8.3%	4	0 (0-70)	1	0 (0-13)
Chicken	2.9%	4	0 (0-155)	1	0 (0-31)
Goat	1.5%	2	0 (0-133)	<1	0 (0-24)
Sheep	1.3%	1	0 (0-70)	<1	0 (0-12)
Pork	0.9%	<1	0 (0-47)	<1	0 (0-6)
Other	0.1%	<1	0 (0-47)	<1	0 (0-18)
Unknown[c]	**5.2%**	**1**	**0 (0-38)**	**<1**	**0 (0-1)**
Food crops	*84.1%*	*1,712*	*1,316 (0-11,510)*	*38*	*29 (0-238)*
Low protein[d]	**79.2%**	**1,697**	**1,316 (0-11,480)**	**34**	**26 (0-230)**
Plantain	62.4%	679	420 (0-5,524)	14	8 (0-110)
Cassava	62.2%	633	462 (0-5,954)	13	9 (0-119)
Cocoyam	13.1%	153	0 (0-5,461)	3	0 (0-109)
White yam	11.8%	133	0 (0-3,030)	3	0 (0-61)
Okra	9.1%	80	0 (0-4,400)	2	0 (0-88)
Yam	1.5%	20	0 (0-2,347)	<1	0 (0-47)
High protein[e]	**23.1%**	**15**	**4 (0-551)**	**3**	**1 (0-122)**
Groundnut	19.3%	7	0 (0-76)	2	0 (0-19)
Beans	4.2%	8	0 (0-545)	2	0 (0-120)

[a] dressed weight for meat/fish is shown. For food crops this refers to wet weight minus 40% skin weight (see Table A.3)
[b] % of interviews recording the consumption of meat/fish or food crops
[c] interviewees stated meat/fish consumption but no further details
[d] food crops with protein content of 2%
[e] food crops with protein content of >20%

6.4.2. Protein consumption and security

The first analysis investigated patterns of protein consumption and security, and their relationship to household vulnerability (H1). Assuming a 2% protein content for "low-protein" food crops, it was found that household protein consumption averaged 70g/AME/day (SD=41) across the community and thereby exceeded the RDA for protein of 52.5g/AME/day. Despite this, however, protein consumption in 14% of the households was below the RDA (mean=43.3g/day/AME ±7.4 SD). About half the households (52%) consumed between 52.5 and 100g protein/AME/day, and a third (32%) consumed more than 100g/AME/day.

In contrast, with a more conservative estimate of 1% protein content, the mean protein consumption was 53g/AME/day (SD=24) and the number of households consuming less than the RDA for protein was 60%. In this scenario 33% of the households consumed between 52.5 and 100g protein/AME/day and only 6% of the households consumed more than 100g/AME/day.

Further analyses revealed very little support for any relationship between either daily protein consumption or protein security with household vulnerability (wealth, seasonality, or gender of the household head), either at the 2% protein content level (ΔAIC_N=0 in both cases, Table A.12 & Table A.13) or at the 1% protein content level (ΔAIC_N<3.0 in both cases, Table A.14 & Table A.15). Thus, overall, there was very limited support for an effect of household vulnerability on either protein consumption or security (H1). However, it is worth noting that both protein consumption per household and household sizes in AME varied across wealth categories and male- and female-headed households (Table A.16), suggesting that wealthier households and male-headed households consumed more protein/household (Figure A.2) but per AME consumption was relatively constant.

6.4.3. Determinants of the importance of protein sources

Although household vulnerability did not affect protein consumption or security, it remained possible that it still influenced the relative importance of animal and plant protein in the diet (H2). This possibility was first explored with animal protein. The results suggest that vulnerability was a strong determinant of the importance of animal protein in household consumption, although not always in the direction predicted. Seasonality received most support from the GLMM (Table 6.3), but this was mainly due to the greater importance of animal protein after the cocoa season rather during the cocoa season (Figure 6.1a). There was also evidence that animal protein comprised a greater share of total protein consumption in the wealthiest (rank 1) households (Figure 6.1b). Support for an effect of the gender of the household head was lower (only appearing in two of the four models with $\Delta AIC_N \leq 2$) and this was confirmed by the minor differences observed between female- and male headed households (Figure 6.1c). The outcome of the analysis did not change substantially when analysing the relative importance of animal protein using a 1% protein content of ”low-protein“ food crops rather than 2% value for the protein content of ”low-protein“ food crops (Table A.17).

Since total protein consumption is comprised of animal and plant protein, the patterns observed for plant protein mirrored those of animal protein and the conclusion drawn for animal protein was also true for plant protein (see Table A.18, Table A.19 & Figure A.3).

Thus there was some evidence in support of the hypothesis (H2) in the case of household wealth, but an ambiguous seasonal pattern that neither fully supports nor rejects the hypothesis, and basically no evidence for an effect of household headship on animal or plant protein consumption.

Although this study was unable to find strong patterns in support of the hypothesis on the effects of household vulnerability on animal or plant protein, it remained possible that vulnerability had a less ambiguous effect on the main sources of protein, namely fish and

Table 6.3.: Results of GLMM analysing the effect of participatory household wealth, gender of the household head and seasonality on the relative importance of animal protein within a household's total protein consumption (assuming 2% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185).

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.33
season	0.8	0.22
wealth+hhsex+season	1.4	0.17
season+hhsex	2.0	0.12
wealth+hhsex*season	3.1	0.07
season*hhsex	3.6	0.05
wealth*season	7.2	0.01
wealth	7.4	0.01
null	8.0	0.01
wealth*season+hhsex	8.5	<0.01
wealth+hhsex	8.8	<0.01
hhsex	9.2	<0.01
wealth*season+hhsex*season	10.0	<0.01

"low-protein" food crops. However, neither was found to co-vary with household vulnerability (wealth, gender of the household head, or season). In both cases, there was relatively little support for an effect with 2% content for low-protein food crops ($\Delta AIC_N \leq 3.0$, see Table A.20 & Table A.21) and even less at the 1% level ($\Delta AIC_N = 1.8$ in both cases, see Table A.22 & Table A.23).

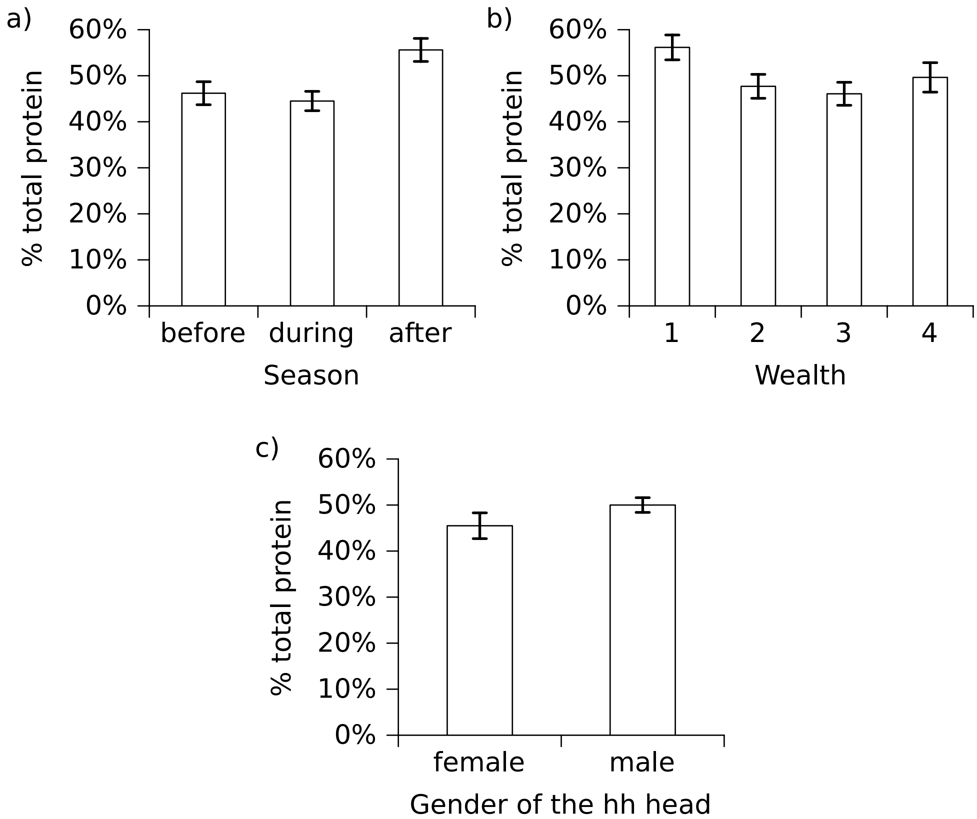

Figure 6.1.: Percentage of total protein consumption derived from animal protein across a) seasons, b) participatory wealth categories, and c) female- and male household headship.

Finally this study also considered the possibility that the relative importance of bushmeat varied with household vulnerability. Among the households that consumed bushmeat within a particular season (74% of cases), it was found that the relative contribution of bushmeat to total protein consumption (at the 2% content of "low-protein" food crops) was lowest during the cocoa season, intermediate before the cocoa season and highest after it (Table 6.4 & Figure 6.2). However, there was less evidence for an effect of household wealth or gender of the household head. The patterns were identical at the level of 1% content of "low-protein" food crops (Table A.24). In a further analysis involving the likelihood of bushmeat consumption across all households, only marginal evidence for an effect of any measure of household vulnerability was found (ΔAIC_N=3.9, Table A.25).

Table 6.4.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of bushmeat protein for households that consumed bushmeat, *i.e.* households that did not consume bushmeat were not included in this analysis (assuming 2% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=136).

Model	ΔAIC_i	Akaike weight
season	0	0.59
season+hhsex	1.7	0.25
wealth+season	4.2	0.07
season*hhsex	4.8	0.05
wealth+hhsex+season	6.1	0.03
wealth+hhsex*season	9.4	0.01
null	11.0	<0.01
hhsex	12.7	<0.01
wealth*season	14.0	<0.01
wealth	15.6	<0.01
wealth*season+hhsex	16.0	<0.01
wealth+hhsex	17.6	<0.01
wealth*season+hhsex*season	19.2	<0.01

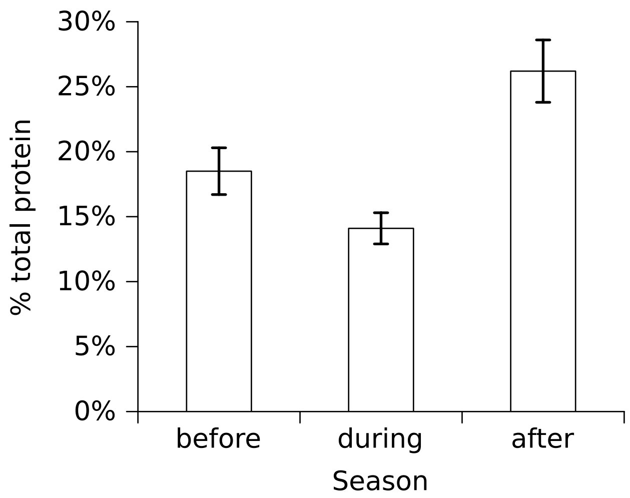

Figure 6.2.: The percentage of total protein derived from bushmeat consumption for households that consumed bushmeat (scale of the response) across seasons.

6.4.4. Does income limit meat/fish consumption?

Finally, to explore the underlying reasons for low animal protein consumption, the hypothesis was tested that household income was insufficient to cover daily protein requirements through the purchase of animal protein in some households (H3). Daily gross income averaged US$7.15/household (SD = 15.08) and US$ 2.73/AME (SD = 5.40). The animal protein source with the highest protein:price ratio available in Wansampo was a type of dried fish (US$ 8.7/kg protein, see Table A.10). For an average household with 3.1 AME (SD = 1.7) the cost of covering the RDA for protein (162.8g) through purchasing dried fish protein was US$ 1.41/household/day. Purchasing a combination of more expensive fresh and dried fish types (US$ 11.9/kg protein) increased the cost to US$ 1.94/household/day, while the cost for covering protein needs through buying the most commonly available type of bushmeat (giant pouched rat, US$ 9.1/kg protein), was similar to dried fish (US$ 1.48).

Comparing the daily gross cash income against the cost of animal protein necessary to achieve the RDA, showed that in 35% of interviews (across 89% of households) household income was insufficient. The level of income insufficiency was strongly seasonal with only marginal evidence for variation across male- and female-headed households and wealth categories (Table 6.5). About 40% of interviewees (across 70% of households) earned insufficient income before and after the cocoa season but only 24% (across 60% of households) during the cocoa season (Figure 6.3a). However, these results assume that all cash income was available for the purchase of meat/fish, which is unlikely to be the case. Re-analysis assuming only 50% of gross cash income was available, indicates that 48% of interviewees (across about 84% of households) had insufficient income before and after the cocoa season, although the same seasonal pattern was obtained (Figure 6.3b). In addition there was some indication that income shortages were lower among the two wealthiest groups than the two poorest groups, for which there was basically no indication at the 100% income level, but even at the 50% income level the differences between wealth categories were small (Figure 6.3c). Thus, the hypothesis that animal protein consumption may be limited by household cash income (H3) was supported.

Table 6.5.: Results of binomial GLMM assessing the likelihood of 100% of household gross income exceeding the money needed to purchase animal protein > RDA in relation to household wealth and seasonality.

Model	ΔAIC_i	Akaike weight
season	0	0.56
season+hhsex	1.8	0.22
wealth+season	3.2	0.12
wealth+hhsex+season	5.0	0.05
season*hhsex	5.3	0.04
wealth+hhsex*season	8.4	0.01
wealth*season	9.8	<0.01
wealth*season+hhsex	11.5	<0.01
wealth*season+hhsex*season	15.3	<0.01
null	24.5	<0.01
hhsex	26.5	<0.01
wealth	27.6	<0.01
wealth+hhsex	29.4	<0.01

Table 6.6.: Results of binomial GLMM assessing the likelihood of 50% of household gross income exceeding the amount needed to purchase animal protein > RDA in relation to household wealth, gender of the household head and seasonality.

Model	ΔAIC_i	Akaike weight
season	0	0.35
wealth+season	0.5	0.28
season+hhsex	1.5	0.16
wealth+hhsex+season	2	0.13
season*hhsex	4.3	0.04
wealth+hhsex*season	4.8	0.03
wealth*season	9.5	<0.01
wealth*season+hhsex	11	<0.01
wealth*season+hhsex*season	13.6	<0.01
null	55.5	<0.01
wealth	55.7	<0.01
hhsex	57.2	<0.01
wealth+hhsex	57.3	<0.01

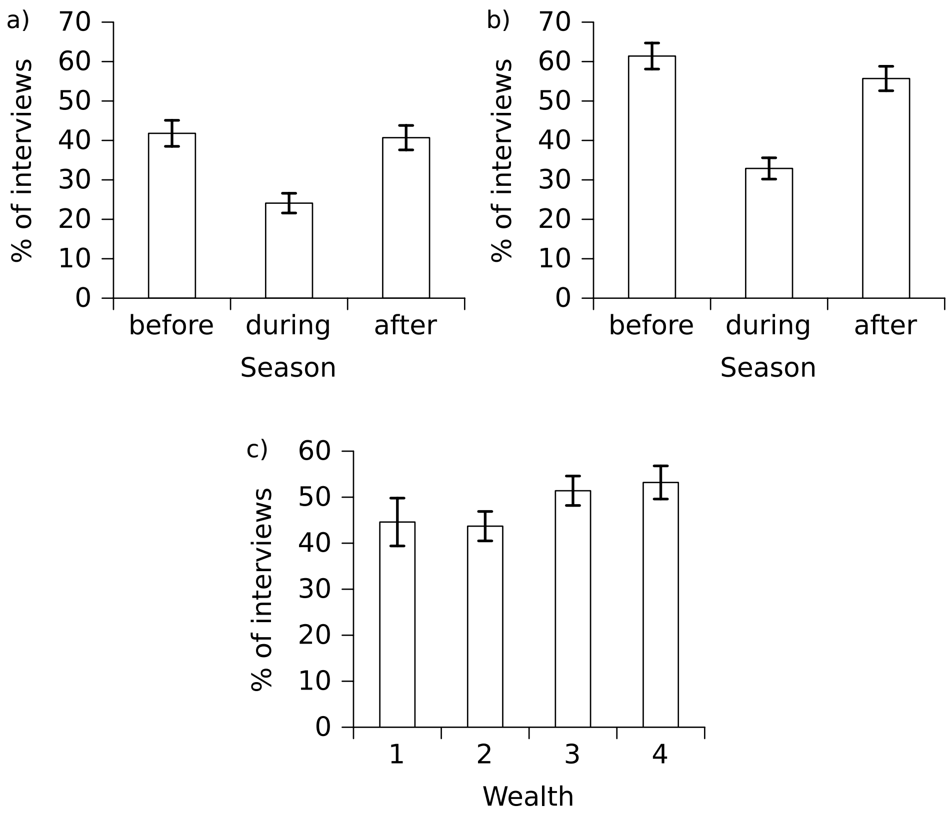

Figure 6.3.: The percentage of interviews with insufficient gross cash income to cover the RDA through purchase of the cheapest animal protein source available. a) 100% income versus season; b) 50% income versus season; c) 50% income versus wealth. Standard errors are shown.

6.5. Discussion

In this West African farming community, it was found that while protein consumption equalled or exceeded the RDA on average (using figures of 1% or 2% protein content for low-protein crops, respectively), between 14-60% of households consumed less than the Recommended Daily Allowance (for 2% or 1% protein content estimates, respectively). Surprisingly, there was no evidence that those households that had lower protein consumption or protein security were those that were more vulnerable (according to seasonality, wealth, or gender of household head). However, there was evidence that more secure households (the wealthiest households, and after the cocoa season) included a greater share of animal protein in their total protein consumption. Notably, there was no relationship between household vulnerability and the relative importance of either of the two main sources of dietary protein (fish and low-protein crops), but the relative importance of bushmeat did increase when households became more vulnerable, *i.e.* before and after the cocoa season. Finally, there was support for the hypothesis that cash income might limit protein consumption, with the greatest shortfall occurring in the lean season and in poorer households.

The finding that there was protein insecurity in some households, but that these patterns of insecurity were unrelated to household vulnerability (contrary to hypothesis H1) was surprising and contradicts studies of rural communities in Gabon (Kumpel *et al.*, 2010b) and national data sets (Speedy, 2003; York & Gossard, 2004). On the other hand the findings support evidence in other Central African studies that likewise found no relationship between household income/wealth and meat consumption (Albrechtsen *et al.*, 2005; Fa *et al.*, 2009) or the nutritional status of household members (Blaney *et al.*, 2009).

To understand this result within the context of this study it is first of all important to note that wealthy and male-headed households consumed more meat/fish at the household level and likely incurred higher expenditures for the purchase of meat/fish than poorer households. However, due to variation in household sizes, consumption per AME was constant across wealth groups. Such mediating effects of household size on protein consumption (Wilkie *et al.*, 2005; Godoy *et al.*, 2009) and nutritional status (Kyereme & Thorbecke, 1987) have commonly been observed.

Furthermore, the consumption of meat/fish was considered a necessity. Interviewees frequently stated that meat/fish was an essential ingredient, albeit in small quantities, of the main meal consumed in the community. Since bushmeat was rarely harvested (Chapter 4) and livestock was of minor importance in the diet, most animal protein consumed was purchased. Households spent a substantial part of their daily expenditures on buying meat/fish (Chapter 5), resembling other rural communities in Africa. In Equatorial Guinea for example, rural communities spent a larger part of their disposable income on meat/fish purchases than urban households, primarily due to the higher costs of animal protein and lower income in rural areas (Fa *et al.*, 2009). It was suggested that differences in the relative cost of animal protein, explained the existence of a wealth related effect on protein consumption in urban areas and its absence in rural areas.

Variation in the consumption of different sources of animal protein due to price differences has been document in various studies assessing the cross-price elasticity of demand for bushmeat in relation to substitutes (Tambi, 1996; Wilkie & Godoy, 2001; Apaza *et al.*, 2002). Similarly rational behaviour that is sensitive to the high price of meat/fish in the community, may explain why households consumed relatively small amounts of animal protein and why vulnerability had no substantial effect on protein security. The consumption of large amounts of meat/fish was considered a luxury even for the wealthiest households and limited to festivities, such as Christmas or the birth of a child. During such occasions, a household would slaughter livestock and large amounts of meat were consumed. Most households owned livestock but since animals were primarily kept for special occasions, they contributed little to protein consumption and were only a minor source of income (Chapter 7).

Food crops and especially low-protein food crops were a staple source of protein that was consumed in large quantities (1.3kg/AME/day) as ingredients for ”fufu“. Due to the importance of plant protein in the diet, estimates of protein security were highly sensitive to variation in the protein content of low-protein food crops, resulting in substantial uncertainty about the level of protein security of the community.

In contrast to meat/fish, ”low-protein“ food crops were mostly obtained from a household's own production and did not incur substantial monetary cost. With a low protein:calories ratio, they were a cheap source of calories that served to satisfy hunger. However, their poor nutritional value with low level of vitamins and micronutrients (Cock, 1982) classes them 'unsatisfactory food' especially for children (Oliviera, 1974; ITTA, 1990), raising questions about the nutritional status of the community beyond protein security.

Despite the absence of an effect of vulnerability on protein security, there was evidence that more secure households (the wealthiest households, and after the cocoa season) included a greater share (about 10%) of animal protein in their total protein consumption. Notably, there was no relationship between household vulnerability and the relative importance of either of the two main sources of dietary protein (fish and low-protein crops), but the relative importance of bushmeat did increase when households became more vulnerable, *i.e.* before and after the cocoa season.

In the absence of variation in total protein consumption/AME across wealth categories, relatively higher animal protein and lower plant protein consumption in the diet of the wealthiest households suggests that these also consumed more animal protein and less plant protein per AME than poorer households. This is an interesting finding, because the level of protein insecurity was similar across wealth groups and wealthy households may have been able to increase their level of protein security by maintaining the level of plant protein consumption. It is unlikely that the wealthiest households had less access to food crops than poorer households. Hence it appears that they actively chose to increase their consumption of animal protein and reduce their consumption of food crops, which may give an indication of preference for animal protein. Neither the relative importance of fish, nor bushmeat or low-protein food crops co-varied with wealth, and livestock and ”high-protein“ food crops were of low importance in the diet (to the point where small sample sizes prevented a statistical analysis). Hence, one may speculate that the observed pattern was due to an accumulative effect of small differences in the consumption between wealth groups across individual protein types.

The peak in the importance of animal protein in the diet after the cocoa season was surprising, since this season represents an intermediate level of vulnerability (Chapter 7) and thereby does neither fully reject nor confirm our hypothesis. The pattern was primarily caused by a peak in the importance of bushmeat consumption during the same period. Overall, bushmeat formed a more important part of protein consumption during the lean season than during the cocoa season, reflecting increased hunting activity during the lean season (Chapter 5). However, the percentage of total protein derived from bushmeat was higher after the cocoa season than before or during the cocoa season. This was the result of a lower likelihood of bushmeat sales after the cocoa season than before the cocoa season (Chapter 5), leaving more bushmeat for household consumption. Hence, this analysis confirms the role of bushmeat as a safety net during times of income shortage in the study community, also found by *e.g.* Dei (1989) and de Merode *et al.* (2004). It also shows that no direct relationship between seasonal vulnerability and the importance of animal protein in the diet exists as such. Instead, the importance of animal protein was highest after the cocoa season (intermediate level of vulnerability), when hunting levels had already increased but not the likelihood of selling bushmeat. The likelihood of bushmeat sales only increased before the cocoa season, when household income was lowest (see Chapter 7).

There was support for the hypothesis that cash income might limit protein consumption, with the greatest shortfall occurring during the lean season and to some extent among poorer households. Overall, a third of interviews recorded insufficient income to cover RDA, and it is possible that this prevented households from purchasing adequate amounts of animal protein and thereby achieving protein security. This finding questions the assumption that income earned through the integration into the market economy compensates adequately for the loss of wildlife populations (Bennett, 2002).

On the other hand, income shortages did not aggravate protein insecurity in the community, as indicated by the absence of an effect of seasonality and households wealth on protein security. This suggests that households adapted their protein consumption pattern to the highly seasonal element of their livelihoods, by a) high dependence on low-protein food crops that were available year-round at basically no monetary cost, and b) minimising meat/fish expenditures to a level that could be afforded all year. This risk minimisation strategy may explain the absence of major effects of wealth or household headship on protein consumption.

The bushmeat consumption recorded in this study was at the lower range of Central African consumption estimates (Auzel & Wilkie, 2000; Eves & Ruggiero, 2000; Starkey, 2004; Wilkie *et al.*, 2005) and comparable to other studies conducted in rural Ghana (Dei, 1989; Ntiamoa-Baidu, 1998) but less than among Ghanaian hunters living near protected areas (Holbech, 1998). While this indicates some geographical variation in the abundance of wildlife populations in Ghana and a potential for higher bushmeat harvest and consumption in some areas, it also shows that Wansampo may be comparable to other Ghanaian communities with generally low level of bushmeat consumption and facing similar difficulties in ensuring protein security.

This study highlights the importance of food crops as a source of protein and the need for greater appreciation of this complementary protein source in the bushmeat literature. With an average plant protein consumption 20-38g/AME/day, depending on the protein content, food crops have the potential to ameliorate the effects of wildlife depletion on protein security. Changes in hunting pressure are commonly accompanied by major changes in human land use, such as logging and agricultural development (Achard *et al.*, 2002). If wildlife depletion coincides with the transition of rural forest communities with a predominant bushmeat focus to an agrarian livelihood, improvements in the cultivation of ”high-protein“ food crops can both reduce occurrences of protein insecurity and reduce the need for bushmeat.

Chapter 7

Linkages between bushmeat hunting, cocoa farming and poverty alleviation: the role of income seasonality

7.1. Summary

(1) It has been suggested that NTFPs can contribute to poverty alleviation in rural communities. Bushmeat is a highly marketable NTFP and an important source of cash income in some areas of the tropics. However, little is known about the importance of bushmeat for household income and poverty alleviation in areas where wildlife populations have already been depleted.

(2) This study investigated the potential of depleted wildlife populations to contribute to poverty alleviation through the sale of bushmeat. The hypotheses were (a) vulnerable households are more likely to be income poor, especially during the lean season; (b) the sale of cocoa beans is the main source income that is keeping households out of poverty; but (c) bushmeat income is still important for some households and reduces the overall level of poverty.

(3) The study took place over a twelve-month period among 63 households with diversified livelihoods in a Ghanaian cocoa-farming community living in a wildlife depleted landscape. Gross monetary and non-monetary incomes were obtained from repeated socio-economic surveys using a combination of 24h- and two-week-recall periods. GLMMs were used for statistical analyses, interpreted using an information theoretic approach.

(4) More than 50% of households were poor (<pppUS$2) or extremely poor (<pppUS$1.25). Seasonally, poverty was highest during the lean season (>60% of households) and lowest during the cocoa season (35%). Lack of income from cocoa sales was the main determinant of poverty, yet poor households depended more on farm income than non-poor households. Bushmeat was a minor source of income overall, but it was important for some households and reduced the overall level of poverty by 5% during the main lean season.

(5) These findings suggest that in a wildlife depleted landscape, income from bushmeat sales can still be an important safety net for some households during the lean season and reduce the extent of income poverty.

7.2. Introduction

With the adoption of the United Nations Millennium Development Goals (MDGs) in 2000, poverty alleviation has been positioned on top of the development agenda (UN, 2010). To halve the number of people living on less than pppUS$1 per day, and those suffering from hunger, by 2015, policy debates have given increasing attention to the possible link between forest income and poverty alleviation (Roe, 2008). The rational for this attention has been that forests provide incomes to rural households, through the harvest and sale of non-timber forest products (NTFPs), and that many of the world's poor live in rural areas with close proximity to natural forests and high levels of biodiversity (WRI, 2000; Sunderlin *et al.*, 2005). In line with this potential linkage, there has also been renewed interest in developing solutions to poverty that include natural resource-based activities (Adams *et al.*, 2004; Roe, 2010; TEEB, 2010). However, our understanding of how natural products might contribute to poverty alleviation remains surprisingly poor (WRI, 2005; Belcher & Schreckenberg, 2007).

There is little doubt that forest resources are an important aspect in rural livelihoods with an estimated 1 billion people of the world's poor depending on forest resources to sustain their livelihoods (Scherr *et al.*, 2003). Research in sub-Saharan Africa (Ambrose-Oji, 2003; Appiah *et al.*, 2007; Cavendish, 1999b; Mamo *et al.*, 2007; Babulo *et al.*, 2009; Cavendish, 2000; Kamanga *et al.*, 2009; Yemiru *et al.*, 2010; Campbell *et al.*, 2002; Paumgarten & Shackleton, 2009; Fisher, 2004), South America (Coomes & Burt, 2001; Lopez-Feldman *et al.*, 2007; Gavin & Anderson, 2007; McSweeney, 2002; Takasaki *et al.*, 2001) and Asia (Das, 2005; Fu *et al.*, 2009; Mahapatra *et al.*, 2005; Adhikari *et al.*, 2004) has shown that rural households depend to varying extents on income earned from the sale of NTFPs. A recent meta-analysis of 51 NTFP studies from 17 developing countries estimated that forest environmental income averaged about 20% of total household income (Vedeld *et al.*, 2007).

The harvest and trade of NTFPs is often easily adaptable within the agricultural schedule, occurring on either a daily basis or whenever the agricultural opportunity costs are low, and their sales enable rural households to earn a cash income (Arnold & Townson, 1998; Marshall *et al.*, 2006). In addition, the trade in NTFPs generally has low entrance barriers and is especially important to vulnerable households, who may find it difficult to gain access to other income-generating activities (Beck & Nesmith, 2001; Cavendish, 2000). For instance, among women in South Africa's dry woodland (Shackleton & Shackleton, 2004), NTFPs may be one of the few income sources available, while in West Africa, women can attain key positions within the bushmeat commodity chain (Mendelson *et al.*, 2003). As such, NTFPs have been shown to act as an important fallback option, or as safety nets, preventing people from falling into poverty during times when few alternative income sources are available (McSweeney, 2002; Takasaki *et al.*, 2004)

However, the question remains whether forest resources can lift rural households out of poverty (Sunderlin *et al.*, 2005) or whether they are an option of last resort that reduces the negative side-effects of poverty but still contribute to persistent poverty (Wunder, 2001). In the latter case, the intensification of rural agricultural systems or migration to urban centres are more likely to reduce the number of households living below the poverty line (Levang *et al.*, 2005). For rural communities in South Africa, Shackleton *et al.* (2008) argued that income from natural resources does not provide a route out of poverty for most households engaged in the business, but can still raise incomes to the national minimum salary and make a valuable contribution to livelihoods portfolios.

To contribute to the debate, this study assesses the potential of bushmeat to prevent households from falling into poverty. While previous studies have investigated the links between bushmeat and poverty (*e.g.* de Merode *et al.* 2004), none of these studies have systematically examined this issue in the context of agricultural communities integrated into a cash economy, where access to bushmeat resources is limited and alternative income sources are available. This study was therefore conducted in a rural Ghanaian community of cocoa farmers living in a forest-farm landscape with impoverished wildlife populations. Previous research in this community has already shown that household wealth has little effect on bushmeat harvest and use patterns, and the relative importance for income (Chapter 5) and protein consumption (Chapter 6). Here we focus on patterns of income poverty over the course of the year rather than household wealth, since this provides a clearer indication of the role of bushmeat relative to household income. In particular, we are interested in testing three hypothesis: that (1) vulnerable households are more likely to be poor, especially during the lean season (when agricultural income is reduced); (2) cocoa income is the main determinant of household income poverty; but (3) bushmeat income is important for some households and contributes to poverty alleviation during the lean season.

7.3. Methods

The analysis of household cash income and poverty is based on household surveys described in detail in Section 3.5.2. For comparison of incomes with international standards of poverty, all cash and non-cash incomes were converted into purchasing power parity US$ in 2005 (pppUS$), using a raw exchange rate of USD$1 = 10,000 GHC and a purchasing power parity conversion of 0.515 (IMF, 2010). To adjust for inflation between 2005 (used by the World Bank as its reference year) and 2008 (the study year), 9.3% were subtracted from households incomes (Anon, 2010). A household was classed as 'poor' if the mean gross cash income was $<$ pppUS$2.00/household member/day and 'extremely poor' if the income was $<$ pppUS$1.25/household member/day (World Bank, 2008). The number of household members was held constant across the study period and was obtained from a census conducted at the end of the study period (June 2009). This was judged to be the most reliable estimate of household composition, although it did not take into account seasonal variation in household size (details are described in Section 3.4.1).

All analyses and summary statistics are based on the mean seasonal income per household across three seasons (before, during and after cocoa), resulting in a total sample size of 187 season-specific incomes from 63 households (two households were not interviewed during the last season). The 'before' and 'after' seasons are also known as the 'lean' season and contrast the main cocoa harvest season (during). Statistical analyses were conducted using GLMMs with household participatory wealth rank, gender of the household head and season as fixed effects (see Section 3.7 for details). All models controlled for the confounding effects of the household variables listed in Table 3.9.

7.4. Results

7.4.1. What is the level of income poverty?

The community was well-integrated into the cash economy and all households earned cash income during the survey period. Overall cash income was recorded in 79% of interviews, showing that most households earned cash income within a two-week period prior to an interview. Across seasons, the household gross cash income averaged pppUS$3.2/capita/day with a median income of pppUS$1.21/capita/day (Table 7.1). The farm sector was the main source of cash income (59% of income) and income from the sale of cocoa beans alone comprised 44% of total household income. The second most important income source was business and nonfarm labour (31%) followed by miscellaneous income (8%). Overall, bushmeat and other NTFPs were of minor importance, contributing only 2% to total household income.

Yet aggregated incomes masked a high level of poverty at the household level. Half of the households (51%) earned less than pppUS$2.00/capita/day (the poverty threshold) and of these 56% of households were extremely poor with a daily income of less than pppUS$1.25/capita. Hence, overall a quarter of the households were poor and another quarter were extremely poor.

Table 7.1.: Household gross cash income per income sources (in pppUS$/capita/day)

	Mean	Median (min-max)	% of income
Total farm	**1.88**	**0.43 (0 - 41.85)**	**59.0%**
Cocoa	1.39	0 (0 - 41.85)	43.7%
Food crops	0.36	0 (0 - 20.55)	11.2%
Labour	0.12	0 (0 - 6.68)	3.8%
Livestock	0.01	0 (0 - 6.92)	0.4%
Total business/labour	**0.99**	**0 (0 - 31.69)**	**31.2%**
Labour	0.26	0 (0 - 17.61)	8.1%
Trade	0.57	0 (0 - 25.53)	17.9%
Service	0.16	0 (0 - 16.61)	5.1%
Total NTFP	**0.07**	**0 (0 - 7.42)**	**2.1%**
Bushmeat	0.05	0 (0 - 7.42)	1.7%
NTFP (excl. bushmeat)	0.01	0 (0 - 4.1)	0.4%
Total miscellaneous	**0.24**	**0 (0 - 55.35)**	**7.6%**
Gift	0.16	0 (0 - 10.57)	5.0%
Other	0.08	0 (0 - 55.35)	2.6%
Total cash income	**3.18**	**1.21 (0 - 58.99)**	**100%**

7.4.2. Does household poverty increase with vulnerability?

To assess the underlying drivers of the high level of poverty observed the effect of vulnerability on the likelihood of a household falling into poverty was modelled. The seasonality of cocoa income was the most important factor determining household income poverty. Contrary to our prediction, a household's participatory wealth rank and gender of the household head were relatively poor indicators of income poverty (Table 7.2). While all three factors appeared in the strongest model, the importance of seasonality was clearly shown by an increase of 19 AIC steps when excluding seasonality from the model.

Table 7.2.: Results of binomial GLMM analysis testing the effects of cocoa income seasonality (season), participatory wealth rank (wealth) and gender of the household head (hhsex) on the likelihood of a household earning less than pppUS$2.00/capita/day (N=187; No. households=63). ΔAIC_i and Akaike weight are shown for all alternative models tested. The model controlled for the effects of household characteristics listed in Table 3.9

Model	ΔAIC_i	Akaike weight
wealth+season+hhsex	0	0.27
wealth+season	0.7	0.19
wealth+season*hhsex	1.7	0.11
season	1.9	0.10
season+hhsex	2.0	0.10
wealth*season+hhsex	2.4	0.08
wealth*season	2.8	0.07
season*hhsex	3.5	0.05
wealth*season+hhsex*season	4.7	0.03
wealth+hhsex	23.2	<0.01
wealth	23.7	<0.01
null	24.7	<0.01
hhsex	24.9	<0.01

Across seasons, poverty levels were lowest during the cocoa season (35% of households) and highest outside the cocoa season (>60% of households) (Figure 7.1a). The difference between before and after the cocoa season was not substantial, although there was a trend for poverty to increase with increasing time since the main cocoa harvest season. Despite the seasonal variation in poverty levels indicating a strong element of transitional poverty, 27% of households were poor in all three seasons. These chronically poor households comprised the majority (77%) of poor households during the cocoa season but only 40% before and 46% after the cocoa season (Figure 7.1b). This was due to households that were not poor during the cocoa season experiencing income shortages outside the cocoa season and falling below the poverty line as a result. Different households experienced poverty during different seasons and combinations of seasons, but more than 75% of poor households were either chronically poor or became poor once the main cocoa season had finished and remained poor until the end of the lean season.

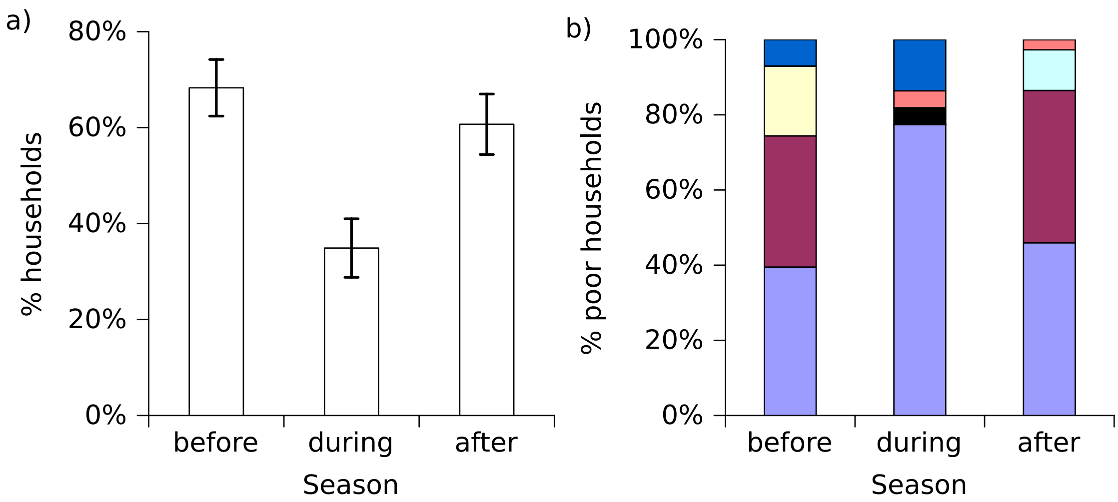

Figure 7.1.: Seasonal poverty: a) percentage of households identified as income poor (<pppUS$2.00/capita/day) across seasons; b) percentage of poor households coming from seven different households poverty groups; households experiencing poverty during the same season/s were grouped into the same category (lavender: poor in all seasons, dark red: poor before and after the cocoa season, dark blue: poor during and before the cocoa season, orange: poor during and after, black: poor during, turquoise: poor after, yellow: poor before). Groups of households included in Table 7.3 and Table 7.4 were 'always poor' (light blue) and 'poor outside' (dark red)

There was a slight trend for the level of poverty to increase with decreasing participatory wealth rank (Figure 7.2a) and slightly fewer male- than female-headed households may have been poor (Figure 7.2b). However, the differences were not substantial, especially when comparing with the near doubling of the number of households in poverty outside the cocoa season. The surprisingly weak relationship between participatory household wealth and income poverty is due to two factors: the effect of household wealth on income poverty varies across seasons (Figure 7.2c), and the number of household members varies across wealth categories (Figure 7.2d). During the cocoa season, households with high participatory wealth level were substantially less likely to experience income poverty than household with of low wealth category. However, before and after the cocoa season there was relatively little variation in the percentage of households per wealth group that experienced income poverty. In addition, due to variation in household sizes (the number of household members increased with household wealth), income poverty that was expressed as income per household member contributed to lack of variation in income poverty across wealth categories.

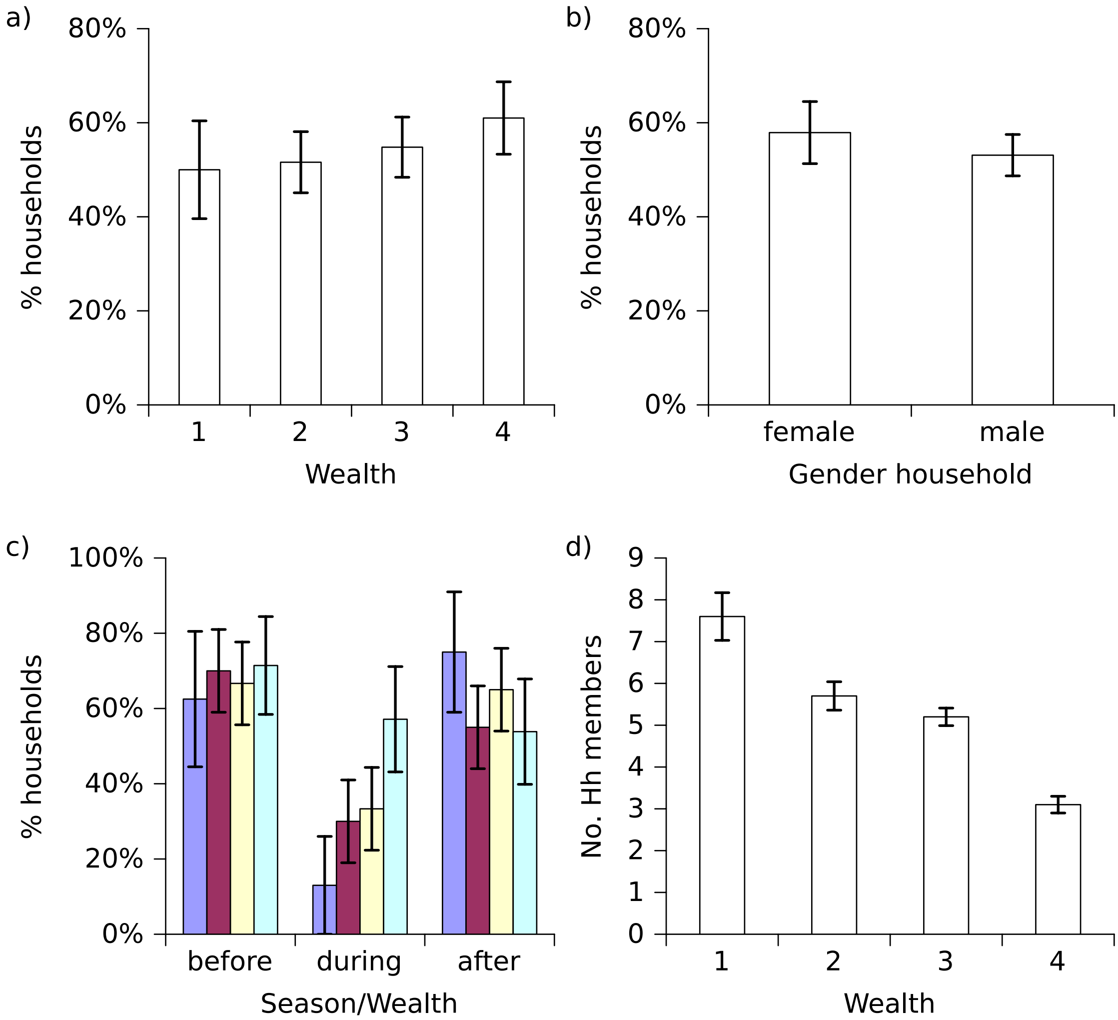

Figure 7.2.: Percentage of households identified as income poor (<pppUS$2.00/capita/day) across (a) participatory wealth categories, (b) male- and female-headed households, and (c) participatory wealth categories for each season (within each season wealth categories are organised from left (wealthiest) to right (poorest)). (d) Mean number of household members across participatory wealth categories.

The effect of vulnerability on the likelihood of a household falling below the extreme poverty threshold (<pppUS$1.25/capita/day) did not differ substantially from the effects on poverty at the pppUS$2/capita/day level already outlined (Table A.26). It is worth noting, however, that the level of extreme poverty increased disproportionately outside the cocoa season,

comprising 50% of poor households during the cocoa season but 78% after and 84% before the cocoa season.

7.4.3. How important is cocoa income for poverty alleviation?

To assess the drivers of seasonal poverty, the following section compared income profiles of households that did not fall below the poverty line in any season ('never poor'; 14 households) with those of households experiencing poverty outside the cocoa season ('outside poor'; 17 households) and chronically poor households ('always poor'; 15 households) (Table 7.3). Households experiencing poverty 'outside' the cocoa season and households that were poor in all three seasons comprised 75% of households that were ever poor during the study period.

The three groups of households were strongly differentiated by their overall level of cash income with the chronically poor earning least and the 'never poor' earning most. All groups earned most cash income during the cocoa season and substantially less outside the cocoa season. Farm income was the most important source of cash income and cocoa was the single most important income source (Table 7.4).

Perhaps not surprisingly, income earned from the sale of cocoa beans was the main determinant of income poverty. 'Never poor' households earned high incomes from the sale of cocoa beans throughout the year (pppUS$1.55-4.95/capita/day). Similarly households experiencing poverty outside the cocoa season earned high incomes from cocoa sales during the cocoa season (pppUS$2.57/capita/day) but little income from cocoa sales in subsequent seasons (pppUS 0.28-0.53/capita/day). Chronically poor households did not earn substantial income from cocoa sales during any season (maximum = pppUS$0.57/capita/day).

In addition to this strong correlation between cocoa sales and income poverty, non-cocoa incomes that could have served as an alternative were generally lower than cocoa income.

Cocoa sales were still a major source of income even for poor households. Only the chronically poor earned higher incomes from the sale of food crops than cocoa beans. However, even in this case, the income from food crops was very low (pppUS$0.18). Overall, households in the categories 'poor outside' and 'always poor' were more dependent on farm income than 'never poor' households, except during the cocoa season. 'Never poor' households had highly diversified income sources throughout the year, earning substantial incomes from a range of sources and sectors. They gained less than 50% of their cash income from the farm sector outside the cocoa season with the vast majority of the remaining cash income being earned from nonfarm activities (pppUS$2.4-3.8/capita/day). High incomes from the sale of cocoa beans increased their share of farm income during the cocoa season (63%) but at the same time they maintained higher incomes from the nonfarm sector than were ever earned by households experiencing poverty.

The 'never poor' households displayed a high level of seasonal income flexibility that was not an option to poorer households. As income from cocoa sales decreased outside the cocoa season, 'never poor' households first invested in the purchase of provisions used for trading in the community, thereby gaining advantage of this income source and also purchasing products for their own consumption at wholesale prices. With increasing time since the cocoa season, overall household income declined and the availability of cash in the community decreased. This reduced the potential for trade in the community and the 'never poor' households focused on the nonfarm labour sector, doubling their income earned from this source compared to after the cocoa season.

Poorer households did not earn comparable incomes from the nonfarm sector and with declining farm incomes their household economies increasingly depended on non-cash income in the form of food crops and NTFPs for their own consumption and food gifts. The relative importance of non-cash income in these household economies increased from around 45% during the cocoa season to around 70% before the cocoa season, while non-cash income did not comprise more than 35% of total income received by the 'never poor' households.

This comparison of seasonal income profiles has shown that 'never poor' households compensated for relatively low, albeit still substantial, income from cocoa sales outside the cocoa season by focusing on the nonfarm sector and thereby maintained their cash incomes well above the poverty threshold. On the other hand, poorer households and especially the chronically poor did not earn comparable incomes in the nonfarm sector and with decreasing income from cocoa sales their household economy became progressively more subsistence oriented. However, 'never poor' households had higher per capita non-cash incomes than poorer households, indicating that their level of consumption was also substantially higher.

Table 7.3.: Income profiles for three groups of households with distinct patterns of seasonal poverty (<pppUS$2.00/capita/day): households that did not experience poverty in any season ('never poor', 14 households); households that were not poor during the cocoa season but were poor outside the cocoa season ('outside poor', 17 households); and chronically poor households that were poor in all seasons ('always poor', 15 households). Less distinct patterns were found among 17 households, which were not included in this comparison. All data are in pppUS$/capita/day)

Income source	Never poor			Poor outside cocoa			Always poor		
	before	during	after	before	during	after	before	during	after
Total Farm (cash)	**2.63**	**5.96**	**3.24**	**0.45**	**2.80**	**0.61**	**0.39**	**0.66**	**0.33**
Cocoa	1.55	4.97	1.92	0.28	2.57	0.53	0.09	0.57	0.21
Food crops	0.78	0.72	1.03	0.13	0.07	0.07	0.18	0.05	0.11
Labour	0.30	0.27	0.30	0.03	0.07	0	0.11	0.04	0.01
Livestock	0	0	0	0	0.10	0.02	0.01	0	0
Total Nonfarm (cash)	**2.40**	**2.98**	**3.80**	**0.18**	**0.71**	**0.33**	**0.13**	**0.21**	**0.13**
Labour	1.44	0.80	0.62	0.02	0.11	0.10	0.01	0.03	0.03
Trade	0.69	1.29	2.00	0.17	0.60	0.23	0.12	0.18	0.10
Service	0.26	0.89	1.19	0	0	0	0	0	0
Total NTFP (cash)	**0.15**	**0.01**	**0.13**	**0.09**	**0.15**	**0.02**	**<0.01**	**0**	**0.01**
Bushmeat	0.15	0	0.11	0.09	0.04	0.02	<0.01	0	0.01
NTFP (excl. bushmeat)	0	0.01	0.02	0	0.12	0	<0.01	0	0
Total Other (cash)	**0.13**	**0.55**	**0.31**	**0.00**	**0.12**	**0.01**	**0.10**	**0.23**	**0.11**
Gift	0.13	0.55	0.20	0	0.10	0.01	0.10	0.23	0.11
Other	0.01	0.00	0.11	0	0.02	0	0	0	0
Total cash	**5.30**	**9.50**	**7.49**	**0.73**	**3.78**	**0.98**	**0.62**	**1.10**	**0.58**
Total non-cash	**2.78**	**2.42**	**1.77**	**1.43**	**3.09**	**0.99**	**1.48**	**1.02**	**1.03**
Total farm (non-cash)	1.56	1.18	0.65	0.94	0.74	0.35	1.00	0.46	0.58
Total NTFP (non-cash)	0.41	0.48	0.25	0.16	1.89	0.31	0.10	0.14	0.18
Total Other (non-cash)	0.80	0.76	0.87	0.32	0.47	0.33	0.38	0.42	0.27

Table 7.4.: Income profiles for three groups of households with distinct patterns of seasonal poverty (<pppUS$2.00/capita/day): households that did not experience poverty in any season ('never poor', 14 households); households that were not poor during the cocoa season but were poor outside the cocoa season ('outside poor', 17 households); and chronically poor households that were poor in all seasons ('always poor', 15 households). Less distinct patterns were found among 17 households, which were not included in this comparison. All data are in pppUS$/capita/day)

Income source	Never poor			Poor outside cocoa			Always poor		
	before	during	after	before	during	after	before	during	after
Total Farm (cash)	**49.6%**	**62.7%**	**43.3%**	**61.6%**	**74.1%**	**62.5%**	**62.9%**	**59.8%**	**57.3%**
Cocoa	29.1%	52.3%	25.6%	38.5%	68.0%	53.9%	14.9%	51.5%	36.7%
Food crops	14.8%	7.6%	13.8%	18.3%	1.7%	7.0%	28.4%	4.3%	18.6%
Labour	5.7%	2.8%	3.9%	4.7%	1.7%	0.0%	17.8%	4.1%	2.0%
Livestock	0.0%	0.0%	0.0%	0.0%	2.6%	1.6%	1.7%	0.0%	0.0%
Total Nonfarm (cash)	**45.2%**	**31.3%**	**50.8%**	**25.4%**	**18.7%**	**33.7%**	**20.6%**	**19.0%**	**21.7%**
Labour	27.1%	8.5%	8.2%	2.2%	2.9%	10.0%	1.0%	2.7%	4.7%
Trade	13.1%	13.5%	26.7%	23.2%	15.8%	23.7%	19.6%	16.3%	17.0%
Service	5.0%	9.4%	15.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total NTFP (cash)	**2.7%**	**0.1%**	**1.8%**	**13.0%**	**4.1%**	**2.4%**	**0.7%**	**0.0%**	**1.5%**
Bushmeat	2.7%	0.0%	1.5%	13.0%	1.0%	2.4%	0.7%	0.0%	1.5%
NTFP (excl. bushmeat)	0.0%	0.1%	0.2%	0.0%	3.1%	0.0%	0.1%	0.0%	0.0%
Total Other (cash)	**2.5%**	**5.8%**	**4.1%**	**0.0%**	**3.2%**	**1.4%**	**15.8%**	**21.1%**	**19.5%**
Gift	2.4%	5.8%	2.6%	0.0%	2.6%	1.4%	15.8%	21.1%	19.5%
Other	0.1%	0.0%	1.5%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
Total cash	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Total non-cash	**34.4%**	**20.3%**	**19.1%**	**66.3%**	**45.0%**	**50.1%**	**70.5%**	**48.0%**	**64.0%**
Total farm (non-cash)	19.3%	9.9%	7.0%	43.8%	10.7%	17.6%	47.5%	21.6%	36.2%
Total NTFP (non-cash)	5.1%	4.0%	2.8%	7.5%	27.5%	15.7%	4.7%	6.5%	11.3%
Total Other (non-cash)	9.9%	6.4%	9.3%	15.0%	6.8%	16.8%	18.3%	19.8%	16.6%

7.4.4. What is the importance of bushmeat for reducing poverty?

In contrast to the income from cocoa sales, bushmeat was a minor part of household income (Table 7.1) and bushmeat is unlikely to have contributed substantially to poverty alleviation across the community as a whole. However, at the level of individual households, bushmeat sales provided an important source of income for some households that earned little or no income from other sources (Table 7.5). This was especially the case before the cocoa season when household incomes were lowest and bushmeat sales were the main source of cash income for 8% of households (mean bushmeat income: pppUS$1.11/capita/day ±0.66 SD).

Table 7.5.: The relative importance of income from bushmeat sales across seasons

Bushmeat income	Households (%) per season		
(% of total income)	during	after	before
0%	92.1%	90.2%	81.0%
1-25%	7.9%	1.6%	11.1%
26-50%	0%	4.9%	0%
51-75%	0%	1.6%	6.3%
>75%	0%	1.6%	1.6%

To provide an estimate of the scale of the importance of bushmeat for poverty alleviation in the community, we subtracted the bushmeat income from total household income and reassessed the number of poor households when bushmeat was excluded. As might be expected, the effect was strongest before the cocoa season (Table 7.6). During this season, income from the sale of harvested bushmeat kept three households from falling below the poverty line and two households classed as poor would have been extremely poor without bushmeat income. Consequently, in the absence of bushmeat income, the level of poverty and extreme poverty before the cocoa season may have been five and three percent higher, respectively.

Table 7.6.: The number of households kept above the poverty line through bushmeat income

	With bushmeat			w/o bushmeat		
				not poor became		poor became
Season	not poor	poor	extr. poor	poor	extr. poor	extr. poor
before	6	2	4	0	3	2
during	3	2	0	0	0	2
after	2	1	3	0	1	1

7.5. Discussion

The analysis of household income data from a Ghanaian cocoa-farming community has shown that while all households were integrated into the cash economy, and gross cash income averaged pppUS$3.2/capita/day, a quarter of the households were poor and another quarter extremely poor. Surprisingly, household wealth and gender of the household head had relatively little effect on the likelihood of a household experiencing poverty. Instead, seasonality was the main determinant of income poverty. Poverty levels were highest during the lean season (>60%) and lowest during the cocoa season (35%). These findings provide partial support for the hypothesis that more vulnerable households were more likely to be poor. We obtained stronger support for the hypothesis that income from the sale of cocoa beans would be the main determinant of household poverty. Interestingly, poor households were more dependent on farm income and received substantially less income from nonfarm income sources than non-poor households. While this pattern was not due to differences in income diversification (all groups had similar access to the range of incomes available in the village) poor households earned substantially less from each source. Finally, there was support for the third hypothesis that bushmeat reduced poverty in the village. Overall, bushmeat was a minor source of household cash income but it was important for some households, especially before the cocoa season when household income was lowest, and prevented 5% of households from falling below the poverty threshold.

The following discussion focuses on three related points: bushmeat and poverty alleviation, cocoa and poverty alleviation and the effect of seasonality on cocoa-farming livelihoods.

When discussing the role of bushmeat in poverty alleviation one needs to distinguish between the potential for bushmeat to (a) act as a social safety net to the poor; and (b) to promote economic growth that results in the large-scale reduction of poverty among hunting households (Brown, 2003). Both are important aspects of poverty-alleviation strategies, but they differ in the sense that economic growth may lift poor people out of poverty while a safety net may only prevent households from falling into poverty (or households experiencing temporary poverty becoming chronically poor).

This study indicates that poverty was common among cocoa farmers in Wansampo but that the sale of bushmeat did not contribute to poverty reduction for most households. Perhaps this is not surprising, considering the high level of wildlife depletion around the village and the low level of bushmeat harvest, of which most was consumed rather than sold (Chapter 4 and Chapter 5). Nevertheless, bushmeat income was important to some households and may have prevented some hunters from falling into poverty during a period of income shortage from the agricultural sector.

In addition, this study found that substantial incomes could be earned from the sale of bushmeat harvested from depleted wildlife populations. Despite the vast majority of hunters' bags comprising small-bodies species (Chapter 4), bushmeat was a valuable commodity with the average sales prices for commonly hunted species ranging from US$1.7 (giant pouched rat) to US$3.7 (tree pangolin) (see also Table A.10). In comparison, the daily salary for farm labour in the village was US$2.1 and the national minimum salary was US$2.15. Similarly, Ntiamoa-Baidu (1998) showed more than ten years ago that full-time hunters in Ghana earned up to 3.5 times the government minimum wage and in some communities hunting may even comprise 35% of total income (Crookes *et al.*, 2007). Yet in this study the value of bushmeat harvests and the level of bushmeat commercialisation were low, and the majority of harvested bushmeat was consumed, enabling households to reduce their meat/fish expenditures (Chapter 5). In fact, the most common response when asking hunters why they would not sell their harvest, was "why sell the meat and spend the money on buying fish?". In contrast, when hunters sold bushmeat, they often needed money for urgent expenditures, presenting a similar rationale for selling bushmeat that was recorded among farmer-hunters in the Democratic Republic of Congo (de Merode *et al.*, 2004). Overall, these patterns suggest that while bushmeat may act as a safety net in Wansampo, it does not serve as an engine for economic growth.

On a methodological note, it could be argued that our assessment of the role of bushmeat in poverty alleviation is inconclusive for two reasons. First the number of households trading bushmeat was small (a maximum of twelve before the cocoa season). Secondly, comparing household incomes when bushmeat is included and when it is excluded is a rough assessment that does not control for the fact that those households that benefited from bushmeat sales could have adopted different strategies to generate cash income in the absence of a bushmeat income. Indeed, it is not known whether some households decided to consume harvested bushmeat instead of selling it because they already earned income from a different source. We also do not know whether some households decided to consume bushmeat in order to reduce expenditure and as a result were classed as poor. These are valid concerns, and the findings presented here should therefore be interpreted with due caution. Nevertheless, these results do suggest that bushmeat has at least the potential to prevent some households from falling into poverty, and to be an important safety-net during times of economic hardship, even where wildlife populations have been depleted.

One question that remains to be addressed is why even a small number of cocoa farmers with access to a range of income sources would still continue to depend on bushmeat as a safety net. The need for bushmeat may have arisen as a result of high level of income poverty among some households. This was especially the case during the lean season when some households gained little income except from the sale of bushmeat. The prevalence of seasonal poverty is widely known (Chambers *et al.*, 1981), but most poverty assessments do not disaggregate income flows across seasons. This is a shortcoming, since seasonal income peaks can overshadow periods of poverty and livelihood insecurity. In this respect it is important to distinguish chronic poverty, where poverty persists over whole agricultural season, versus transient or seasonal poverty, where households repeatedly experience poverty during certain seasons of the year (Hulme & Shepherd, 2003; Mckay & Lawson, 2003). Such seasonal poverty is common in tropical agricultural systems and may even be more pervasive than chronic poverty (Muller, 1997). In this study, chronically poor households comprised 77% of poor households during the cocoa season but less than 50% outside the cocoa season as more households climbed above the poverty line.

This pattern was primarily driven by seasonal fluctuations in cocoa incomes. The sale of cocoa beans was the main source of cash income in the community (44% of total cash income) and provided substantial incomes (mean=pppUS$1.4/capita/day). Poor households had substantially lower cocoa incomes than non-poor households during the same season, demonstrating that cocoa farming in the study village made an important contribution to poverty reduction. This also confirms conclusions drawn from the analysis of national data sets that show a stronger decline in poverty among Ghanaian cocoa farmers compared with the rest of the population between 1992 and 2006 (Coulombe & Wodon, 2007).

However, the disadvantage of cocoa production is the high seasonal fluctuation in harvest, whereby 50% of cocoa income is earned during only four months of the year (Section 3.6.2). In the words of the MP for the Bia constituency: "Always there is the issue of "no-money syndrome" after the cocoa season. Poverty here is seasonal. When the cocoa season is over everything becomes standstill" (Armah, 2009). Furthermore, cocoa income was also strongly associated with high income from other sources. Comparison of income profiles showed that overall access to income sources was not a limiting factor, but cocoa incomes and possibly its investment was positively related to the value earned from other sources. Similarly, Knudsen (2007) in his study of cocoa farmers in Ghana's Western Region concluded that all households received income from a range of sources, but those with few assets tend to diversify into low investment activities that result in low returns, and the opposite is true to households with a more assets. This resulted in households with little access to cocoa income also having little access to income from other sources, leading to severe income shortages, especially during the lean season.

Overall, this study suggests that the sale of bushmeat harvested from depleted wildlife populations does not reduce poverty for a large proportion of cash-crop farming households. However, within an agricultural system experiencing high income fluctuations, bushmeat remains an important source of income for some households and is likely to act as a seasonal safety net that reduces the extent of seasonal poverty.

Chapter 8

Discussion

8.1. Chapter overview

The four preceding chapters have explored a range of aspects of the importance of bushmeat harvested from depleted wildlife populations in the livelihoods of cash-crop farmers with diversified income sources. To gain a broader understanding of the role of bushmeat, particularly in relation to household vulnerability and income seasonality, this discussion synthesises the findings of those chapters and concludes by drawing a series of recommendations that may be helpful for improving the outcomes of conservation and livelihoods activities in farming-hunting systems.

8.2. Rationale

The harvest of bushmeat is widespread and an important livelihood activity in many rural communities in sub-Saharan Africa. Rural households utilise bushmeat in a variety of ways and its relative importance in livelihoods varies between households. The year-round availability of wild animals and the generally low access restrictions mean that bushmeat may be harvested when incomes from other livelihood activities are low, potentially making it a vital element of income and consumption smoothing in rural areas. This could be particularly important for vulnerable households with less access to alternative livelihood sources. For this reason, bushmeat has been suggested to contribute to poverty alleviation by providing incomes to poor communities and households experiencing economic marginalisation (Brown, 2003). Yet bushmeat harvest rates exceed wildlife production in many localities, resulting in the unsustainable harvest and local extinction of prey species. This is especially the case in West Africa, where a long history of high human population density and land use pressure has resulted in severe environmental degradation.

Until recently, research has largely focused on assessing the sustainability of bushmeat hunting, *i.e.* comparing actual harvest levels with an estimated sustainable harvest level, in areas of high wildlife abundance (*e.g.* Fitzgibbon *et al.* 1995; Refisch & Kone 2005). While this research has played an important role in determining the scale of unsustainable hunting, approaching the "bushmeat crisis" purely from a conservation perspective leaves the human component out of the equation, and limits management recommendations to sustainable offtake rates (*e.g.* Bodmer *et al.* 1994) without integrating it into rural livelihoods. Such conservation management approaches may be unlikely to succeed.

Fortunately, insights into the interaction between bushmeat and livelihoods have recently been gained, primarily from Central African forest communities (de Merode *et al.*, 2004; Davies & Brown, 2007; Allebone-Webb, 2008; Kumpel *et al.*, 2010b). However, very little is still known about the role of bushmeat in agricultural communities that are well-integrated into the cash economy. Furthermore, there has been growing interest in patterns of bushmeat hunting in farm-forest mosaics, since these landscapes might be more productive than high forests and may offer the promise of a relatively sustainable trade in rodents and small ungulates (*e.g.* Wilkie 1989; Robinson & Bennett 2004; Cowlishaw *et al.* 2005b). Research is urgently needed to see if this promise might be realised.

8.3. Research aims

The aim of this thesis was to assess whether bushmeat harvested from depleted wildlife populations plays an important role in the livelihoods of cash crop farmers with access to a range of income sources. The question was approached by placing bushmeat within a livelihoods framework and assessing its contribution to income and protein security in relation to alternative sources, with particular emphasis on the effects of household vulnerability and income seasonality. The main hypothesis was that the importance of bushmeat in livelihoods would increase with household vulnerability (*i.e.* poor and female-headed households), especially during the agricultural lean season. The specific research questions were:

- Chapter 4: Does farm land provide an alternative to hunting in forests? What is the level of wildlife depletion and hunting patterns in both forest and farm land?
- Chapter 5: Can depleted wildlife populations support rural livelihoods? What are the effects of household vulnerability and income seasonality on bushmeat harvest and use patterns?
- Chapter 6: Does wildlife depletion lead to protein insecurity? What are the effects of household vulnerability and income seasonality on protein security and the relative importance of bushmeat compared to other types of protein?
- Chapter 7: Can depleted wildlife populations contribute to poverty alleviation? What are the effects of household vulnerability and income seasonality on income poverty and the relative importance of bushmeat compared to other incomes?

8.4. The importance of bushmeat for vulnerable households

While the use of bushmeat is widespread, it is not necessarily clear whether bushmeat users depend on bushmeat for income or consumption or both. The analytical framework employed in this study assessed bushmeat harvest/use and its relative importance for income and consumption in relation to household vulnerability. It is through this analysis of bushmeat as a safety net for the most vulnerable households or during vulnerable times that we begin to understand whether people depend on bushmeat or use it as a complementary resource. Here I synthesise the findings of this study for each of the three axes of household vulnerability - wealth, gender of the household head, and seasonality - in turn.

8.4.1. The importance of bushmeat for poor households

Contrary to prediction household wealth was not a strong determinant of bushmeat harvest and use patterns (Chapter 5), nor did it have a strong effect on the relative importance of bushmeat for protein consumption/security (Chapter 6) or household income (Chapter 7).

The level of protein insecurity in the village was high (14% - 60% of households) and it is surprising that poor households were not less protein secure than wealthy households. Furthermore, households had access to a range of protein sources with both animal and plant protein each comprising about 50% of total protein consumed, yet in contrast to the predictions there was no indication that poorer households were less likely to consume animal protein or fish, or more likely to consume bushmeat than wealthy households.

In addition, the level of income poverty in the community was high and about half the households earned less than pppUS$2/capita/day, yet income poverty did not vary strongly with household wealth. Although, there was some indication for poorer households to be more likely to fall below the income poverty threshold of pppUS$2/capita/day than wealthy households, these differences were not substantial.

Overall, household wealth had little effect on protein security and poverty levels. This may be due to two reasons, either or both of which may exert an influence. Firstly, protein security and poverty levels were assessed per AME rather than per household. Consequently, since wealthy households were larger (*i.e.* they had more household members) than poorer households, total protein consumption and income were in fact higher among wealthier households. This confounding effect of household composition on the outcomes of livelihood studies has been noted in previous studies (*e.g.* for pastoralists: Sellen 2003), but requires further research to disentangle the effects of household wealth and household size on the relative importance of bushmeat. Secondly, the existing evidence for wealth-related differentiation among households derives from studies conducted in areas of high wildlife abundance and among people with few alternative income opportunities. Households in the study village had relatively high incomes (although a large part was poor by international standards) and wildlife populations were depleted. It is possible that this combination of factors limited the potential for wealth differentiation in bushmeat harvest patterns and the importance in livelihoods to arise.

However, this study also showed that bushmeat income was of particular importance to households with little access to other sources of income (*i.e.* they were income poor), and this was particularly the case during the lean season. This suggests that there is a connection between poverty and bushmeat use, but that static measures of household wealth may have limitations in systems with high seasonal income variability. It is also possible that repeating the participatory wealth ranking exercises during different seasons may have led to some households moving between wealth categories, leading to a clearer relationship between wealth and the relative importance of bushmeat in livelihoods.

Furthermore, it should be noted that these analyses focused at the household level. It is therefore possible that, within households, bushmeat income was more important for poorer than for wealthier household members. Intra-household wealth differentiation is a well-documented phenomenon in sub-Saharan Africa (Bird, 2003) where assets are frequently controlled by only a minority of household members (often men), leading to the unequal distribution of resources (Wheeler, 1991; Maxwell & Smith, 1992). If this were the case in Wansampo, some people from the same household may have benefited more from bushmeat income and consumption than others.

In conclusion, this study suggests that the importance of bushmeat does not vary across household wealth categories, and most importantly does not increase with poor households. There is therefore little evidence for bushmeat to act as a safety net for poor households. This finding strongly contrasts with those studies that recorded an increase in the importance of bushmeat among poor households (*e.g.* Starkey 2004) but confirms other studies that found no relationship between household income/wealth and either meat consumption (*e.g.* Albrechtsen *et al.* 2005) or the nutritional status of household members (Blaney *et al.*, 2009).

8.4.2. The importance of bushmeat for female-headed households

Female-headed households (FHHs) feature prominently in the development literature (*e.g.* Appleton 1996; Rogers 1996), but their role in determining the importance of bushmeat in rural livelihoods has not previously been assessed. This may be because bushmeat hunting is predominantly a male activity (*e.g.* Caspary 1999) and earlier studies have focused on full-time hunters, who are invariably male. Some work has been done on the role of women in the wholesale and retail links in the the bushmeat commodity chain, but these are normally in an urban rather than rural setting, *e.g.* Mendelson *et al.* (2003). This study found that FHHs did harvest bushmeat but, contrary to the expectations based on household vulnerability, they were less likely to harvest bushmeat than MHHs (Chapter 5). Personal observations during the study indicated that the presence of an active male household member was a strong determinant of whether a FHH utilised traps or predominantly gathered animals. This gender separation in bushmeat harvest patterns appeared to be the result of cultural norms that prevented women from setting traps, and were the most likely reason for the lower bushmeat harvest recorded among FHHs. Nevertheless, despite the difference in the bushmeat harvest pattern, the relative importance of bushmeat in both household production and the likelihood of consuming/selling bushmeat did not vary between FHHs and MHHs (Chapter 5). Furthermore, FHHs consumed similar amounts of protein as MHHs. They were equally protein secure, and there was no indication for the relative importance of different protein sources to vary between FHHs and MHHs (Chapter 6). Finally, although no FHH was represented in the highest wealth category, there was no indication that FHHs were more likely to be income poor than MHHs (Chapter 7).

This similarity between FHHs and MHHs is surprising. One possible explanation is that the lack of differences was due to similar livelihoods. Except for the trapping of bushmeat, there were no taboos preventing women from engaging in other livelihood activities. All FHHs farmed cocoa, and among the remaining livelihood strategies available in the community there were no obvious differences in participation between FHHs and MHHs. Similarly, Paumgarten & Shackleton (2011), working in South Africa, noted that both FHHs and MHHs experience the same types of shocks and will respond to them in the same way.

However, in respect to the importance of bushmeat, there may be more complex patterns that underlie the lack of differences between FHHs and MHHs observed. First, it is possible that the relative importance of bushmeat varied strongly among FHHs, thus complicating the interpretation of the "average" pattern. For example, bushmeat may have been more important for FHHs with active male household members than for MHHs (*i.e.* FHHs, because of their vulnerability, may be more dependent on bushmeat than MHHs when they have the labour resources necessary to access it), but less important for FHHs without active male household members than for MHHs, leading to no discernible difference between FHHs and MHHs. This could have been the case despite controlling for the effects of household composition due to the relatively small sample size of FHHs, but further analyses are required to systematically assess this. Secondly, the lack of a difference in the relative importance of bushmeat in the diet between MHHs and FHHs could have been due to the latter receiving more bushmeat gifts and thereby compensating for their lower bushmeat harvest rate. Further analysis of gift exchange patterns would enable us to test this hypothesis in the future. Regardless of the clarification of these details, the conclusion remains that bushmeat was no more likely to be a safety net for FHHs as a whole than for MHHs.

8.4.3. The importance of bushmeat during the lean season

Seasonality is the defining characteristic of livelihoods in Wansampo. The sale of cocoa beans contributed 44% of total household income, yet half of this income was earned during four months of the year. This led to highly seasonal cash income flows, with only 22% of households maintaining high incomes from cocoa throughout the year and the remaining households experiencing poverty either after or before the cocoa season, or both (Chapter 7).

As income poverty increased during the lean season, the percentage of households with insufficient income to cover their protein needs through meat/fish purchases increased as well (Chapter 6). In response to this income shortage, households harvested bushmeat more frequently, resulting in a strong increase in the relative importance of bushmeat in the diet. Furthermore, at the end of the lean season, when household incomes were lowest, hunters were most likely to sell bushmeat (Chapter 5), and it was during this period that bushmeat income was most likely to lift households out of poverty (Chapter 7).

Based on these findings, this study suggests that the seasonal variation in the use of bushmeat and its relative importance for protein consumption and household income were primarily determined by the seasonal pattern of the main livelihood activity in the village. Furthermore, it highlights the importance of bushmeat as a safety net during times of economic hardship, when incomes from other sources were strongly reduced. These findings support a large number of studies on bushmeat and NTFPs in general that have shown seasonal variation in both resource harvest patterns (Noss, 1997; Jachmann, 2008; van Vliet & Nasi, 2008) and the relative importance of these resources in livelihoods (Dei, 1989; Townson, 1995b; de Merode *et al.*, 2004). It contrasts, however, with those studies that recorded no seasonal variation in hunting patterns and the relative importance of bushmeat (*e.g.* Kumpel 2006). In the latter case, this primarily reflects local differences in the livelihood role of bushmeat: acting as a safety net in Wansampo, but as the main livelihood activity in Kumpel's study. Since the harvest of bushmeat was relatively low throughout the year in Wansampo, this study also highlights that the importance of bushmeat as a safety net is dependent on the timing of its harvest rather than on the actual value harvested (Arnold & Ruiz-Perez, 1998)

8.5. Cocoa farming and bushmeat hunting

It has been suggested that the harvest of resilient species in farm land could provide an alternative to the hunting of less resilient forest species (Robinson & Bennett, 2004). The present study indicates that this may not be the case in intensively managed farm land that contains few food resources for animals and little understorey growth for shelter or reproduction (Chapter 4).

Hunters in Wansampo harvested most bushmeat in forest rather than farm land, and overall farm land was not an important source of bushmeat. However, the bushmeat harvest from farm land was disproportionately larger than the relative availability of farm land around the community. This suggests that farmers had integrated hunting in farm land into their farming activities by focusing on trapping along the farm-forest boundary and harvesting bushmeat opportunistically, thereby making it an efficient addition to their livelihood portfolio with low opportunity cost.

Yet the low bushmeat harvest in farm land was likely due to three reasons. Firstly, the area has a very high human population density (81 people/km^2), leading to intensive farming across the landscape and none or very short periods of fallow (*i.e.* intensive in both spatial and temporal terms). Fallow areas can act as refuges and corridors for wildlife in an otherwise intensively used landscape, and potentially exhibit higher productivity in forests. Their absence is therefore likely to have a strong negative impact on wildlife abundance in farm land (Bennett, 1998). Secondly, a strong agricultural focus on cash crops that provide few food resources for wildlife is unlikely to be wildlife friendly, especially when farmed as monocultures and when most forest trees have been removed from farm land, resulting in low structural diversity (Phalan, 2009). Thirdly, the existence of a Taungya system in the study area that reduced the need to grow food crops on farms may have resulted in more intense cocoa farming than would have occurred otherwise.

These three factors may help to explain the high level of wildlife depletion observed in this study. Comparing the mammals harvested in both the farm land and forest reserve showed that 80% of species present in the forest were absent in farm land. Interestingly, a farm land species that is common elsewhere and currently provides the bulk of trade in urban bushmeat markets in Ghana (Crookes *et al.*, 2005), namely the grasscutter, was rarely harvested in Wansampo. Given that dense human populations and cocoa farming are characteristic of other areas in Ghana where grasscutters are harvested, the rarity of grasscutter in Wansampo may primarily reflect the presence of the Taungya system (the distribution of which is limited to communities neighbouring forest reserves). This, in turn, suggests that the Taungya system may be exerting a surprisingly strong influence on the bushmeat harvest in this farm-forest landscape.

More generally, cocoa farms have recently received attention by conservationists, since they may offer a potential for both biodiversity conservation and carbon storage outside protected areas (Rice & Greenberg, 2000; Schroth *et al.*, 2004; Schroth & Harvey, 2007; Clough *et al.*, 2009). While cocoa agroforests may be of biodiversity value, the high level of wildlife depletion observed in this study showed that intensively managed cocoa plantations are of little value to the conservation of mammals - and that the landscape-wide intensification of cocoa farming may pose a threat to biodiversity conservation (Gockowski & Sonwa, 2010).

Overall, it appears that the intensive cocoa-farming practise in Wansampo - possibly facilitated in part by the presence of a taungya - was the main cause of the strongly depleted farm fauna, reduced the options available for conservation management and may have contributed to the high level of protein insecurity in the village.

8.6. Policy and management implications

8.6.1. Locating Wansampo

Before embarking on drawing policy implications from this study it is important to place the study within the wider socio-economic and environmental context to appreciate its role within the bushmeat literature.

This study describes an extreme case in both an economic and environmental context. From an economic perspective, the hunters studied were primarily cash-crop farmers and overall bushmeat comprised a relatively small part of household production and income. The main cash crop was cocoa and the seasonality of cocoa harvests meant that households experienced strong seasonal income fluctuations that were the main determinants of both bushmeat harvest and utilisation patterns, and household income poverty. In contrast to most bushmeat studies, this research took place in a heavily impacted farm-forest landscape with heavily depleted wildlife populations. The remaining natural forests in this landscape are confined to timber production reserves that have been logged on an industrial scale for decades. Meanwhile, the majority of the wider landscape comprises intensively used cocoa plantations, primarily growing non-shade varieties, resulting in low structural diversity and low levels of food resources for wildlife.

8.6.2. Policy relevant findings

This study supports the statement that the ”bushmeat crisis” in West Africa is primarily a livelihoods crisis (Bennett *et al.*, 2007). Most species of conservation concern have already been extirpated in the farm-forest landscape. There is strong evidence that, despite wildlife depletion, bushmeat acts as an important safety net for some households, especially during the lean season, and enables people to maintain living standards through income and consumption smoothing. These findings differ strongly from Central African bushmeat hunting systems, where the hunting of large-bodied animals is frequently the main livelihood activity (Coad *et al.*, 2010; Kumpel *et al.*, 2010b). It is important that these differences - primarily due to lower wildlife abundance and a greater availability of alternative income sources - are taken into account by conservation and development practitioners, and that locally appropriate strategies are developed.

8.6.2.1. Findings relevant to conservation

The high level of wildlife depletion in the study site and especially in the farmland was caused by the intensification of land use and hunting pressure. As such, it provides an example of the negative effects of land use intensification on wildlife populations and highlights the dangers of the conversion of cocoa agroforests into sun-grown cocoa plantations. Intensive cocoa farming is clearly not wildlife friendly and efforts should be made to prevent the conversion of cocoa agroforests, especially in areas such as the Brazilian Atlantic Forest, where cocoa agroforests provide a crucial wildlife refuge in light of the high levels of deforestation (Johns, 1999).

A second finding of relevance to conservation is that rural households with access to alternative sources of income and protein continue to exploit depleted wildlife populations. While none of the species present in the study area were of conservation concern, protected areas in SW Ghana still harbour a wide range of species of conservation concern (*e.g. Pan troglodytes verus, Cercopithecus diana roloway* and *Colobus vellerosus*), and the high level of wildlife depletion in this farm-forest mosaic - and possibly elsewhere in the region - may provide an incentive for hunting in protected areas. Reducing the pressure on already depleted wildlife populations outside protected areas may benefit conservation management inside protected areas, especially if the two are in close proximity.

Conservationists have advocated reducing the urban demand for bushmeat by increasing prices and utilising an effect called ”cross-price-elasticity of demand“ to direct urban consumption towards domesticated animals and/or fish, and thus reduce the incentive for rural hunters to harvest bushmeat. While this may be an appropriate strategy in some areas, it is unlikely to reduce hunting levels where most bushmeat is consumed in the hunter's household - as was the case in this community. This shows the need for a more differentiated discussion about the likely effect of management strategies in urban areas on rural livelihoods as well as on bushmeat harvest rates.

Management interventions directly targeting rural hunters in villages where the role of bushmeat is foremost that of a safety-net must consider that restricting the harvest and sale of bushmeat without providing an alternative may increase livelihood insecurity, especially during the lean season. This is problematic from an ethical point of view and is unlikely to be a cost-effective management strategy.

8.6.2.2. Findings relevant to development

From a sustainable development perspective, the main finding of this study is that cocoa farming may not provide enough income to cover the basic needs of rural populations, especially during the lean season. Across southern Ghana, cocoa farming has contributed to poverty reduction in the rural areas (Coulombe & Wodon, 2007) and the agricultural sector is envisaged to act as the economic growth engine in the absence of a strong manufacturing sector (Breisinger *et al.*, 2008). Average household cash income in Wansampo was substantial (pppUS$3.2/capita/day), but the aggregate figure masks high seasonal cash flow variation and a largely impoverished rural community during the lean season (>60% of households were poor).

While some people argue that wildlife populations in West Africa are beyond the point where conservation money should be spent (Terborgh, 1999), from a development perspective the continued need for wildlife populations to act as a safety net among cash crop farmers provides a strong case for bushmeat to be included in development assistance strategies (Davies, 2002).

More generally, there is a need for poverty assessments and development projects to pay closer attention to seasonal income flows and income diversification strategies that promote income and consumption smoothing strategies in highly seasonal farming systems, especially among poorer households.

8.7. Limitations and further study

This study presents a detailed assessment of a West African farming-hunting system, based on a comprehensive and high-resolution assessment of household income and protein consumption patterns within a community displaying a high degree of socio-economic variation. Yet it is important to bear in mind that the findings derive from a snapshot of one community during a one-year period, which inevitably limits the study's representativeness. While the field period is similar to other Ph.D. projects, the decision to study a limited number of households in one community was a conscious choice to maximise data quality, data resolution and our understanding of the role of bushmeat in one case-study community. It is hoped that further studies will build on the insights gained during this research and complement its shortcomings.

8.7.1. Alternative environmental settings

One direct shortcoming of studying only one community is that it cannot capture the full range of environmental conditions present in the wider landscape. While the present study highlights the importance of bushmeat harvested from forests for rural livelihoods, it is important to keep in mind that this finding would have been strongly influenced by the close proximity of the village to forest, and different results would be obtained for forest-distant communities. Further studies should therefore aim to provide similarly detailed studies for farming communities living in different environmental settings, to improve our understanding of agricultural livelihoods and the role of bushmeat across the landscape.

Similarly, while this study suggests that the presence of a taungya (which is limited to villages near a forest) may have resulted in higher cocoa farming intensity and lower prevalence of food crops in the farmland, and hence a lower abundance/diversity of wildlife in farmland, this hypothesis remains untested. The virtual absence of grasscutters in hunters' bags, despite this species being the main species in the urban trade, was especially surprising in this respect. As such, the study site was probably not typical of the habitat that mostly supplies urban markets. Further research should therefore examine the effect of taungya farming on the intensity of cocoa farming and the implications for wildlife.

8.7.2. Protein consumption

This study showed that protein consumption and security did not vary strongly across wealth groups, and suggested that this was due to a combination of meat/fish being considered a necessity, the high importance of plant protein in diets and the mediating effects of household sizes on protein consumption. The linkages between these covariates clearly needs further research. While this study presents a detailed picture of protein consumption, it was not designed to be a household consumption study and a more specialist nutritional assessment would clearly improve our understanding. In this respect, a related shortcoming is the absence of consumption data at the personal level. Further research should also assess intra-household consumption variation to assess variation in vulnerability among members of the same household and how this affects consumption patterns.

Finally, protein security or the lack thereof was assessed by comparison of protein consumption against a generic threshold. Yet it is not known whether this threshold reflects local protein consumption needs and whether the low levels recorded had negative health effects. These uncertainties should be addressed in future studies, and ideally complemented with research into how protein consumption is affected by peoples' aspirations and spending preferences, and how these vary with the characteristics of the household.

8.7.3. Interactions between wealth and gender

The study community showed a high level of socio-economic differentiation enabling a detailed assessment of its effect on bushmeat harvest and use patterns. However, FHHs were not represented in the highest wealth group, preventing the full analysis of interaction effects between the gender of the household head and household wealth (*e.g.* are wealthy FHHs less likely to harvest bushmeat than poor FHHs). This limited the assessment of household vulnerability as a determinant of bushmeat harvest and use. It would therefore be useful if further studies could study household sets with a more even distribution of MHHs and FHHs across wealth categories.

The validity of participatory wealth assessments was verified against independent measures strongly related to household wealth, *i.e.* household expenditure and roof value (Adams *et al.*, 1997; Ghirotti, 1992). Yet farm characteristics were the main criteria used to rank households and the absence of independently collected data on farm sizes could be interpreted as a shortcoming. It is therefore suggested that future research among cocoa farmers should aim to verify the outcomes of wealth ranking exercises against farm sizes.

8.7.4. Levels of wildlife depletion

The assessment of wildlife depletion in this study was based on a long series of hunter surveys using short (24hr) and long (two weeks) recall periods. Such an approach is considered valid and appropriate (see discussion in Chapter 4), but it is important to note that the absence of independent wildlife surveys prevented the verification of the interview data. While this represents a shortcoming of this study, it should be considered that sighting rates of mammals in two nearby national parks were very low (0.09 encounters/km for Bia; 0.25 encounters/km for Ankasa, Gatti 2009) and a reliable assessment of wildlife species in the study area would have required a substantial effort, which would have undermined the quality of the interview data. It is hoped that future research using intensive wildlife surveys outside protected areas in SW Ghana can corroborate the findings reported here.

8.7.5. Income seasonality

The seasonality of cocoa incomes was a defining characteristic of the pattern of bushmeat harvest and use, and it was strongly linked to the level of poverty in Wansampo. However, it is possible that this strong pattern of seasonal income variation does not equally apply to all other cocoa-farming communities. The traditional categorisation of the cocoa farming year into main-crop (October to May) and mid-crop (May to August) periods (Barrientos & Asenso-Okyere, 2008) suggests that cocoa-farming households normally gain income throughout a larger part of the year than was the case in Wansampo. However, a recent study conducted in a nearby area (Bia district) found a similarly short cocoa season (September/October - January), with corresponding evidence for poverty to increase once the harvest had ended (Knudsen, 2007; Armah, 2009). Thus, while the lack of seasonal income data from more than one community is a shortcoming and should be addressed in future research, there is at least evidence of similar patterns in other villages in the region.

Finding livelihood options that facilitate the income smoothing of cash-crop farmers with highly seasonal harvest patterns is important from both a development and conservation perspective. In this respect it is interesting to note that some households harvested cocoa throughout the year, while the majority harvested cocoa during a few months only. It is unlikely that the extended harvest period was due to larger farm sizes since cocoa was harvested as soon as it matured. Further studies should assess variation in cocoa harvesting periods among households and determine the factors responsible. This would facilitate the development of new income smoothing strategies that would, in turn, reduce the need for harvesting bushmeat.

An alternative option for income smoothing is the diversification of crops farmed. There is evidence that cash crops such as oil palm may provide comparable incomes to cocoa and display less seasonal income variation (Phalan, 2009). A better understanding of income patterns associated with alternative crops and how these can be grown most effectively in association with cocoa trees is crucial for developing farming strategies. Cocoa farmers have adopted other crops in the past, due to soil depletion and low cocoa prices (Amanor, 1994). Such an economic study should be complemented with a more qualitative anthropological study that assesses the cultural, legal and economic connotations of farming cocoa and alternative crops, and how these could be utilised to promote the adoption of more varied farming patterns.

Appendix A

Appendix

Table A.1.: English, scientific and local names of taxa mentioned in the thesis.

English name	Scientific name	Local name
African civet	*Civettictis civetta*	Kankane
Ahanta francolin	*Francolinus ahantensis*	
Pel's flying squirrel	*Anomalurus peli*	Oha[1]
Brush-tailed porcupine	*Atherurus africanus*	Apese
Common cusimanse	*Crossarchus obscurus*	Ahwea
Crab	various	
Crayfish	various	
Giant pouched rat	*Cricetomys emini*	Kussie/Ebute
Giant squirrel	*Protoxerus stangeri*	Okukuban
Grasscutter	*Thryonomys swinderianus*	Akrantie
Lesser spot-nosed monkey	*Cercopithecus petaurista*	Ahinhema/Ellele
Maxwell's duiker	*Cephalophus maxwelli*	Okye
Monitor lizard	*Varanus niloticus*	Mampam
Potto	*Periodicticus potto*	Aposso
Royal antelope	*Neotragus pygmaeus*	Adowa
Slender mongoose	*Herpestes sanguinea*	Kokobo
Snail	*Archachatina* spp.	Nwa
Squirrel	various	Opuro
Tortoise	*Kinixys belliana*	Akyekyeree
Tree hyrax	*Dendrohyrax dorsalis*	Owea
Tree pangolin	*Phataginus tricuspis*	Aprawa
Cassava	*Manihot esculenta*	Bankye
Plantain	*Musa paradisiaca*	Brode
Yam	*Dioscorea* spp.	Baire
Cocoyam[a]	*Xanthosoma sagittifolium*	Amankani
White yam	*Dioscorea alata*	Cocoase

[a] two types of white yam exist in West Africa, *Xanthosoma sagittifolium* and *Colocasia esculenta*. The former has partly replaced the latter but both may still occur (FAO, 1996)

A.1. Appendix for Chapter 3

Table A.2.: Bodyweight and conversion factors for bushmeat species used during the analyses.

Species	Bodyweight (kg)	Conversion factor	
		Dressed meat	Protein content
Bushmeat-mammal			
African civet	6.0[1]	0.6[2]	0.275[2]
Pel's anomalure	1.6[3]	0.6[2]	0.275[2]
Common cusimanse	1.3[3]	0.6[2]	0.275[2]
Giant squirrel	0.8[3]	0.6[2]	0.275[2]
Grasscutter	6.7[3]	0.6[2]	0.275[2]
Maxwell's duiker	8.0[3]	0.6[2]	0.275[2]
Slender mongoose	0.6[3]	0.6[2]	0.275[2]
Lesser spot-nosed monkey	3.3[3]	0.6[2]	0.275[2]
Brush-tailed porcupine	2.8[3]	0.6[2]	0.275[2]
Bosman's potto	1.2[3]	0.6[2]	0.275[2]
Giant pouched rat	1.1[3]	0.6[2]	0.275[2]
Royal antelope	2.3[3]	0.6[2]	0.275[2]
Squirrel (various)	0.3[1]	0.6[2]	0.275[2]
Tortoise	0.8[4]	0.6[2]	0.275[2]
Tree hyrax	3.0[3]	0.6[2]	0.275[2]
Tree pangolin	2.4[3]	0.6[2]	0.275[2]
Bushmeat-other			
Crab (various)	0.05[4]	1.0[4]	0.195[5]
Crayfish (various)	0.09[4]	1.0[4]	0.195[5]
Ahanta francolin	0.4[4]	0.7[6]	0.2[6]
Monitor lizard	4.2[1]	0.6[7]	0.275[7]
Snails (various)	0.2[4]	0.4[8]	0.1[9]

[1] Kumpel (2006) [2] Albrechtsen *et al.* (2005) [3] Kingdon (1997) [4] this study
[5] Sudhakar *et al.* (2011) [6] same as chicken [7] same as bushmeat
[8] Cobbinah *et al.* (2008) [9] Milinsk *et al.* (2006)

Table A.3.: Bodyweight and conversion factors for livestock, fish and food crops used during the analyses.

Species	Bodyweight (kg)	Conversion factor	
		Dressed meat	Protein content
Livestock			
Chicken	1.0[1]	0.7[2]	0.2[3]
Goat	13.0[4]	0.6[2]	0.18[5]
Sheep	19.7[4]	0.6[2]	0.17[5]
Fish			
Tilapia (dried)	n/a	1.0[6]	0.47[2]
Herring (dried)	n/a	1.0[6]	0.47[2]
Mudfish (dried)	n/a	1.0[6]	0.47[2]
Fish (fresh)	n/a	1[6]	0.47[7]
Fish (tinned)	n/a	1[6]	0.47[7]
Plant protein			
Beans	n/a	1.0[6]	0.22[9]
Cassava	n/a	0.6[8]	0.02[9]
Cocoyam	n/a	0.6[8]	0.02[9]
Groundnut	n/a	1.0[6]	0.25[9]
Okra	n/a	1.0[6]	0.02[9]
Plantain	n/a	0.6[8]	0.02[9]
White yam	n/a	0.6[8]	0.02[9]
Yam	n/a	0.6[8]	0.02[9]

[1] National Research Council (1991) [2] FAO (1997) [3] Kingori *et al.* (2010)
[4] Armbruster & Peters (1993) [5] same as bushmeat [6] this study
[7] Albrechtsen *et al.* (2005) [8] see Section 6.3.1 [9] see Table A.9

There are no substantial correlations between covariates used in the model, namely age of the household head (age), education of the household head (education), dependence ratio and number of active male household members (active male) (Table A.4). The exception is education and dependence ratio, which are significantly correlated but the correlation coefficient is weak (0.23). As might be expected, there is significant correlation between the number of household members (hh members), dependence ratio and number of active male (active male), justifying the exclusion of hh members from further analysis. Due to the categorisation of the wealthiest households as 1 and the poorest as 4, the negative relationship between wealth and household size variables indicates that household size increases as household wealth increases (see also Figure 7.2d).

Table A.4.: Correlation between explanatory variables (N=63; significant correlations are marked: *= p<0.05; **=p<0.01).

	Hhsex	Wealth	AME	Age	Education	Dependence ratio	Active male	Hh members
Hhsex	1	-0.09	0.30*	-0.20	0.26*	-0.03	0.46**	0.26
Wealth	-0.09	1	-0.45*	-0.26*	-0.07	-0.14	-0.28	-0.52**
AME	0.30*	-0.45*	1	0.20	-0.07	0.31**	0.64**	0.86**
Age	-0.20	-0.26*	0.20	1	-0.25	-0.05	-0.11	0.15
Education	0.26*	-0.07	-0.07	-0.25	1	0.23*	-0.03	0.02
Dependence ratio	-0.03	-0.14	0.31**	-0.05	0.23*	1	-0.13	0.39*
Active male	0.46**	-0.28	0.64**	-0.11	-0.03	-0.13	1	0.56**
Hh members	0.26	-0.52**	0.86**	0.15	0.02	0.39*	0.56**	1

A.2. Appendix for Chapter 4

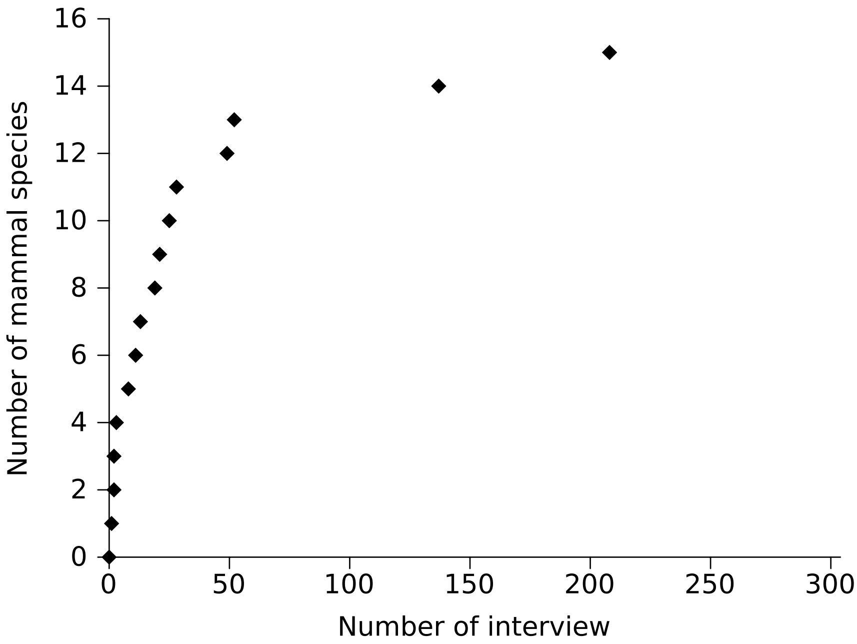

Figure A.1.: Accumulative number of mammal species confirmed present in the study area during the course of 304 surveys that recorded bushmeat harvest in the last two weeks (shown are 15 species instead of 16 species confirmed present because *Tragelaphus scriptus* was observed but never recorded in interviews).

A.3. Appendix for Chapter 5

Table A.5.: Results of GLMM analysis assessing the scale of bushmeat harvest value in relation to household wealth, seasonality and gender of the household head (N=97; No. households=38). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
null	0	0.42
season	1.5	0.20
hhsex	1.7	0.18
season+hhsex	4.1	0.05
wealth	4.2	0.05
season*hhsex	4.7	0.04
wealth+hhsex	5.6	0.03
wealth+season	6.4	0.02
wealth+season+hhsex	9.0	<0.01
wealth+season*hhsex	10.0	<0.01
wealth*season	13.3	<0.01
wealth*season+hhsex	16.2	<0.01
wealth*season+hhsex*season	16.5	<0.01

Table A.6.: Results of GLMM analysis assessing the proportion of household production value derived from bushmeat harvest in relation to household wealth, seasonality and gender of the household head (N=97; No. households=38). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
season	0	0.30
wealth+season	0.4	0.24
null	1.8	0.12
season+hhsex	2.5	0.08
wealth+season+hhsex	2.7	0.08
hhsex	3.7	0.05
wealth	3.9	0.04
wealth+season*hhsex	4.3	0.03
season*hhsex	4.7	0.03
wealth+hhsex	5.7	0.02
wealth*season	9.2	<0.01
wealth*season+hhsex	12.0	<0.01
wealth*season+hhsex*season	13.1	<0.01

Table A.7.: Results of binomial GLMM analysis assessing the effect of household wealth, income seasonality and gender of the household head on the likelihood of a household consuming harvested bushmeat (N=97; No. households=38). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
null	0	0.30
hhsex	0.3	0.26
season	1.7	0.13
season+hhsex	2.2	0.10
wealth	2.8	0.07
wealth+hhsex	3.0	0.07
wealth+season	5.0	0.03
wealth+season+hhsex	5.5	0.02
season*hhsex	5.7	0.02
wealth+season*hhsex	8.9	<0.01
wealth*season	15.1	<0.01
wealth*season+hhsex	15.6	<0.01
wealth*season+hhsex*season	16.0	<0.01

Table A.8.: Results of GLMM analysis assessing the effect of household wealth, income seasonality and gender of the household head on the value of harvested bushmeat consumed (N=86, No. households=37). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
null	0	0.45
hhsex	1.8	0.18
season	1.9	0.18
season+hhsex	4.5	0.05
wealth	4.7	0.04
season*hhsex	4.7	0.04
wealth+hhsex	5.9	0.02
wealth+season	6.7	0.02
wealth*season	8.4	0.01
wealth+season+hhsex	9.2	<0.01
wealth+season*hhsex	10.3	<0.01
wealth*season+hhsex	10.4	<0.01
wealth*season+hhsex*season	13.5	<0.01

A.4. Appendix for Chapter 6

Table A.10.: Sales prices for animals consumed/sold in Wansampo.

Taxa	US$/animal ± SD	US$/kg (dressed)	US$/kg (protein)	N
Bushmeat mammals				
African civet	21.08±5.96	5.85	21.29	2
Brush-tailed porcupine	7.39±2.34	4.40	15.99	17
Pel's anomalure	3.22±0.6	3.35	12.18	19
Common cusimanse	2.11±0.42	2.70	9.83	3
Giant pouched rat	1.65±0.46	2.50	9.09	255
Giant squirrel	1.31±0.54	2.83	10.28	2
Grasscutter	5.86±3.32	1.47	5.34	11
Lesser spot-nosed monkey	11.59±9.35	5.85	21.29	4
Maxwell's duiker	25.29±4.62	5.27	19.16	6
Slender mongoose	2.11±0.42	5.85	21.29	3
Bosman's potto	2.25±1.06	3.12	11.35	6
Royal antelope	6.43±3.22	4.76	17.31	4
Squirrel	0.98±0.49	5.47	19.89	25
Tree hyrax	4.04±1.48	2.24	8.16	31
Tree pangolin	3.71±1.14	2.58	9.38	42
Bushmeat-other				
Ahanta francolin	1.21±0.78	4.20	20.98	3
Crab	0.07±0.03	1.44	7.39	42
Crayfish	0.11±0.09	1.25	6.40	3
Monitor lizard	4.07±2.23	1.62	5.88	6
Snail	0.24±0.26	2.96	29.63	71
Tortoise	1.26±0.61	2.63	9.57	72
Livestock				
Beef[a]	n/a	3.96	22.02	20
Chicken[b]	5.11±1.17	7.09	35.45	27
Goat[b]	24.85±10.13	3.19	17.70	25
Pork[a]	n/a	2.99	24.94	15
Sheep[b]	33.08±10.7	2.80	16.46	33
Fish				
Tilapia (dried)	0.24±0.18	4.76	10.13	26
Herring (dried)	0.16±0.04	4.08	8.68	19
Mudfish (dried)	0.18±0.12	8.43	17.94	12
Fish (not dried)	0.49±0.11	2.06	10.95	11
Fish (industrial)[c]	n/a	6.00	31.91	7

[a] due to insufficient data, these are based on market data in Sefwi Dwenasi and consumption data in Wansampo
[b] based on livestock survey in Wansampo using mean value per adult animal
[c] industrial fish refers to tinned sardines and tuna; conversion factors were estimated from price per kg data

Table A.9.: Literature estimates of food crop protein content (wet weight unless otherwise stated).

Species	% protein	Source
Low protein crops		
Cassava	0.5	Bradbury & Holloway (1988)
	0.6	Food Standards Agency (2002)
	1.0	FAO (1990)
	1.0	Gomez & Valdivieso (1983)
	1.2	Ayankunbi *et al.* (1991)
	1.4	Saxholt *et al.* (2008)
	1.5	ITTA (1990)
	4.0	Ceballos *et al.* (2006)
Plantain	0.9	FAO (1990)
	1.1	Food Standards Agency (2002)
	1.3	Saxholt *et al.* (2008)
	1.7	Giami & Alu (1994)
	3.0-3.5	Ketiku (1973)
Yam	1.5	Saxholt *et al.* (2008)
	1.5	Food Standards Agency (2002)
	2.0	FAO (1990)
	2.0	Bradbury & Holloway (1988)
Cocoyam[a]	3.0-5.5	Sefa-Dedeh & Agyir-Sackey (2004)
	10.4	Hussain *et al.* (1984)
Okra	2.0	Saxholt *et al.* (2008)
	2.8	Food Standards Agency (2002)
High protein crops		
Groundnut	22.6	Saxholt *et al.* (2008)
	22.8	Food Standards Agency (2002)
	23.0	FAO (1997)
	25.8	Food Standards Agency (2002)
	28.0	Lusas (1979)
Beans[b]	22.0	FAO (1997)

[a] % protein of dry weight
[b] soy beans have a higher protent content (34.0-35.9%, Advisory Committee on Technological Innovation 1975; Food Standards Agency 2002; Saxholt *et al.* 2008), but these were rarely consumed

Table A.11.: Cost of plant protein in dressed and protein weight[a].

Taxa	US$/kg (dressed)[a]	US$/kg (protein)	N
Plant protein			
Beans	0.62±0.12	2.83	13
Cassava	0.20±0.17	9.87	63
Cocoyam	0.55±0.39	27.38	44
Okra	0.65±0.28	32.69	20
Peanut	2.30 ±1.30	9.18	5
Peanut butter	2.38±0.29	9.52	5
Plantain	0.36±0.28	10.58	100
White yam	0.42±0.22	17.78	13
Yam	0.32±0.17	21.16	3

[a] dress weight for plant protein refers to wet weight minus the weight of peel (40%), except for beans, peanut and okra (Section 6.3)

Table A.12.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on household protein consumption (g/AME/day). Consumption estimates assume 2% protein content of low protein food crops. Analysed were mean consumption estimates per household per season (N=185; households=63). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
null	0	0.27
hhsex	0.8	0.18
wealth	1.2	0.15
season	1.8	0.11
season+hhsex	2.5	0.08
wealth+season	2.8	0.07
wealth+hhsex	3.0	0.06
season*hhsex	3.7	0.04
wealth+hhsex+season	4.6	0.03
wealth+hhsex*season	5.8	0.02
wealth*season	9.7	<0.01
wealth*season+hhsex	11.5	<0.01
wealth*season+hhsex*season	12.8	<0.01

Table A.13.: Results of binomial GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the likelihood of a household members consuming less protein than 52.5g/AME/day (assuming 2% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
null	0	0.50
hhsex	1.6	0.22
wealth	3.0	0.11
season	3.9	0.07
wealth+hhsex	4.9	0.04
season+hhsex	5.5	0.03
wealth+season	7.0	0.02
wealth+hhsex+season	8.8	0.01
season*hhsex	9.2	<0.01
wealth+hhsex*season	12.4	<0.01
wealth*season	15.4	<0.01
wealth*season+hhsex	17.2	<0.01
wealth*season+hhsex*season	20.7	<0.01

Table A.14.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on household protein consumption (g/AME/day). Consumption estimates assume 1% protein content of low protein food crops. Analysed were mean consumption estimates per household per season (N=185; households=63). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth	0	0.23
hhsex	0.7	0.16
null	0.8	0.16
wealth+hhsex	1.4	0.12
wealth+season	1.8	0.10
season+hhsex	2.5	0.07
season	2.7	0.06
wealth+hhsex+season	3.1	0.05
season*hhsex	4.2	0.03
wealth+hhsex*season	4.8	0.02
wealth*season	8.1	<0.01
wealth*season+hhsex	9.4	<0.01
wealth*season+hhsex*season	11.1	<0.01

Table A.15.: Results of binomial GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the likelihood of a household members consuming less protein than 52.5g/AME/day (assuming 1% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
hhsex	0	0.29
wealth+hhsex	1.0	0.18
wealth	1.0	0.17
null	2.1	0.10
season+hhsex	2.5	0.08
wealth+hhsex+season	3.4	0.05
wealth+season	3.5	0.05
season	4.7	0.03
season*hhsex	5.1	0.02
wealth+hhsex*season	6.1	0.01
wealth*season+hhsex	7.1	0.01
wealth*season	7.2	0.01
wealth*season+hhsex*season	10.0	<0.01

Table A.16.: Results of GLMM analysing the effect of participatory household wealth category and gender of the household head on protein consumption per household (assuming 1% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+hhsex	0.0	0.36
hhsex	0.6	0.26
wealth+season+hhsex	2.0	0.13
season+hhsex	2.5	0.10
wealth+season*hhsex	3.4	0.07
season*hhsex	4.1	0.05
wealth	6.3	0.02
null	7.4	0.01
wealth+season	8.4	0.01
wealth*season+hhsex	9.1	<0.01
season	9.4	<0.01
wealth*season + season*hhsex	11.1	<0.01
wealth*season	15.5	<0.01

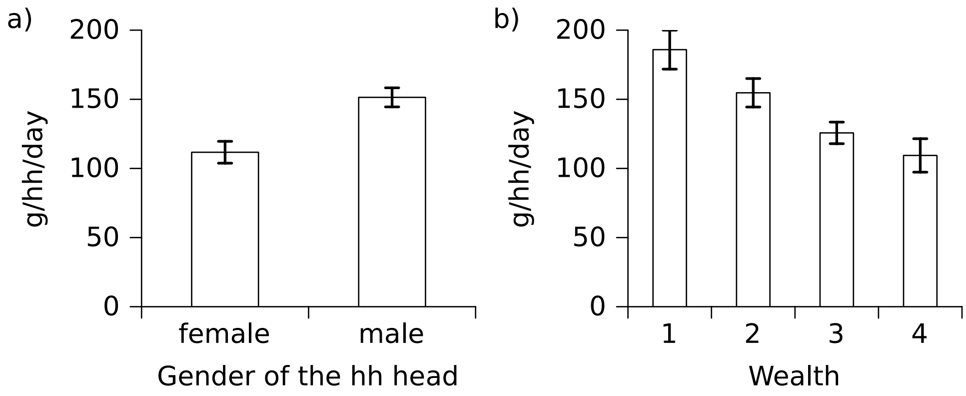

Figure A.2.: Total daily protein consumption per household across (a) male- and female-headed households, and (b) participatory wealth categories.

Table A.17.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of animal protein within a household's total protein consumption (assuming 1% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.43
wealth+hhsex+season	1.1	0.24
season	2.8	0.10
wealth+hhsex*season	3.3	0.08
season+hhsex	3.5	0.07
season*hhsex	5.7	0.03
wealth	7.0	0.01
wealth*season	7.3	0.01
wealth+hhsex	8.2	0.01
wealth*season+hhsex	8.4	0.01
null	9.6	<0.01
wealth*season+hhsex*season	10.3	<0.01
hhsex	10.4	<0.01

Table A.18.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of plant protein within a household's total protein consumption (assuming 2% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.37
wealth+hhsex+season	0.7	0.26
season+hhsex	2.9	0.09
season	3.0	0.08
wealth+hhsex*season	3.2	0.07
wealth	4.7	0.04
season*hhsex	5.4	0.03
wealth+hhsex	5.4	0.02
wealth*season	7.3	0.01
null	7.5	0.01
hhsex	7.6	0.01
wealth*season+hhsex	8.0	0.01
wealth*season+hhsex*season	10.1	<0.01

Table A.19.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of plant protein within a household's total protein consumption (assuming 1% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.38
wealth+hhsex+season	0.8	0.26
wealth	3.2	0.08
season+hhsex	3.8	0.06
wealth+hhsex*season	3.8	0.06
season	3.9	0.05
wealth+hhsex	4.1	0.05
season*hhsex	6.8	0.01
hhsex	7.0	0.01
null	7.1	0.01
wealth*season	7.3	0.01
wealth*season+hhsex	8.0	0.01
wealth*season+hhsex*season	10.6	<0.01

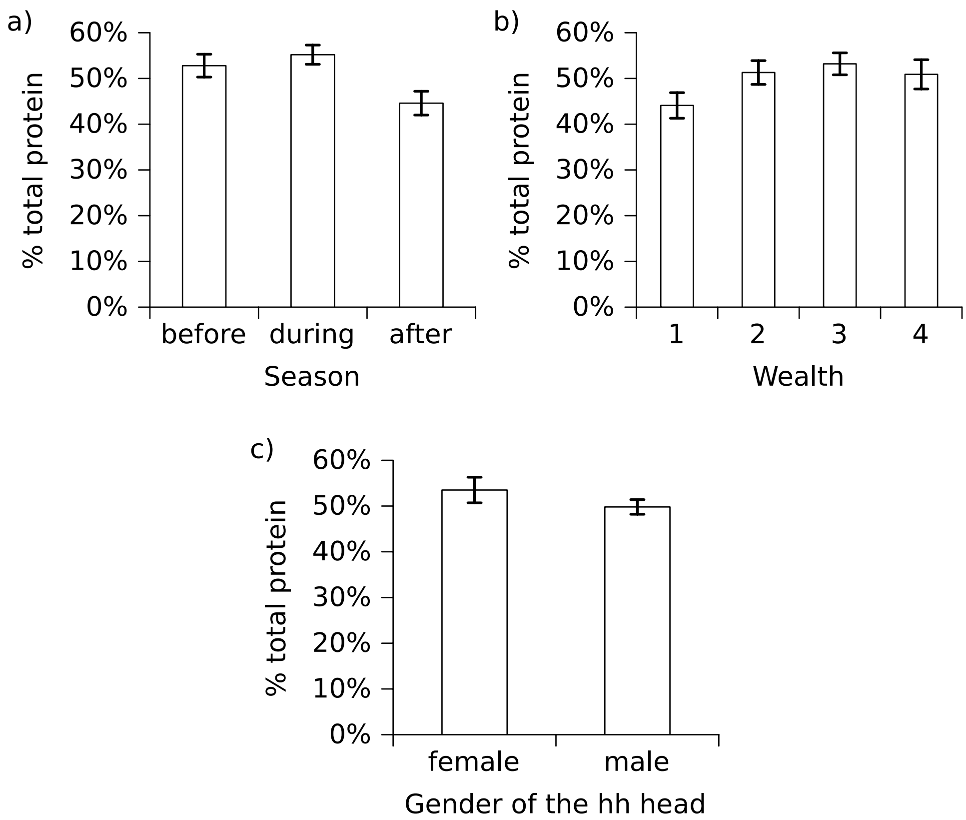

Figure A.3.: Percentage of total protein consumption derived from plant protein (assuming 2% protein content of "low-protein" food crops) across a) seasons, b) participatory wealth categories, and c) female- and male-headed households.

Table A.20.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of fish protein within a household's total protein consumption (assuming 2% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.26
season	0.6	0.19
wealth	1.6	0.12
wealth+hhsex+season	1.8	0.11
season+hhsex	2.2	0.09
null	2.4	0.08
wealth+hhsex	3.4	0.05
hhsex	3.9	0.04
wealth+hhsex*season	4.2	0.03
season*hhsex	4.6	0.03
wealth*season	7.9	0.01
wealth*season+hhsex	9.7	<0.01
wealth*season+hhsex*season	12.3	<0.01

Table A.21.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of food crops with low protein content within a household's total protein consumption (assuming 2% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
season	0	0.23
season+hhsex	0	0.23
wealth+season	0.5	0.18
wealth+hhsex+season	1.3	0.12
season*hhsex	3.0	0.05
null	3.0	0.05
hhsex	3.1	0.05
wealth	3.4	0.04
wealth+hhsex*season	4.3	0.03
wealth+hhsex	4.3	0.03
wealth*season	8.6	<0.01
wealth*season+hhsex	9.3	<0.01
wealth*season+hhsex*season	12.0	<0.01

Table A.22.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of fish protein within a household's total protein consumption (assuming 1% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.24
wealth	0.5	0.18
season	1.1	0.14
wealth+hhsex+season	1.8	0.10
null	1.8	0.09
wealth+hhsex	2.4	0.07
season+hhsex	2.6	0.07
hhsex	3.3	0.05
wealth+hhsex*season	3.7	0.04
season*hhsex	4.5	0.02
wealth*season	7.4	0.01
wealth*season+hhsex	9.3	<0.01
wealth*season+hhsex*season	11.5	<0.01

Table A.23.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of food crops with low protein content within a household's total protein consumption (assuming 1% protein content of low protein food crops). Analysed were mean consumption estimates per household per season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
season+hhsex	0	0.19
wealth+season	0.2	0.17
season	0.2	0.17
wealth+hhsex+season	0.9	0.12
wealth	1.7	0.08
hhsex	1.7	0.08
null	1.8	0.08
wealth+hhsex	2.5	0.05
season*hhsex	3.4	0.03
wealth+hhsex*season	4.3	0.02
wealth*season	8.2	<0.01
wealth*season+hhsex	8.9	<0.01
wealth*season+hhsex*season	12.0	<0.01

Table A.24.: Results of GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the relative importance of bushmeat protein for households that consumed bushmeat, *i.e.* households that did not consume bushmeat were not included in this analysis (assuming 1% protein content of "low-protein" food crops). Analysed were mean consumption estimates per household per season (N=136). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
season	0	0.59
season+hhsex	1.7	0.25
wealth+season	4.0	0.08
season*hhsex	5.4	0.04
wealth+hhsex+season	6.0	0.03
wealth+hhsex*season	9.8	<0.01
null	10.9	<0.01
hhsex	12.7	<0.01
wealth*season	14.2	<0.01
wealth	15.4	<0.01
wealth*season+hhsex	16.2	<0.01
wealth+hhsex	17.4	<0.01
wealth*season+hhsex*season	20.0	<0.01

Table A.25.: Results of binomial GLMM analysing the effect of participatory household wealth category, gender of the household head and seasonality on the likelihood of a household consuming bushmeat during a season (N=185). The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth*season	0	0.35
wealth*season+hhsex	0.3	0.31
wealth*season+hhsex*season	1.2	0.19
null	3.9	0.05
hhsex	4.9	0.03
season	5.8	0.02
wealth	6.4	0.01
season+hhsex	6.9	0.01
wealth+hhsex	7.0	0.01
season*hhsex	7.1	0.01
wealth+season	8.3	0.01
wealth+hhsex+season	8.9	<0.01
wealth+hhsex*season	8.9	<0.01

A.5. Appendix for Chapter 7

Table A.26.: Results of binomial GLMM analysis testing the effects of seasonality, household wealth and gender of the household head on the likelihood of a household earning less than pppUS$1.25/capita/day (N=187; No. households=63). ΔAIC_i and Akaike weight are shown for all alternative models tested. The model controlled for the effects of household characteristics listed in Table 3.9.

Model	ΔAIC_i	Akaike weight
wealth+season	0	0.55
wealth+season+hhsex	1.3	0.29
wealth+season*hhsex	4.5	0.06
season	5.0	0.05
season+hhsex	6.5	0.02
wealth*season	6.8	0.02
wealth*season+hhsex	7.9	0.01
season*hhsex	9.7	<0.01
wealth*season+hhsex*season	10.1	<0.01
wealth	35.6	<0.01
wealth+hhsex	37.0	<0.01
null	39.6	<0.01
hhsex	41.1	<0.01

A.6. Oral history of Wansampo

Written by Raphael Asare

Wansampo town belongs to the people of Wansampo, but the land belongs to Aboduam stool land. The Wansampo people belong to the Aduana tribe from Apropro in Côte d'Ivoire. The person who established Wansampo was Aphia, who came with her daughter, Amoah. Before establishing Wansampo, they stayed in Proboyn. Aphia brought a golden doll with her. She was given this by the people from her tribe (she was from the royal family and their ancestral land was full of gold). She was given the doll to play with, but it was also a means to pay for land if they needed to buy some. Amoah was an adolescent girl. She was given charge of pretty much all the money, because she stayed in the house whilst the others went out to collect cassava or to go hunting, so they thought it would be safe with her. But then one day the dwarfs came! They met Amoah when Aphia had left her to go to collect cassava. The dwarfs took the golden doll, which meant the people could not go back to Apropro because they would be interrogated as to where the doll was. There was no other currency at the time, so they had to stay in the area. So they went to the Betekye tribe (near Aboduam) to borrow money so that they could go home. They got the money, but the condition was that they had to become Betekye (and hence Aboduam) servants. They accepted this, but, when they became servants, they were treated very badly, so they gave the money back. The person who paid the money back (at the Sefwi Wiawso Palace) was Nana Kofi Amoah. After this, they had to leave the Betekye tribe and establish their own village. Tei Gyama from Abodiam established Wansampo. This person gave birth to Nana Kwaku Amohene, So Kwaejo and Kwame Sow. All three were hunters, not farmers. Nana Kwaku Amohene married Nana Akosuama (Raphael's grandmother). She gave birth to Kofi Amoah, Kwaku Nkrumah, Yaa Benea (she was called "Bϵ yϵ sϵ", meaning "what have been doing with it", because she was a female who could not give birth, and women who cannot give birth are not recognised because they must be cursed by gods), Kwadjo Owusu and Kofi Anto. Nana Kwaku Amohene was the very first chief of Wansampo and Nyameadiso. When he died, his successor was his son, Kwadjo Owuso. When he died, the next chief was Nana Kwasi Amoah, who was in the royal family, but not directly related to Kwadjo Owuso. Kwasi Amoah established Nyameadiso as a village, because he stayed there due to his farms being there. The next chief was Nana Ngyabuo, who is still alive and living in Kremokrom (Sefwi Wiawso District). He abdicated the stool because there was some trouble with people saying he had misused money from Nana Kwasi Amoah's farm (which acted as a substitute for stool land), and he had also failed to build a palace.

Written by Nana Kofi Amoah

Sefwi Wansampobreampa was a small cottage of houses not more than five. The houses were built by mud only and roofed with bamboo. At that time there were no aluminium roofing sheets as we can see today. In fact, this place was a typically remote area. There was no access to road, pipe born water, school etc. In addition the people were in economic hardship with a high level of poverty and great risk of disease. Largely due to the remoteness of their location, the absence of any job opportunities and the incompetence of elected representatives amongst other things. That is to say, citizens do not enjoy social orders since time of immemorial. The immediate settlers for this land were Ayiins from Côte d'Ivoire. They named this place after a small stream called Nyansampobreampa which has unfortunately disappeared as a result of improper preservation, maintenance and care. Hunting was the main occupation of the immediate settlers, largely due to the location being in the middle of deep forest where many animals lived. The hunters killed numbers of these animals day in day out, resulting in a massive decline of animal numbers in the surrounding forest. Some years later the Asakyiri family from Sefwi Aboduam fought and defeated the Ayiins and claimed ownership of Nyansampobrampa. The land became the legal property of the Asakyiri family and they protected it from strangers. The Asakyiri family was very large and was the royal family of Sefwi Aboduam. They became linked, through marriage, with the Ayaabosofoo family - the royal family of Sefwi Asantekrom. The two families united and became one as a result of the contracting marriage between them. After a period of time a member of the Ayaabosofoo family sent a petition to the Asakyiri family seeking permission to hunt on their land. This land was Wansampobreampa and the man's name was Nana Sokwaduo. Nana Sokwaduo was a great hunter, a true expert and a very brave man. In spite of the numerous dangers and wild animals in the deep forest he hunted ceaselessly to provide food for himself and his family. Fresh meat was nothing to write home about during that time. This man was indeed a noble hunter as is shown in the records of Wansampobreampa. He had a brother who would accompany him called Opanin Amoahene who was also a good hunter. When Nana Sokwaduo died unexpectedly his brother succeeded him. Nana Sokwaduo was given a burial at Sefwi Aboduam - his in-law's town. Opanin Amoahene married Nana Akosua Ampoma who came from Sefwi Aboduam. Nana Akosua Ampoma and family were strangers at Sefwi Aboduam so they were welcomed and accommodated by Nana Ntowkwaws family - Sefwi Aboduam Betekye. Opanin Amoahene, who was then the chief for this land, and wife Nana Akosua Ampoma gave birth to Kofi Amoah. After the death of Opanin Amoahene, who was a royal from the Ayaabosofoo family of Sefwi Asantekrom, none of his family came to Nyansampobranba to succeed him. This meant his son Kofi Amoah succeeded him. It was not tradition on this land that a son should succeed his father but Kofi Amoah was asked to do so, making him the new chief. His chieftaincy was under the recommendation of the Ayaabosofoo family - his father's family in Sefwi Asantekrom. Nana Kofi Amoah also married a woman called Nana Akua Ankamah from Sefwi Aboduam - Nana Addae's family - Aboduam Kontihene's family. Nana Kofi Amoah brought his wife to Wansampobreampa and gave birth to the following; Kwaku Amoahene, first son who was named after his grandfather the late Opanin Amoahene. He gave birth to Opanin Kwabena Asiamah, Abena Armah (alive), Ama Bernnie(dead), Nana Kwame Ntori (alive). Nana Kwame Ntori is the current Kontihene for Aboduam and he is living at Wansampobreampa. The sixth child was Opanin Kofi Anam (dead) and last born Opanin Kwaku Nkuah who is also living at Wansampobreampa. The second wife of Nana Kofi Amoah was called Akosua Kobiri, a royal from Sefwi Atabokaa. They gave birth to the following; Kwaku Addae (dead), he named his second son after his father's brother Nana Sokwaduo (who first came to expand the village), Ama Wuah (alive) was the third born. The fourth born was Nana Kwame Somiah Atabokaahene. He was made the king for that town because his mother was a royal and hails from there. Nana Kwame Somiah was named after a member from Nana Ntow Kwaw's family. Nana Ntow Kwaw is Aboduam Betkyehene. He is the "Tumtumhene" for the whole of Sefwi Wiawso Traditional Area. The meaning of "Tumtumhene" is supreme soldier in the Omanhene's Palace (traditional soldier's commander). The fifth child of Nana Kofi Amoah was Nana Akosua Gari (dead), Yaw Afi (alive and living at Wansampobreampa). Lastly Afua Amoah who is also alive. Nana Kofi Amoah also kicked the bucket and was succeeded by his biological brother Nana Kwadwo

Owusus who also died. He was succeeded by his nephew Nana Kwasi Amoah, who was entitled the “Odikoro“ of Wansampobreampa. ”Odikoro“ means ”to look after the village“. Eventually Aboduamhene who honoured Nana Kwasi Amoah as ”Odikoro” promoted him to “Adontihene”. “Adontihene” means “chairman for kings maker in Aboduam Palace”. Two years later he rejected the position. He was then called upon by Aboduamhene. As customs he was called to perform customary rites for the disgrace he had caused to the thrown “Odikoro“. This had very serious effects on his generation concerning the taking of that position. When Nana Kwasi Amoah rejected or destooled himself as ”Adontihene”, Aboduamhene asked him to step down from the “Odikoro”. This was because Ayaabosofoo customary owes that position “Odikoro“. The Aboduamhene by then is current chief called Nana Kwabena Aduhene. He was a man with political visions and was selfless leader to the community. He became a Member of Parliament for Sefwi Wiawso constituency during Dr Kwame Nkrumah’s regime and later a member of Council of State in J.J. Rawlings’ regime. To flashback, Aboduam is the legal possessor of this village and lands, therefore Aboduamhene denied Nana Kwadwo Owusu the right to look over Wansampobreampa lands. On the contrary he was not denied the right to lead his family - ”Abusuapanin“. Consequently, Aboduamhene appointed his own person called Opanin Kwabena Asiamah from Aboduam (Kontihene Nana Addae’s family) in 1966. Opanin Kwabena Asiamah was a very great and noble man. He was a man of justice, was fair and outspoken and commanded respect from people. Because of his character many began to hit him. He never gave up, he did his work assiduously. In spite of his work he did not forget establishing a family. He married three wives but the elder wife divorced him, leaving him with Nana Adua Kesewa second wife and other counterpart. Nana Adua Kesewa bore him five children who are as follows; Nana Ama Nkrumah (Queen mother of Ntow Kwaw royal family), followed by Nana David Amoah, Ama Ankamah, Yaw Asiamah (owner) and lastly Amakyi who are all alive and kicking. Some years later, Opanin Kwabena Asiamah suddenly joined his ancestors. Opanin Anam and Opanin Kwaku Addae from Aboduam continued his work. They did come down to stay in Wansampobreampa but they often came to carry out their work. Opanin Anam later fell sick and was not able to come again.

Therefore Aboduamhene appointed somebody from his royal family to look over his land for him. This man was called Nana Kwadwo Mensah - Nana Aduhene-s nephew. Nana Kwadwo Mensah was honoured the “Odikoro“. After taking the throne for almost four years he became arrogant and very rude to his elders. Consequently Aboduamhene destooled him. According to historical facts there came misunderstanding among the people in Aboduam against Nana Aduhene of which they decided to overthrow him long time ago. He stayed away from the town until the people cooled down and the situation returned to normal. He came to realise that the position ”Odikoro“ had been given to Nana Kwasi Amoah’s grandson called Abuo. Aboduamhene did not support this idea and therefore asked him to step down since his uncle had disgraced the throne by asking Aboduamhene to take his position very long time ago. The Queen Mother in that Odikoro’s family did not agree to that decision by Aboduamhene. She therefore called him to authorities. Eventually Aboduamhene was judged right and truth on the side of the issue. Hence a handsome apology was given to Aboduamhene by the Queen mother and her brother, the then Odikoro. The Aboduamhene, Nana Kwabena Aduhene, sat down with his elders and asked Nana David Amoah, a son to Opanin Kwabena Asiamah from Nana Ntow Kwaw’s royal family, to look after Wansampobreampa land. Nyamediso, the nearby village, is also subjected to his control and care. In fact Nana David Amoah is somebody who like his late father is very outspoken, just, fair, brave, a selfless leader and what have you. Nana David Amoah was not given Odikoro of Wansampobreampa after his appointment as somebody to take care of lands belonging to Aboduamhene. The position Odikoro was vacant from the time it was collected from Aboduamhene’s nephew, Nana Kwadwo Mensah, as a result of his arrogance and rudeness. This issue was presided over by Aboduamhene and his elders in his palace when they decided to give the position of Odikoro to somebody from Nana Kwasi Amoah’s family. Fortunately Kofi Adjei was chosen upon the recommendation of most elders in Nana Aduhene’s palace and hence he was honoured as the Odikoro. Nana Kofi Adjei is a very humble man, respectful and hard working who satisfies all the conscience of the Aboduamhene and his elders. Six months later Nana Kofi Adjei went to ask Aboduamhene the reason why the lands are not subjected under his Odikoro’s control.

More so he furthered this by seeking prior control of these lands. He was answered that it is from his grandparent's generation that the lands were excluded from their control. As a result of that Nana Kofi Adjei, from his own discretion, saw no reason why he should continue to hold the position Odikoro. He gave up and put down the Odikoro. As of now this village has no Odikoro but the person acting as such is Opanin Kwadwo Kora who is doing so until somebody is chosen to take over the Odikoro.

A.7. Household questionnaire

HH SURVEY	Date:	Time start:	Time stop:	Original / Copy	HhID:	SheetID: Hh0	Problem:
Interviewee name/PersID:		Observer:		Sheet checked by:	Inputted by:	Input checked by:	

T1	**PRODUCTION** Product name	# unit	UnitID	#/unit	Size	Tot. KG	Total WSP price	Collector PersID	Carrier PersID	From where Location	LandTyp	Purpose % Cons	Sale	Proc	Gift	Plant	FarmID
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	

T2	**EXPENDITURE** Expenditure type	Food	Meal	Item	Work	Service	Planted	24hr	Origin P/G/B	# units	Unit name	Tot. Kg	Total value	Credit	Lender PersID	Who paid PersID	Recipient PersID	Location	Purpose % Cons	Sale	Proc	Gift	Plant
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							

T3	**INCOME (Labour)** Labour details	Worker PersID	Employer PersID	Employer Work Rel.	Recipient PersID	Hrs worked	Salary/chop (old cedi)	Crop salary value	Work location	Food provided	Provider PersID	Value of food
1												

T4	**INCOME (RawProd)**	#	unit name	Size	Tot.	Total Sales	Origin	24hr	Collector	Collected where		SoldBy	SoldTo	Location	Transp.	Market
	Sold product type	units			Kg	price	P/G/B		PersID	Location	LandType	PersID	PersID	sale	cost	cost
1																
2																
3																

T5	**GIFTS**	Income	Expend	Food	Meal	Item	Work	Money	Plant	From	Recipient	#	unit name	Weight	Total Amount /	24hr	Origin	Purpose %				
	Gift details									PersID	PersID	units		(kg)	WSP price		P/G/B	Cons	Sale	Proc	Gift	Plant
1																						
2																						
3																						
4																						
5																						
6																						
7																						
9																						

T6	**MEAT CONSUMP**	# meat meals			Eaten at Hh or bought & eaten			Origin this %		
	Type of meat	D	B	L	# HhMem	# NonHhM	cedis this / other Hh	P	G	B
1										
2										
3										
4										

T7		# meat meals			Meat eaten outside	
	Type of meat	D	B	L	# HhMem	cedis this / other Hh
1						
2						
3						
4						

LAST NIGHT'S DINNER SURVEY – Hh & Non-Hh members consuming dinner at this house

T8	Eater Name	PersID	HhMem
1			
2			
3			
4			

	Eater Name	PersID	HhMem
5			
6			
7			
8			

	Eater Name	PersID	HhMem
9			
10			
11			
12			

	Eater Name	PersID	HhMem
13			
14			
15			
16			

Food consumed outside this house by Hh members

T9	Eater Name	PersID	HhID
1			
2			
3			

	Eater Name	PersID	HhID
5			
6			
7			

	Eater Name	PersID	HhID
8			
9			
10			

	Eater Name	PersID	HhID
11			
12			
13			

T	**HUNT/TRAP/FISH**	24hr	2Wk	Hunter	#	Size	Method	Location	Land	Edge	Time	Total WSP	Take	Check	Costs	Other	% Purpose			
10	Animal name			PersID	Animals		G/T/D/H		Type		M/A/E/N	price	gun	traps	(bullet/wire)	activity	Cons	Sale	Proc	Gift
1																				
2																				
3																				
4																				
5																				
6																				

T	**INCOME (Non-Raw)**	End	Input	# units	Unit	Total	Origin	SoldBy	SoldTo	Location	Transport	Market
11	Product name				ID	price	P/G/B	PersID	PersID		cost	cost
1												
2												
3												
4												
5												
6												

T	**EXPENDITURE/GIFT**	Buy	Gift	Lend	Food	Meal	Item	Work	Money	Service	Credit	Lender	#	unit name	Total	Value per	Who paid	Recipient	Location
12	**> 50,000 last 2 weeks**											PersID	units		Value	term	PersID	PersID	
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			

T	**INCOME/GIFT**	Income	Gift	Borrow	Food	Meal	Item	Work	Money	Service	Credit	Lender	#	unit name	Total	Who paid	Recipient	Location
13	**> 50,000 last 2 weeks**											PersID	units		Value	PersID	PersID	
1																		
2																		
3																		
4																		
5																		

Expenditures at market within last week that are not covered by 24hr recall

T	**Markets not last 24hr**	Income	Expend	Market ID			Food	Meal	Service	Item	Car	Market	#	unit name	Total	Who paid	Who sold	% Purpose			
14	Product			DW	NS	Other							units		Value	PersID	PersID	Cons	Sale	Proc	Gift
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					
13																					
14																					

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