Evaluating dependence on wildlife products in rural Equatorial Guinea

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Abstract

It is often stated that wildlife is extremely important to poor rural households, particularly in tropical forest regions, and many have proposed that rural populations depend on wildife. There is evidence that the harvest of forest products such as bushmeat is highly unsustainable, and so there is a need to assess this dependence on forest resources in order to evaluate the potential impacts to people following a reduction in forest offtake whether due to declining wildlife populations or to management. There is clear evidence that the use of forest products, including bushmeat, wild fish and forest plants, is widespread, but the more ambiguous term 'dependence' is harder to demonstrate. I show that two rural villages in continental Equatorial Guinea consume, produce and earn significant amounts from wildlife resources, particularly bushmeat. I show that the consumption of wild foods, particularly plants, increases during the lean season, implying that wild plants reduce vulnerability to food shortages in times of stress, and are therefore important for food security. Production and income from wildlife is highest for poorer, food insecure households, and this represents a significantly higher proportion of their income than for the rest of the population, suggesting that these vulnerable households with few livelihood options rely on wildlife for regular income. The less accessible village is more food insecure and has fewer income sources, and is also more reliant on forest resources, particularly bushmeat for income. Finally, I give evidence to demonstrate that monitoring sales of wildlife products in urban markets is a useful way to assess changes in offtakes. However, these markets may represent only a small fraction of the total harvest, and may underrepresent vulnerable taxa such as primates that have a relatively low price for their size. The data suggest that bushmeat harvest in continental Equatorial Guinea is likely to be unsustainable. This study has used a number of different approaches to explore dependence on wildlife in rural Equatorial Guinea, and I conclude that poorer families in the more remote village are indeed dependent on a range of wildlife resources, both for income and consumption. This must be taken into account in any policy responses to unsustainable harvests.

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List of Acronyms

AME	Adult Male Equivalent
CAR	Central African Republic
CUREF	Project for the Conservation and Management of Forest Ecosystems in Equatorial Guinea
CFA	Central African Franc (currency of Equatorial Guinea)
DRC	Democratic Republic of Congo
FAO	Food and Agricultural Organisation of the United Nations
GLM	Generalised Linear Model
GLMM	Generalised Linear Mixed Model
GDP	Gross Domestic Product
HH	Household
IMF	International Monetary Fund
INDEFOR	National Institute for forest development and the management of protected areas
LMM	Linear Mixed Model
MAM	Minimum Adequate Model
MDG	Millennium Development Goal
NTFP	Non-timber forest product
UNDP	United Nation Development Program
WAZ	Weight-for-Age z-score
WHO	World Health Organisation
WR	Wealth Rank

Chapter 1.

Introduction

1.1 Dependence on wildlife resources

It is often stated that wildlife and forests are extremely important to poor rural households, particularly in tropical forest regions, for a number of products and services, including food, food security, income, livelihoods and fuelwood (FAO 1990; Hoskins 1990; Guijt et al. 1995; Levang & FPP-Bulungan team 2002; Fa et al. 2003; Milner-Gulland et al. 2003), and many have proposed that rural populations depend or rely on wildlife products, or that the forest is necessary to them. Wildlife products encompass a range of different resources, but are generally understood to include 'all specimens of wild animal, plant and fungal species, both terrestrial and aquatic, which continue to occur in the wild in non-domesticated form, regardless of whether domestic variables have been developed' (Roe et al. 2002). Perhaps most important among wildlife products are those resources that constitute 'wild foods', namely wild plants, wild-caught freshwater fish ('hereafter simply 'fish' unless specified otherwise) and bushmeat (or 'wild meat', wild animals killed for food). In this study, bushmeat is taken to mean all wild animals except fish, including mammals, birds, herpetiles and invertebrates.

It is relatively simple to demonstrate the use of a particular forest product (if it is used), and the widespread use of wildlife products has indeed been shown in abundance (LWAG 2002; Peres & Lake 2003; Davies & Brown 2007). However, the more ambiguous term 'dependence' is far harder to demonstrate, and yet there is mounting evidence implying, and in some cases beginning to prove, that many populations may indeed depend on forests in a range of ways. In the case of bushmeat, for example, initial studies looking at the importance of this resource focussed on consumption (Owusu et al. 2006), showing high levels in urban and rural areas. Others have gone further, looking at consumption, production and income and demonstrated that wild foods may be more important for income than for food (de Merode et al. 2004; Kümpel 2006). This has also been demonstrated at larger scales, such as by Vedeld *et al* (2007) who showed that forests can provide an average 22% of income, mainly through fuelwood, wild foods and fodder, in a meta-analysis of over 50 studies. In addition to bushmeat, a wide variety of wildlife products have been shown to be important for livelihoods and food security, including wild plants, fish, insects and other invertebrates, hertepiles, wood, reeds and honey (Shackleton & Shackleton 2004).

Assessing dependence on wild foods is important for a number of reasons. Evidence has shown that across Central Africa, bushmeat hunting levels are likely to be unsustainable (Robinson & Bennett 2000). Although there is less information on the sustainability of wild fish and plant harvests, there have been reductions in wild plant harvests in areas where they have been

harvested for food (Pandit & Thapa 2003) and for other uses (e.g. rattan, Sunderland et al. 2004). Given the rising human population levels across Africa (UNDP 2006), the demand for, and commercialisation of, these products is likely to grow substantially in the near future. This coupled with increasing access to forests means that wild resources are likely to be harvested at greater levels than ever before. If people do depend on wildlife resources, then a reduction in wildlife populations is likely to have important repercussions for development. Despite widespread recognition of the importance of wildlife products to people by many conservation and development practitioners, the importance of wildlife harvests and sales are often outside the formal economy and so overlooked by policy by policy makers (FAO 1996; Bird & Dickson 2007). Thus there is a need to formally demonstrate this dependence.

In order to assess the potential of forest products to continue to provide these important services, there is a need to develop accurate, cost-effective tools for monitoring changes in wildlife. This is particularly true for bushmeat, arguably most at risk from unsustainable harvesting. Some practitioners have used urban bushmeat market data as a way of assessing regional bushmeat offtake, but there are currently few, if any, data demonstrating the accuracy of these market data in reflecting rural bushmeat harvest.

In this thesis, I examine the overall importance of wild resources to rural populations, as well as the variations within those populations. By investigating the variation in use of forest resources among different wealth and demographic groups, and between different communities, we can further assess factors affecting dependence on wildlife. In addition, this will allow me to ascertain which people should be targeted by management strategies or will be affected by wildlife population decreases. In the remainder of this introduction, I will present an overview of the key concepts and issues in this field, followed by a summary of my aims and research questions, and finally an outline of the rest of the thesis.

1.2 Sustainability of wildlife harvests

Both habitat loss and hunting are major threats to wildlife across the world, but some now believe that the hunting of wild animals for food will be more of a threat to the conservation of biological diversity in the tropics over the next 15-25 years than habitat loss, particularly in Central Africa (Robinson & Bennett 1999; Robinson et al. 1999; Wilkie & Carpenter 1999). Hunting by humans is believed to be responsible for a third of the species threatened with extinction (Hilton-Taylor 2000), and has resulted in serious population declines (e.g. Wilkie & Carpenter 1999; Robinson & Bennett 2000) and local species extinctions (Brashares et al. 2001). Unsustainable bushmeat harvests of certain species are particularly critical in Africa,

where bushmeat use tends to be higher and more evenly spread than it is in other continents (Brown & Williams 2003), and where there are fewer alternative protein sources. In West and Central Africa alone, 84 mammalian species and sub-species are estimated threatened with extinction, as a result of hunting (IUCN 2003) and it is thought that half of Africa's chimpanzees and gorillas have disappeared over the last 20 years, primarily due to hunting (Walsh et al. 2003). Some estimates of hunting sustainability across all species have also indicated unsustainability. In the Congo basin (Cameroon, CAR, DRC, Equatorial Guinea, Gabon and Congo), the current annual bushmeat harvest is thought to be up to six times the sustainable amount (Robinson & Bennett 2000; Bennett 2002) and at unsustainable levels for 60% of mammalian species (Fa & Wilkie 2002) for species studied. However, sustainability estimates, particularly those generalising across many species, should be treated with some caution: studies often focus on a limited number of species (usually the more vulnerable species) and calculations are often based on estimates of biological data which are flawed or simply unknown (Nasi et al. 2008). Consequently, although it is clear that for many vulnerable species hunting is unlikely to ever be sustainable except at the lowest possible rates, there are also some species which can withstand fairly high rates of hunting (e.g. see Cowlishaw et al. 2003 for evidence of post-depletion sustainability in a mature bushmeat market).

Many of the characteristics of bushmeat hunting thought to make it inherently prone to unsustainable harvests are also applicable to other forest products. Forests are an open access resource and therefore subject to over-exploitation (Ludwig et al. 1993), and hunting, fishing and gathering are low cost activities, and so can be an attractive livelihood option. They are often multi-species activities, so vulnerable species may continue to be exploited beyond the point where they would otherwise be profitable ('piggy-back extinction' Clayton et al. 1997). In addition, tropical moist forests are inherently unproductive and maximum yields of wild animals are very low, estimated able to support only one person/km^2 (Robinson & Bennett 2000). Recent causes of increased bushmeat harvests are also relevant to forest plants and fish. The large increases in human populations in developing countries, and particularly urban populations, have increased demand and consumption of all products, as well as of bushmeat, while deforestation has resulted in a smaller supply of forest products. The logging of tropical forests increases access to those forests, as well as to infrastructure for market trading and consumers (Stromayer & Ekobo 1991; Blake 1994; Bowen-Jones 1998). Lack of access to alternative employment and dysfunctional market economies can mean there are few livelihood alternatives, and lack of access to alternative sources of protein theoretically impacts fish harvests as well as bushmeat harvests. There are few studies to show forest plant and fish harvest sustainability in Africa, and the extent of commercialisation is not nearly so

great, but empirical studies have shown that the marketing of plant forest products can lead to their competitive exploitation and subsequent degradation (Pandit & Thapa 2003) or at least be associated with resource depletion (Nkwatoh & Yinda 2007). The higher value of bushmeat by weight and by volume, coupled with modernisations of hunting technology (such as guns) mean that bushmeat is likely to remain more vulnerable to over-exploitation than other forest products. However, care should be taken to monitor use of all forest products.

1.3 The importance of wildlife resources to people

For rural households, there are at least three important potential benefits from forest products:

- Direct uses by the household (e.g. consumption);
- Direct trade or sale, providing an income to households;
- As a safety net which reduces the vulnerability of household (i.e. presents the potential to provide food or income).

Studies have shown that wild food consumption is widespread amongst tropical forest peoples, and may contribute substantially to diets (e.g. Chardonnet et al. 1995; Wilkie & Carpenter 1999; Williams 1999; Bhattacharya & Patra 2007). Other studies have shown that wildlife can be more important to livelihoods than consumption (Godoy et al. 1995), demonstrating high income levels from wildlife sales among resources users (e.g. Dethier 1995; Foppes & Dechaineux 2000; Awono et al. 2002). However, it is through the evaluation of the use of wild foods as a safety net that we begin to assess people's dependence on wildlife products. There is some evidence that wildlife resource use increases during vulnerable times, such as during seasonal shortfalls (Fleuret 1979; Sullivan 1998; Pattanayak & Sills 2001) or amongst vulnerable people, such as the poor and food insecure (Scoones et al. 1992; Nasi & Cunningham 2001; Neumann et al. 2002; Vedeld et al. 2007). The importance of wildlife products are discussed at length in the relevant chapters.

Despite evidence on the scale and importance of forest products, the extent and value of wildlife harvests is often over-looked or underestimated. Wild foods often make up more of a subsistence population's dietary value that is realised (Hoskins 1990) and forests in general continue to be undervalued by planners and policy makers (Katerere 1998). It is currently believed that inland fisheries are greatly underreported (Revenga & Cassar 2002), and some studies continue to ignore non-marketed NTFPs in estimates of the economic role that wildlife products play in people's livelihoods (e.g. Narendran et al. 2001). African

forestry specialists assert that one of the major constraints to sustainable forest management is the marginalisation of forestry within policy sectors such as agriculture (FAO 1996; Mlay et al. 2000), and forestry and bushmeat have low coverage in national poverty reduction strategies (Bird & Dickson 2007).

However, some practitioners have cautioned that in certain cases the benefits of wildlife to people may have been over-emphasised in the desire to merge community interests with conservation objectives (Luxmore 1994), and the precise benefits to rural people are not always clear. External conservation lobby groups have been accused of compounding misconceptions over the economic contribution that wildlife makes to the rural economy, causing Luxmore (1994) to state that "where there is a spark of interest in wildlife conservation, the flimsiest of economic arguments may be sufficient to fan it into life". In addition, there may be alternative and non-consumptive reasons for harvesting wild resources. Hunting and trapping is often cited as important for pest control in some areas, and the range of the grass-cutter rat, *Thyronomys swinderianus,* has extended into agricultural land south of its original range in West Africa, possibly due to the increasing conversion of dense forest into arable fields. Conflicts between people and animals over crop damage and perceived threats to human safety have been the primary cause of hunting in parts of Africa (Gillingham & Lee 2003), and elsewhere, wildlife may be important for cultural and ceremonial uses.

1.4 Food security and nutrition

1.4.1 Definitions

Food security is defined as "when all people at all times have physical and economic access to sufficient, safe and nutritious food for a healthy and active life" (World Food Summit 1996; FAO 2003). It is made up of three principal components:

- the **availability** of food, or the amount of food that actually exists (from local production and other sources);
- people's physical, economic and social **access** to adequate, nutritional food (i.e. the capacity to produce, buy or acquire food), and the stability of this access over time; and
- people's **ability to utilise** this food, including the patterns of control over who eats what and the physical ability to absorb nutrients (affected by health status factors such as intestinal parasites).

These are determined by physical, economic, political and other conditions within communities, and are undermined by shocks such as natural disasters and conflict.

Food insecurity is the absence of food security and applies to a wide range of phenomena, from famine to periodic hunger to uncertain food supply. Hunger can be experienced temporarily by people who are not food insecure, as well as those who are. In the literature, hunger is often used to refer in general terms to Millennium Development Goal (MDG) 1 and food insecurity. Acute hunger affects ten percent of the world population and is when lack of food is short term, often caused when shocks such as drought or war affect vulnerable populations. Chronic hunger is a constant or recurrent lack of food and results in underweight and stunted children and high infant mortality. Undernourishment is when there is insufficient energy intake. It is also an indicator sometimes used to assess food security levels, and is based on national food production figures so is essentially a measure of food availability. Malnutrition is the condition caused by deficiencies or imbalances in energy, protein and/or other nutrients (FAO 2003; UN Task Force on Hunger 2005).

1.4.2 The impacts of food insecurity

Hunger, poverty and disease are interlinked, with each contributing to the occurrence of the other two (WHO 1997). Hunger reduces natural defences against most diseases, and is the main risk factor for illness worldwide (WFP; WHO 2003; UN Task Force on Hunger 2005). People living in poverty often cannot produce or buy enough food to eat and so are more susceptible to disease, while sick people are less able to work or produce food.

Hunger is a major constraint to a country's immediate and long term economic, social and political development. The UN Standing Committee on Nutrition concluded that nutrition is an essential foundation for poverty alleviation, and also for meeting MDGs related to improved education, gender equality, child mortality, maternal health and disease (UN Standing Committee on Nutrition 2004). Food security is also seen as a prerequisite for economic development. Undernourishment pre-birth and of young children is associated with poor cognitive development, resulting in lower productivity and lifetime earnings potential (FAO 2004) and losses in labour productivity due to hunger can cause at least 6-10% reduction in per capita gross domestic product (GDP) (UN Task Force on Hunger 2005). Deficiencies in micro-nutrients (vitamins and minerals) can also affect mental and physical health. For example iron deficiency anaemia remains a major health problem and can negatively impact on health, life-expectancy, work productivity and economies, and is responsible for 2-7% of forgone GDP in the ten developing countries with good estimates.

Food and nutrition security remain Africa's most fundamental challenge, with 78% of the countries in Africa being food insecure (FAO 2003). In 2003-05 over 200 million people on the

continent were undernourished, their numbers having increased by 25 percent since the early 1990s (although the proportion has decreased from 34 to 30%), and virtually doubling since the late 1960s. Consequently, any management plans controlling forest harvest or evidence showing a reduction in these harvests should assess the impact of a reduction in forest goods to local diets, and consider that it may push some people into unacceptably low levels of nutrition.

Demand and need for food is influenced by many factors, but population growth has been the single most important factor in the last 25 years, explaining between 50% and 75% of the increases in demand. Proportionately, the population has grown more in developing countries, with 60% of people living in developing countries in 1950 compared to 80 % in 1995. Among developing countries, those in Africa have shown the most rapid population growth, and the continent's population is expected to exceed 1 billion people by 2010 (UN 1994). For many years, experts have been concerned about the ability of agricultural production to match these growing global food demands (Ehrlich & Ehrlich 1990; Brown & Kane 1994).

The second major cause of food insecurity is the huge increase in urban populations. By 2010, more than 50% of the world's 7 billion people will be concentrated in urban areas (UNDP 2003) and by 2025, urban population is expected to reach 5.1 billion people, of which 80% are living in developing countries (de Nigris 1997; UN 2003), making up 61% of expected total population. Africa has shown the most rapid urbanisation due to intrinsic population increases and rural-urban migration, and by 2025, 53% of Africa's population (755 million people) will be urbanised (FAO 2003). Urban populations in developing countries are rapidly out-growing their food resources, a condition made worse by inadequate marketing, processing and distribution systems, a decreasing supply from rural areas, and in some cases disruptions due to wars or natural disasters. The background of low incomes means that increasing numbers of urbanites are unable to buy adequate food. Domestic output in many countries is insufficient to support this growing demand, which has led some countries increasingly to rely on imports (e.g. the massively increased cereal imports into Africa, FAOSTAT). Other causes of food insecurity include distribution problems such as bad roads between rural and urban areas (de Nigris 1997), nutrition requirements, changes in income and changes in relative prices. Potential problems also include climate change (International Panel on Climate Change 2001) and HIV/AIDS (FAO 2001).

1.5 Research questions

The dependence of people on a particular resource is often difficult to establish because there is not a direct link between use and dependence – because someone uses or eats something,

doesn't mean they necessarily depend on it; they may have many different, equally good options open to them. Dependence is demonstrated by exploring the availability of alternatives and patterns of use during stressful times and among vulnerable people. My overall aim in this thesis is to assess dependence on forest products among rural people. My specific research questions are:

1. How important are wild foods for regular use?
2. How important are wild foods as a safety net?
3. Are wild foods more important for vulnerable members of the community?
4. How useful are urban market data as a tool for monitoring wildlife offtake such as bushmeat?
5. What are the implications for wildlife harvest, particularly bushmeat, in the future in Equatorial Guinea?

Despite recent increases in urban populations, rural people still make up the majority of African populations at present, and harvest the vast majority of forest products. In this thesis, I consider dependence among rural people in the central Africa country of Equatorial Guinea.

1.6 Thesis outline

In Chapter 2, I describe the study site and outline the general methods used to obtain the data analysed in Chapters 3, 4 and 5. In addition, I describe how household and individual level variables were collected and analysed, and in particular describe the collection of three indicators of household wealth, and their relationship to each other and to other household variables.

In Chapter 3, I analyse data on individual and household consumption in two rural villages in Equatorial Guinea to examine the contribution of wild foods to diets compared to other foods. I assess variations in total food consumption, and then analyse differences in calorie and protein consumption from different food sources (i.e. bought foods, foods received as a present, foods harvested directly from the forest and agricultural foods produced by the household) and food types (imported foods, coastal foods, agricultural foods and forest foods) to assess the contribution of these food sources and types to diets. I analyse differences in consumption with individual, household and seasonal variables, and assess the importance of bushmeat, wild fish and forest plants individually, as well as forest foods as a whole.

In Chapter 4, I analyse data on individual and household income in the same two study villages to assess the contribution of forest products to livelihoods, compared to other income sources. I

describe the general characteristics of the main livelihoods used in each village, particularly agriculture and forest livelihoods. I analyse the contribution to individual production and income from all livelihood categories (agriculture, forest livelihoods, trade and paid work). Forest livelihoods are further divided into bushmeat, wild fish and forest plants to assess their individual contributions to livelihoods.

In Chapter 5, I differentiate between the use of wildlife products and dependence on them by the most vulnerable people and at the most vulnerable times of year. I establish which households are most likely to be food insecure by identifying food coping mechanisms commonly used, and then measuring the use and severity of these mechanisms for households in both villages. I analyse five years of data on child weights and ages for children under five years old in one of the villages to assess in which season children are most likely to weigh relatively less, and use this as an indication of a lean season. I analyse the relative contribution of wildlife to the diets and livelihoods of the least food secure and the poorest households in each village, and compare this to the consumption, production and income from wildlife by other households in the same village to assess dependence on wildlife among the most vulnerable households. I then analyse the relative contribution of wildlife to diets and income during the lean season, compared to the rest of the year, to assess dependence on wildlife during the most vulnerable season, and use these results to draw conclusions on the dependence on wildlife products among the two study villages.

In Chapter 6, compare bushmeat offtake data from the two study villages with data from two 'hunter' villages and urban market data, putting the study villages into context. I evaluate the accuracy of urban bushmeat market data as a tool for monitoring village hunter offtake, I analyse which characteristics of rural communities are most likely to affect bushmeat offtake species profile, and then assess indicators of hunting sustainability in continental Equatorial Guinea. I use data on hunter offtake from the two hunter villages and compare these to urban market data on species purporting to originate from the same villages, to assess what factors affect the likelihood of a species being sold to urban markets, and consequently show how accurate market data is as a reflection of rural village offtake. I then look at the effects of regional characteristics such as human population density, market access and forest cover on the composition of bushmeat species that they supply to urban markets. Finally, I compare data collected between two years within the same catchment areas, to assess changes in species profiles within limited geographical regions, to give an indication of hunting sustainability in continental Equatorial Guinea.

The use of wildlife resources for food and income is widespread across much of Africa, and yet is unsustainable in many areas. A better understanding of this use; which people harvest it and why, and their dependence on it, and a better understanding of the tools used to measure the impact of this use, is necessary in order to reveal where wildlife populations are at risk and the consequent effect on food and livelihood security.

Chapter 2.
Study site and methods

2.1 Study area: Equatorial Guinea

The Republic of Equatorial Guinea is a small, Spanish-speaking country in Central Africa (Figure 2.1) situated on the coast between Cameroon and Gabon. It was chosen as suitable for a study of this type because it is small enough to permit a study of the entire system and research shows that the country has high levels of biodiversity for its size (Chapman et al. 1999). In addition, there is a no regulation of wildlife trade, making it relatively easy to collect data on wildlife harvesting, including hunting and bushmeat sales. Furthermore, recent oil discoveries have led to an economic boom that has fuelled increased urban wealth and consumption, and has been associated with an increased commercialisation of the bushmeat trade. Thus it represents a study of the consequences of economic change, as well as a country with rapidly increasing threats to wildlife.

Previous studies have researched urban bushmeat markets on the island of Bioko and on continental Equatorial Guinea (Fa et al. 1995; Fa 2000), the rural-urban bushmeat commodity chain from Bata to Sendje (Kümpel 2006), urban and rural bushmeat consumption (Albrechtsen 2007) and the impacts of hunting on wildlife populations (Rist 2007). However, to gain fuller understanding of the system, there is a need for additional socio-economic data on the contribution of all wildlife resources to food and livelihoods, particularly in villages that are not 'specialist' hunter villages, and particularly for non-bushmeat wild products.

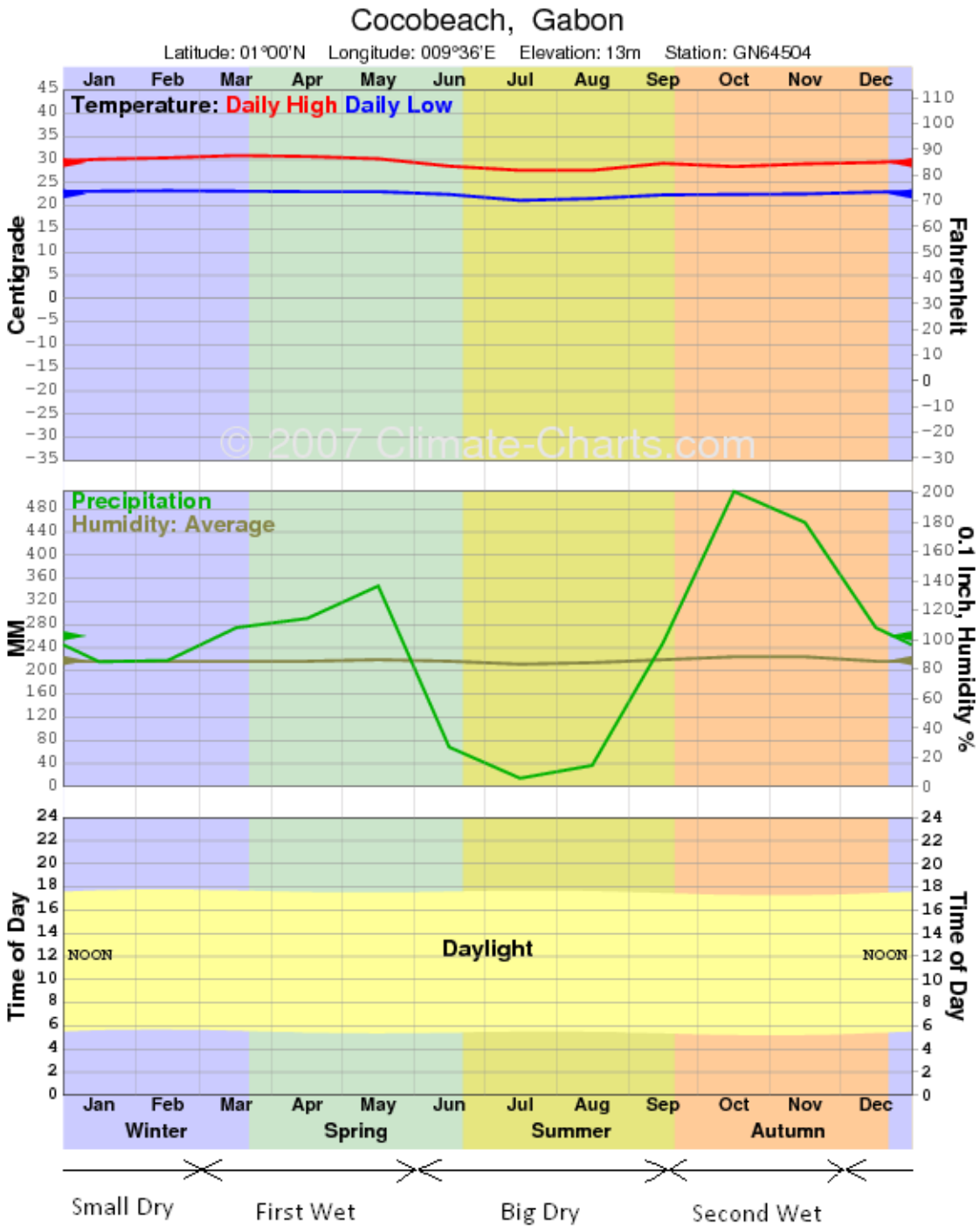
2.1.1 Geography and climate

Equatorial Guinea consists of the continental region, Río Muni (26,000km^2), and several islands (Bioko, Corisco, Annobón, Elobey Grande and Elobey Chico) of which Bioko is the largest (2,000km^2) and politically most important, containing the capital city Malabo (Figure 2.1). Average rainfall is about 2,500mm per year, with a smaller rainy season between March and May, and a greater one between September and November (Wilks & Issembe 2000, and see Figure 2.2). The equatorial climate has an average 90% humidity (although higher in the rainy seasons) and average minimum temperature of 25^{O}C throughout the year.

Figure 2.1 Map of Equatorial Guinea, including mainland Río Muni and the island Bioko. Inset shows the location of Equatorial Guinea in Africa.

Figure 2.2 Temperature, humidity and daylight for Cocobeach, Gabon

These data are not easily accessible for mainland Equatorial Guinea, but Cocobeach is directly on the border of Equatorial Guinea, approximately 80km from Teguete (see Figure 2.1 for location). Data provided by the National Oceanic and Atomspheric Administration (NOAA). Figure reproduced from World Climate Index (2007), www.climate-charts.com.



2.1.2 History and politics

The Pygmies are believed to be the first inhabitants of Equatorial Guinea, but now remain only in isolated pockets in northern Río Muni, having been replaced in the 17th and 19th centuries by Bantu migrations, bringing first the coastal tribes, and followed by the Fang. Some Fang people may have generated the Bubi, who immigrated to Bioko from the mainland in several stages, succeeding the former Neolithic populations. Bioko was 'discovered' by the Portuguese explorer, Fernando Po in 1471, after whom it was named for many years. The Portuguese retained control of the island until 1778, when it passed to Spanish who remained there until the mid 20th century, albeit with a contested half century hiatus under British rule in the 19th century (U.S. Department of State 2008).

Equatorial Guinea (then known as Spanish Guinea) was eventually established as a Spanish territory in 1959, and following a brief period of autonomy, was granted independence in 1968. At this time, the country had one of the highest per capita incomes and highest literacy rates in Africa, largely due to the large cacao plantations developed by the Spanish. On independence, Francisco Macias Nguema was elected first president of the country, but he quickly discarded key portions of the constitution, becoming 'President-for-Life' in 1972. During a decade of rule, countless human rights abuses, a complete neglect of the country's infrastructure and total suppression of religion and education, the economy collapsed and a third of the population were killed, exiled or fled. He was eventually displaced in a *coup d'etat* led by his nephew, Teodoro Obiang Nguema Mbasogo in 1979 (U.S. Department of State 2008).

Since 1979, President Obiang has remained in power, winning his first multi-party re-election in 1997 with 99% of the vote, and accompanied by widespread accusations of election fraud and irregularities (BBC 2008). Similar reports have attended a second presidential election in 2002 and a legislative election in May 2008, when Obiang and his party, Partido Democrático de Guinea Ecuatorial' (PDGE), were elected by 97% and 99% respectively, with 95% and 100% respective electoral turn-outs (BBC 2008; JeuneAfrique 2008). Equatorial Guinea is now listed as among the world's top five 'most-censored countries' by the Committee to Protect Journalists (CPJ), among the world's top most-corrupt states by Transparency International (BBC 2008) and Obiang is consistently listed among the world's top ten worst living dictators (Wallechinsky 2007). When asked why so much of the oil revenue produced by the country goes into his personal bank accounts, he explained that it was to 'avoid corruption' (Wallechinsky 2007).

2.1.3 Economy and development

The discovery of offshore oil in 1995 has led to a booming economy that was one of the world's fastest-growing in 2001 (UNSD 2008), averaging at 37% annual growth in the decade 1996-2006 (IMF 2006). Urban incomes have also increased, and the official monthly minimum wage increased from 25,000 CFA (US$46) in 2000, to 90,000 CFA (US$164) in 2003, at which it remained until at least 2005 (Education International 2007). This has led to a 39% increase in cost of living and general consumer prices between December 2000 and December 2005 (IMF 2006). Despite President Obiang's claim that 'there is no poverty in Equatorial Guinea' (Wallechinsky 2007), minimum wages and economic improvement have yet to reach the majority of the population, and Equatorial Guinea remains near the bottom of the Human Development Index, at 120th place out of 177 (UNDP 2006), despite having a high per capita income (ranked 4th, 34th and 43rd by, respectively, IMF 2007; World Bank 2007; CIA 2008).

2.1.4 Human population

Total population in Equatorial Guinea is estimated to be half a million by international bodies (World Bank 2006), and although the latest national census data gave the much higher figure of 1,157,000 in 2003 (Oficina Central del Censo 2002) this is probably an overestimate (personal observation, based on comparisons of village census' with records collected during this thesis). Approximately 50,000 people live in Bata, and 60,000 in Malabo (Oficina Central del Censo 1997). Urban populations have increased with the economic wealth of the country, and the proportion of urban population of the country rose from 35% in 1990 to 50% in 2000 (UNPD 2004). However, as with many countries in Africa, there is a high fertility rate (5.9 births per woman) and infant mortality rate (122.4 infants per 1,000 births, 2004 figures, World Bank 2006).

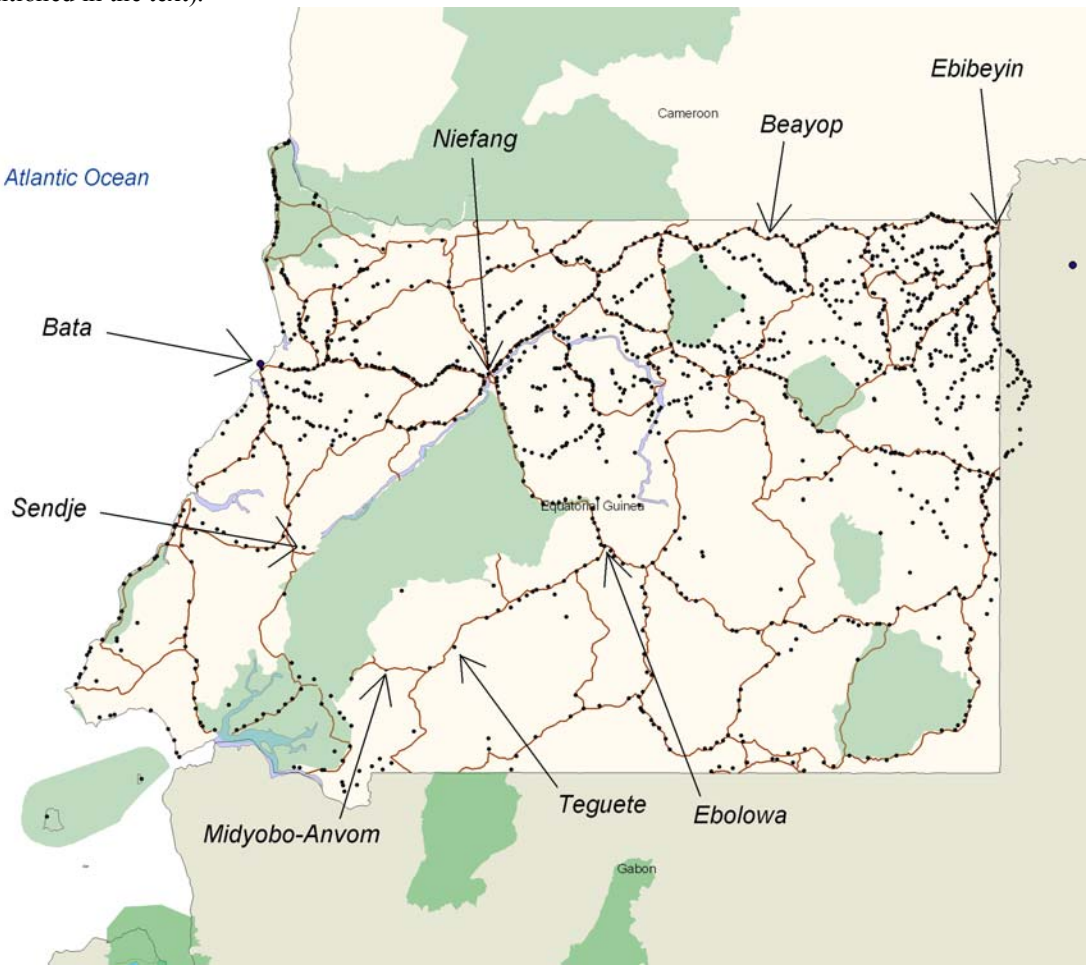
2.1.5 Biodiversity and conservation

Of the 28,051km^2 total area of the country, 16,321km^2 is estimated to be forested (World Bank 2006). High levels of biodiversity have been recorded, including the fourth highest primate density in Africa for the country (Chapman et al. 1999). Within Rio Muni, the Monte Alén National Park (1,400km^2) is considered of high conservation value, and is included in the European Union's regional program for the Conservation and rational use of forest ecosystems in Central Africa (ECOFAC 2003).

2.1.6 Study villages

This study was conducted in two villages in Río Muni, the mainland province of Equatorial Guinea. The two study villages were chosen as being of similar sizes and similar distance by road to the mainland capital, Bata, but having different access to forests, and to urban markets, in the form of better roads and more regular transport to Beayop (Figure 2.3). The road from Bata to Beayop is a regularly maintained, main road, which at the beginning of the study in January 2005 was tarmac (up to Niefang) and levelled loam, and which by November 2005 was all tarmac. Buses passed the village three or four times a day, costing 2000 - 2500cfa and taking around three hours. In contrast, the road to Teguete is tarmac until Niefang, and after that is a poorly maintained dirt road. There is no regular transport between Ebolowa and Teguete, so people wanting to travel from Teguete must wait on the side of the road and hope that a car passes that day and will take them to Ebolowa in time for one of the 3 or 4 daily bushtaxis. This process can take between 6 and 9 hours and cost 7000 – 8000cfa. Population density varies between the two villages, with Teguete being in a more sparsely populated area, and closer to a large tract of relatively undisturbed national park, Monte Alén.

Figure 2.3. Map of mainland Equatorial Guinea (Rio Muni) showing study villages Beayop and Teguete. Roads shown in red, protected areas in green, and villages as black dots. Urban areas Bata, Niefang and Ebibeyin are shown, as are Sendje and Midyobo-Anvom (villages contributing to market data) and Ebolowa (mentioned in the text).



2.2 Data Collection

In this section, I discuss the general methods of data collection, particularly for variables that were used in multiple chapters.

2.2.1 Overview of the data collected

- Individual and household demographic characteristics: Data on household composition, the age, sex, tribe and education level if individuals, and household head gender were collected from village census questionnaire;
- Individual and household consumption and livelihood activities: 24-hour recall data were collected on food consumption, expenditure, remittances, livelihoods activities (including goods and quantities produced), paid work, items sold, and other income;

- Participatory wealth ranks;
- Value of fixed assets owned by the household;
- The value and monetary income of large remittances.

For discussion of data relating to specific chapters, see the relevant chapter. Similarly, additional data collected on weekly hunter and fisher offtake, anthropometric information, food coping mechanisms, and urban market data, are discussed in the chapters they are specifically used.

2.2.2 Village census

Before beginning data collection, extensive discussions and interviews were held in both main study villages, to explain the project and what I hoped to do. During this phase, a map and census of the village was completed, asking all household members about their age, date of birth where possible, education, number of children, and livelihood activities. Mothers or other near relatives were asked about the age of infants. Where date of birth was unknown or uncertain, information was used from other sources if possible and where permission given, including the local village health centre records and most commonly by looking at kitchen walls, where the date of birth of children born to the household is traditionally written. As a final resort, respondents were asked to estimate their age (relatively common in the elderly). At the end of the study, all census information was checked with each household and ages updated. See Appendix 1.

2.2.3 Regular questionnaires

All households in each village were visited approximately every fortnight and adults over 18 asked about all food consumption, expenditure, gifts received, livelihood activities, goods produced, work done (paid or otherwise), items sold, and any other sources of income for the previous day, as well as that of any children in the household (Table A 1.2). Most of these data are discussed in the following chapters, but these data were also used to calculate annual household income, which is discussed in detail here. An interview was deemed invalid if any household member could not be found, or did not answer the questions. This did not include occasions where a household member was away from the village for the whole of the previous day (i.e. if they were on a journey). If an adult was not in the village because they were hunting in the forest, this was also noted.

All questionnaires were written in Spanish and conducted in Spanish and/or Fang by a trained local research assistant (RA) in each village and accompanied by myself or one of two volunteers (one in each village) every day for the first three months and then every other day after that for the next three six months. After six months, the two volunteers left and I divided my time between the two

villages, spending two weeks in each village at a time, until a third volunteer arrived, after which I continued to travel between the two villages, but spent more time in Beayop while the volunteer remained in Teguete. This allowed the vast majority of interviews to be checked the day of the interview, and all questionnaires to be revised within 15 days throughout the study. Interviews were conducted from around 6.30am to 11am (or until people had left for the fields and other activities) and continued in the afternoon from 4pm until around 8pm or until the households scheduled for the day had been completed. Where members of the household were not present or it was an inconvenient time, interviewers returned until they had interviewed every adult in the household. A maximum of eight households per day per village were interviewed and were rotated in groups to sample an equal number of days of the week and rotating the order of household groups to ensure that households did not know when they were to be interviewed.

A typical household consisted of a house, with bedroom(s) and a living room area, and a separate building for a kitchen, which often also had some beds. Some houses had more than one kitchen associated with them, and where this occurred, separate kitchens were interviewed separately, but on the same day. This was often the case where a man had more than one wife (with each wife having their own kitchen), but occasionally grown up children, siblings or parents had a separate kitchen associated with one house. At the end of the study, an analysis was done to look at where people commonly ate, and where people from different kitchens shared meals more than half of the time, these kitchens were classified as a single household.

Questionnaires were reviewed by the RA and myself or a volunteer to clarify any points that had not been clear in the interview, usually relating to species identification of new food items named in Fang. Fang or local names of all forest animals, fish and wild plants were used to avoid misidentification. Tables of all items recorded (food and non-food), the average prices for each village, and the proportion of interviews in which they were recorded are shown in Appendix 10.

Income, Wealth and Participatory Wealth Ranking

Income and wealth are two important dimensions of socio-economic position, and although often related (and often confused), they are two different concepts. In this study, I measure wealth, income, and record the participatory wealth ranking for each household.

- The value of material assets is taken as a proxy for **wealth**, or 'fixed wealth'.
- **Income** is often measured using proxys of household consumption. Here, actual monetary income and non-monetary income (the value of goods of services received) have been recorded over one year. Monetary income is taken as "income" while monetary and non-monetary combined are taken as "production".
- **Participatory wealth rankings** of households are recorded in focus groups. Previous studies have shown this to be a valid way to stratify households, with wealth rankings correlating to economic, demographic and health variables (Adams et al. 1997). However, because this measure is often based on community perception of other households socio-economic status and standard of living, it may be a composite of perceived wealth and income.

Box 2.1 Income, wealth and participatory wealth ranking

2.2.4 Material Assets

The value of material assets owned by the household (called 'fixed wealth' here) of each household was assessed as the current value of all goods owned by that household, including buildings, household furniture and items, livestock and livelihood equipment. Respondents were asked about buildings owned, including who bought the materials, who currently owned it, and who looked after it; owners occasionally did not live in the village, and so the house was used, rented or looked after by other members of the village, usually family members. Where the building was not owned by the family members living there, the value of the house was not included in the calculations. Where a building was bought by someone else, but currently owned by a household member, the value was included in calculations. With the respondents' permission we also collected data on the number of rooms, the types of buildings (bar, kitchen, house, toilet, etc), numbers and types of doors and windows, types of flooring, walls, roof and ceiling, and condition of the house by direct observation (see Appendix 1 for questionnaire). Details of any buildings owned by the household outside of the village were also obtained. The price of building materials (and thus houses) was assessed by asking local builders and carpenters in each village about the current cost of building a range of different sized houses and buildings using different materials, and house values calculated based on these costs. See Appendix 3 for an example of the breakdown of housing costs and the calculation of house value. Houses that were abandoned or not suitable for habitation were not included in the results.

Each household was asked questions on all goods owned by the household, including the age, condition, price when bought, who bought it, current owner and estimated current market value where possible (see Questionnaire 2, Appendix 2). The total value of items was summed for the entire household, to give a monetary value of total goods owned. Items that were broken, unusable or owned by people not living in the house (i.e. on loan) were not included in the final total. Although questions were asked on the age of the item, we did not try to calculate values based on depreciation rates, but rather on the estimated current value of the item. Estimates were made by directly asking participants, and by comparing prices of similar items in similar condition sold within the last year. Prices were estimated based on village price, rather than city or trader price. See Appendix 4 for a full list of assets recorded in each village, and average reported prices.

Data on the value of land 'owned' by households was not included, as there was no official or documented ownership of land and because land scarcity was not a problem in either village. Different agricultural areas were unofficially recognised as belonging to different households, but any family wanting to farm more land than they currently had access to would either reach an agreement with another household to use part of their land that was not being cultivated, or simply clear more forest. In practice, the only time this occurred was when new families moved to the village (not a common occurance) and each time land was used belonging to another family without payment (monetary or otherwise). See Box 4.1 for further details.

2.2.5 Income

Income was recorded in the regular household questionnaires conducted approximately fortnightly in every household. Questions were asked about any paid work (salaried or casual work, paid in cash or in kind), any goods sold (including source of those goods, to calculate net profit where appropriate), any goods gained, harvested or received as gifts and any other sources of income for the previous day.

Income from village shops/bars (there was no real distinction between the two, and most selling venues were both) was calculated from the daily total monetary takings (as reported by the shop owners) and the average price mark-up specific to that bar, as calculated from monthly shop inventories and surveys on shop supplies (including quantities and price of bulk bought goods), to give an average daily net income from bars. Average daily net income from other goods sold during sample days was calculated from the regular questionnaires, while the value of goods harvested was not included (even when those goods were intended to be sold) to avoid double counting (i.e. things were counted only on the day of sale, not the day of harvest). An average daily household wage was

calculated for any casual paid work, and scaled up to the annual income, taking into account the number of days worked during the study year. Annual salary from regular jobs was calculated from monthly salaries plus any paid bonus reported, and including information on the number of months worked that year. Average annual earned monetary income was calculated by summing cash income across all sources excluding gifts of money (see family support below) for each sample day, then taking the average income per day and multiplying to get annual income (taking into account days of the week). Annual total monetary income was calculated as the sum of earned monetary income and any monetary gifts.

2.2.6 Reminances or Family Support

A number of people in the study reported large irregular gifts of money and items such as food, building materials and household items. Questions were asked in the fortnightly questionnaire about any journeys undertaken during the last two weeks by members of the family, or visits to the household by external family, and any objects or money exchanged at these times. However, because such gifts were often erratically timed and occasionally one-off large lump sums, a further questionnaire was conducted at the end of the study. Questions were asked at each household about any gifts (in cash or in kind) received over the entire previous year (the study period), focussing on items over 5000cfa (~£5). The value of any objects received (actual or estimated) was also asked in this questionnaire. The total family support was taken as the sum of the value of all items and money received over the previous year. The monetary family support was the sum of the cash gifts received. Care was taken not to double count money or items recorded in the regular questionnaires and the family support questionnaire.

2.2.7 Wealth rankings

Towards the end of the study, a series of group discussions were held in both Beayop and Teguete to discuss people's concepts of wealth and to try eventually to put each of the village households into a group of similarly wealthy households within the village. For each discussion, four different members of the village were selected, with each group having a balance of people of different age, gender and coming from different sections of the village. Respondents were also chosen for being relatively informed members of the community, sometimes being in a position of authority (e.g. a functionary or teacher) or of other social positions (e.g. tribal leader or women's and agricultural leader). In each group, the aims of the exercise were explained with care taken to avoid imposing any of the interviewers' own ideas of wealth on the respondents. The only stipulation that was made was that the households were to be placed into five groups, depending on their level of wealth. It was also explained that all discussions were confidential, and that although they might use the terms

richer and poorer, this was only at the level of the village, and not at the level of the country. This was particularly said in response to many initial concerns that everyone in the village was extremely poor.

Cards with the name of the household head(s) were put on a table, and the group members began discussing each family. The names on the cards included both male and female heads of the household where both existed. After all households had been classified, the characteristics of each group were discussed, in order to try and identify defining characteristics or commonalities for each group. The respondents then went through each group again, and made any adjustments to the groups, so that the majority of the focus group (at least three of the four people) was happy with the classification of each of the households. The households of respondents present were not included in the exercise. This was repeated three times in total in each village, and the median result taken as the final wealth ranking. Results across discussion groups were very similar with virtually all households being ranked as one,or two adjoining wealth ranks, across the three exercises in each village. Very few households were placed in category 5 (the richest) in either village, so this wealth group was combined with wealth rank 4 for most calculations.

2.3 Village demographics and wealth ranking

There were some demographic differences between the two main study villages, Beayop and Teguete. Beayop is the larger village (498 people compared to 372), but had a lower proportion of males compared to Teguete (Table 2.1). Households in Teguete had a lower average proportion of active adult males per household, so the higher proportion of males in that village appears to be made up of old men and male children. This may also reflect the lower availability of work in Teguete, leading to many active adults (particularly males) seeking work elsewhere.

Table 2.1 Demographic and wealth characteristics for Beayop and Teguete

	Beayop	Teguete
No. Households	105	86
Total No. People	498	372
Total No. Males	118	116
Total No. Females	195	154
Total No. Children (<16)	185	102
Average No. People/HH	4.89	4.44
Average No. Males/HH	1.15	1.38
Average No. Females/HH	1.92	1.84
Average No. Children/HH	1.82	1.22
Average No. Active Adults/HH	1.98	1.66
Average No. Active Adult Males/HH	0.70	0.55
Average No. Active Adult Females/HH	1.29	1.10
Average Proportion Active Adults/HH	0.46	0.43
Average Proportion Active Adult Males/HH	0.17	0.14
Average Proportion Active Adult Females/HH	0.30	0.30
Average Proportion Female/HH	0.62	0.57
Average Age	28.8	36.3
Average Food Security Score (2006)/HH	1.22	2.87
Average HH income (earned)/year (cfa)	399235	302311
Average Fixed Wealth (cfa)	2048207	2216954
Average Fixed Wealth (10 years)/HH (cfa)	1370780	1323089
Average Family Support/HH/Year (cfa)	105063	67732

It is difficult to directly compare indicators of wealth between villages, without taking into account other social and economic factors (such as commodity prices, food availability, and well-being) but there is some evidence that households in Teguete are generally worse-off. Households in Teguete were recorded as earning lower incomes, being less food secure and gaining less income from remittances (Table 2.1).

While wealth rankings in each village are not necessarily comparable, the descriptions of each wealth rank as devised by the focus groups in each village are surprisingly similar (Table 2.2), focussing on food availability, livelihood activities, and external family support. Emphasis was particularly placed on family support, especially from relatives living in towns or cities, and virtually no households in the wealthier two categories were without external support in either village. Similarly, the defining characteristic of the lower two wealth catergories was a lack of family support, including a lack of family even within the village for the very poorest families. The likely wealthier status of Beayop was also reflected in the differently skewed allocation of households into the five wealth ranks between the villages. was differently skewed in Beayop and Teguete: the majority of households were placed in the medium and second-richest categories in

Beayop (ranks 3 and 4), but in the medium and second-poorest ranks in Teguete (ranks 2 and 3), see Table 2.3.

The participatory wealth ranking appears to be a reflection of both income and fixed wealth, with the wealthier ranking households having higher average household income, higher fixed wealth, more money from remittances, lower food security scores (indicated a more food secure household) and household heads have more education (see Table 2.3, Figure 2.4, Figure 2.5).

Table 2.2. Definitions given to each wealth rank in Beayop and Teguete during focus group discussions. 1 = poorest group, 5 = richest group

	Beayop	Teguete
1	This group lives very badly. They have problems finding food most days. They have very few, if any, people in the house or village that can help them.	This group has real problems living. If they want to eat they have to search for food themselves, or walk around the village looking for gifts of food. None have family or children and most don't have spouses or parents. They mainly don't work fields or have traps, but if they do, they don't produce much at all from them. Many don't have their health and may have problems walking.
2	This group lives a bit badly. Many live only from the fields or forest (trapping), with no other income. Others may get some support from elsewhere but if so, they waste it (usually on drink).	This group lives a bit badly. They may work (have fields and trap) but this only gains enough to eat, not to sell. They have little or no income and little or no family/outside support. Some have no real head of the household, or have many children that are still too young to contribute to the household.
3	This group lives okay. Many work in the fields and forest but also do some kind of selling/trading or have a gun as well. Some get some kind of help from elsewhere.	This group lives okay. They either work with little or no income but have lots of family such as children and siblings that can help them, even if just at the village level. Others have some sort of income, although none own bars.

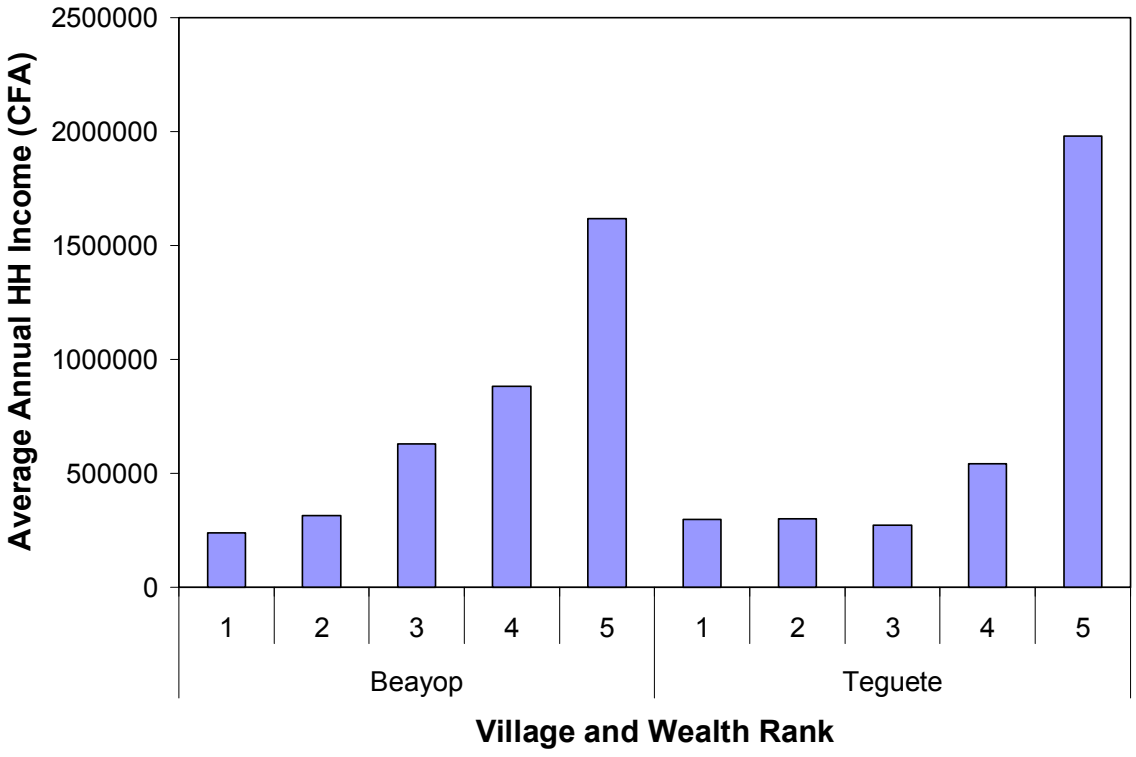
4	This group lives a bit well. Most still have to work hard, but also have outside help. Some only have income they've earned themselves, but it's reasonable (e.g. have a bar, do carpentry, have gun), or the have a reasonable salary.	This group lives quite well. Most have some support from outside the village, such as children who send a reasonable amount of support (5000 – 15000) so that they can live an okay life. On market day they can buy what they want to.
5	This group lives well. They eat what they want every day. Usually have some or a lot of outside support, or may earn a good salary (e.g. school director, professor, etc.).	This group lives well. They all have some sort of income or have husbands or sons away from the village who work/have an income. Women in this group have bars and make money from this.

Table 2.3 Average characteristics for wealth ranks within each village.

	Beayop					Teguete				
Wealth Rank	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
No. Households	15	23	29	28	9	16	25	23	15	7
Average No. People/HH	2.27	4.96	4.24	4.96	1.44	2.13	4.00	4.26	5.07	3.00
Average No. Males/HH	0.97	1.20	1.44	0.96	1.11	0.96	1.47	1.44	1.82	1.82
Average No. Females/HH	1.04	2.57	1.95	2.22	0.70	1.12	1.97	1.84	2.36	2.04
Average No. Children/HH	0.77	2.11	1.96	2.51	0.39	0.26	1.09	1.54	1.91	1.41
Average No. Active Adults/HH	0.55	0.61	0.80	0.68	0.94	0.35	0.49	0.70	0.65	0.53
Average No. Active Adult Males/HH	1.26	2.07	2.09	2.34	1.62	0.84	1.61	1.79	2.52	1.31
Average No. Active Adult Females/HH	0.70	1.45	1.29	1.67	0.67	0.49	1.11	1.09	1.87	0.79
Proportion Active Adults/HH	0.48	0.37	0.44	0.43	0.66	0.55	0.37	0.44	0.45	0.33
Proportion Active Adult Males/HH	0.22	0.12	0.13	0.12	0.34	0.18	0.10	0.18	0.09	0.16
Proportion Active Adult Females/HH	0.26	0.26	0.30	0.31	0.32	0.37	0.27	0.26	0.36	0.18
Proportion Female	0.52	0.68	0.58	0.70	0.39	0.54	0.57	0.56	0.56	0.75
Average Age/HH	45.6	24.3	26.2	23.5	34.9	55.0	31.8	36.4	28.0	22.8
Average Food Security Score (2006)/HH	3.12	1.06	1.00	0.97	0.60	5.54	3.24	2.17	1.16	0.59
Average HH income (earned)	238907	316927	628989	882223	1617272	299788	302017	273779	543732	1980856
Average Fixed Wealth	2011953	1484801	2017660	2474352	3102241	1291486	1767960	2525233	3324604	3229785
Average Fixed Wealth (10 years)	1092813	995702	1349228	1742643	2337033	582723	1174594	1151256	2453738	2157491
Average Family Support	20330	55902	138355	157922	60042	13643	16561	43741	149367	450131

Figure 2.4 The relationship between wealth rank and household head education

Figure 2.5 The relationship between household income and wealth rank



2.4 Data Analysis

2.4.1 Explanatory variables

The following explanatory variables were used in all analyses:

- Village
- Season – the year was split into four seasons according to the calendar produced at village focus groups, including details of agricultural activity and harvests, changes in weather and locally defined seasons. These were: Small Dry (1st December – 28th February), First Wet (1st March – 31st May), Big Dry (1st June – 15th September), and Second Wet (16th September – 30th November), see Appendix 2. These also corresponded to the seasons given by climatologists (Figure 2.2) with the except of the Small Dry (their 'winter'), which villagers claimed ended at the end of February, rather than in mid March.
- Wealth rank – a score of 1 (poorest) to 5 (wealthiest) were analysed as an ordinal variable. Given the low number of households in the wealthiest rank, these ranks were combined to give only four wealth ranks for most analyses.
- Fixed wealth - total current value of all assets (items and buildings).
- Income – annual total of all earned income and money received as a gift.
- Household size – the total number of people in the household. Where people were living in the household for only part of the year, they were counted as a fraction (i.e. someone living in the household for 6 months of the study period was counted as 0.5 people). People living in the household for less than three months were counted as visitors.
- Number of productive adults – the number of people in the household between 18 and 65, who were able to work (i.e. not counting those with chronic ill health). Where people were living in the household for only part of the year, they were counted as a fraction (as above).
- Number of productive females - the number of females in the household between 18 and 65, who were able to work (i.e. not counting those with chronic ill health). Where people were living in the household for only part of the year, they were counted as a fraction (as above).
- Productive males (present/absent) – there were a large number of households with no productive males, making this variable impossible to transform to a Normal distribution. Consequently a binary variable, representing the presence or absence of a productive male for more than two thirds of the year, was used.
- Proportion productive adults – the proportion of the total household size (as above) made up by productive adults (see above).

- Proportion productive females – the proportion of the total household size (as above) made up by productive females (see above). Due to the large number of households with no productive males, it was not possible to analyse the proportion of the household made up of productive males.
- Household head education level – the education level reported by the head of the household, grouped into four categories – none, primary, secondary, and higher education.
- Household head gender – the sex of the head of the household.
- Individual education level - the individual education level, grouped into four categories – none, primary, secondary, and higher education. For people still in education (i.e. children), the education level taken was that achieved by the end of the study.
- Age – taken as the best estimate for 31st December 2005 (i.e. towards the end of the study). Where the relationship with age was not linear, age was grouped into five categories: < 18; 18 ≥ and < 30; 30 ≥ and <50; 50 ≥ and < 65; ≥ 65.
- Sex.

Of 86 households in Teguete only data from 76 were used: one moved away during the study; one arrived during the study; four were where myself and the volunteers lived or were the households of the local research assistants; and four had insufficient data. Of 101 households in Beayop, only data from 79 were used: four moved away; four were where myself and the volunteers lived, or were the households of local research assistants; four decided they would prefer not to continue with the study; two had insufficient data due to many absences; and one household was suspected of giving inaccurate data.

2.4.2 Correlation between explanatory variables

There is significant correlation between some of the wealth and household demographic variables (Table 2.4, Table 2.5 and Table 2.6). Income and fixed wealth were not significantly correlated (0.29) and so have both been used in the analyses. If wealth rank is treated as a continuous variable it is correlated with both fixed wealth and total income, suggesting that perceived wealth is a composite of many measures of wealth, including fixed assets and income (Figure 2.5). There was also some evidence of a correlation between wealth rank and the education level of the household head (Figure 2.4). However, due to the non-linear nature of the wealth ranking, it has been used as a categorical variable throughout the analyses.

The household size and the number of productive adults are correlated with each other and are both correlated with the number of productive females and the number of productive males. Numbers of productive males and females are not correlated. The proportion of productive

adults is also correlated with the proportion of males and proportion of females in the household. These suggest that while unsurprisingly, all measures of household size are affected by both numbers of adult males and adult females, there seems to be no relationship between the numbers or proportions of males and females within households. There are no clear correlations between wealth and household size.

Table 2.4. Correlation of household variables (both villages).
Variables showing a correlation of 0.5 or greater are shaded. No. peop (frac) = HH size as a continuous variable, No. peop (int) = HH size as an integer, No prodv Ad., M, F = number of productive adults, males and females, respectively, Prop Ad, M, F = proportion productive adults, males and females respectively, WR = wealth rank, FW = total value of assets (fixed wealth), FW (10y) = value of assets accumulated in the last 10 years, Value Bdg = value of buildings, Value Bdg (10y) = value of buildings obtained in the last 10 years), Inc = HH income, Inc (earned) = income earned, Inc (family) = monetary remittances, Family Support = value of all gifts received, HH head edn = number of years in education of HH head.

	No. peop fract	No. peop (int)	No. prodv Ad.	No. prodv M.	No. prodv F.	Prop Ad	Prop. M	Prop. F	WR	FW	FW (10y)	Value Bdg	Value Bdgs (10y)	Inc (all)	Inc. (earnd)	Inc. (fam)	Fam. Support	HH head edn
No. peop (fract)	1.00	0.93	0.76	0.52	0.70	-0.28	-0.11	-0.22	0.22	0.36	0.35	0.31	0.28	0.18	0.16	0.00	0.06	0.09
No. peop (int)	0.93	1.00	0.64	0.46	0.58	-0.29	-0.10	-0.26	0.18	0.32	0.27	0.27	0.20	0.17	0.19	-0.03	0.04	0.10
No. prodv Ad.	0.76	0.64	1.00	0.77	0.87	0.26	0.20	0.12	0.28	0.44	0.50	0.39	0.42	0.27	0.27	0.02	0.10	0.17
No. prodv M.	0.52	0.46	0.77	1.00	0.36	0.27	0.60	-0.19	0.13	0.28	0.33	0.24	0.27	0.20	0.26	-0.04	0.02	0.15
No. prodv F.	0.70	0.58	0.87	0.36	1.00	0.17	-0.15	0.33	0.31	0.43	0.48	0.39	0.41	0.24	0.20	0.05	0.13	0.13
Prop. Ad	-0.28	-0.29	0.26	0.27	0.17	1.00	0.54	0.70	0.01	0.03	0.07	0.01	0.04	0.10	0.14	0.00	0.01	0.17
Prop. M	-0.11	-0.10	0.20	0.60	-0.15	0.54	1.00	-0.22	0.02	-0.02	0.01	-0.07	-0.04	0.12	0.19	-0.03	-0.03	0.19
Prop. F	-0.22	-0.26	0.12	-0.19	0.33	0.70	-0.22	1.00	0.00	0.05	0.07	0.08	0.08	0.01	0.00	0.02	0.04	0.04
WR	0.22	0.18	0.28	0.13	0.31	0.01	0.02	0.00	1.00	0.44	0.42	0.34	0.29	0.45	0.34	0.28	0.32	0.44
FW	0.36	0.32	0.44	0.28	0.43	0.03	-0.02	0.05	0.44	1.00	0.76	0.95	0.63	0.29	0.21	0.18	0.21	0.12
FW (10y)	0.35	0.27	0.50	0.33	0.48	0.07	0.01	0.07	0.42	0.76	1.00	0.68	0.93	0.24	0.15	0.16	0.20	0.15
Value Bdg	0.31	0.27	0.39	0.24	0.39	0.01	-0.07	0.08	0.34	0.95	0.68	1.00	0.65	0.19	0.14	0.11	0.10	0.08
Value Bdg (10y)	0.28	0.20	0.42	0.27	0.41	0.04	-0.04	0.08	0.29	0.63	0.93	0.65	1.00	0.11	0.06	0.07	0.06	0.09
Inc (all)	0.18	0.17	0.27	0.20	0.24	0.10	0.12	0.01	0.45	0.29	0.24	0.19	0.11	1.00	0.77	0.61	0.47	0.23
Inc (earned)	0.16	0.19	0.27	0.26	0.20	0.14	0.19	0.00	0.34	0.21	0.15	0.14	0.06	0.77	1.00	-0.01	-0.02	0.23
Inc (family)	0.00	-0.03	0.02	-0.04	0.05	0.00	-0.03	0.02	0.28	0.18	0.16	0.11	0.07	0.61	-0.01	1.00	0.79	0.08
Family Support	0.06	0.04	0.10	0.02	0.13	0.01	-0.03	0.04	0.32	0.21	0.20	0.10	0.06	0.47	-0.02	0.79	1.00	0.15
HH head edn	0.09	0.10	0.17	0.15	0.13	0.17	0.19	0.04	0.44	0.12	0.15	0.08	0.09	0.23	0.23	0.08	0.15	1.00

Table 2.5. Correlation of household variables (Teguete)
Variables showing a correlation of 0.5 or greater are shaded. Variables as for Table 2.2.

	No. peop fract	No. peop (int)	No. prodv Ad.	No. prodv M.	No. prodv F.	Prop Ad	Prop. M	Prop. F	WR	FW	FW (10y)	Value Bdg	Value Bdgs (10y)	Inc (all)	Inc. (earnd)	Inc. (fam)	Fam. Support	HH head edn
No. peop (fract)	1.00	0.95	0.74	0.59	0.66	-0.26	-0.05	-0.26	0.35	0.42	0.37	0.38	0.32	0.20	0.17	0.02	0.04	0.02
No. peop (int)	0.95	1.00	0.65	0.56	0.55	-0.28	-0.03	-0.29	0.31	0.35	0.31	0.32	0.25	0.24	0.21	0.05	0.07	0.05
No. prodv Ad.	0.74	0.65	1.00	0.79	0.90	0.29	0.27	0.13	0.34	0.40	0.49	0.38	0.46	0.26	0.26	-0.01	0.03	0.06
No. prodv M.	0.59	0.56	0.79	1.00	0.44	0.24	0.62	-0.16	0.19	0.19	0.29	0.17	0.28	0.20	0.24	-0.03	-0.01	0.07
No. prodv F.	0.66	0.55	0.90	0.44	1.00	0.24	-0.05	0.31	0.37	0.45	0.52	0.43	0.48	0.24	0.21	0.01	0.06	0.03
Prop. Ad	-0.26	-0.28	0.29	0.24	0.24	1.00	0.48	0.79	-0.09	-0.04	0.01	-0.02	0.02	0.07	0.13	-0.05	-0.04	0.12
Prop. M	-0.05	-0.03	0.27	0.62	-0.05	0.48	1.00	-0.16	0.01	-0.11	-0.05	-0.12	-0.05	0.13	0.16	0.02	-0.01	0.19
Prop. F	-0.26	-0.29	0.13	-0.16	0.31	0.79	-0.16	1.00	-0.10	0.03	0.05	0.06	0.06	-0.01	0.03	-0.07	-0.03	0.00
WR	0.35	0.31	0.34	0.19	0.37	-0.09	0.01	-0.10	1.00	0.54	0.46	0.48	0.38	0.37	0.24	0.30	0.32	0.36
FW	0.42	0.35	0.40	0.19	0.45	-0.04	-0.11	0.03	0.54	1.00	0.74	0.96	0.64	0.29	0.21	0.22	0.24	0.10
FW (10y)	0.37	0.31	0.49	0.29	0.52	0.01	-0.05	0.05	0.46	0.74	1.00	0.66	0.95	0.21	0.11	0.20	0.22	0.11
Value Bdg	0.38	0.32	0.38	0.17	0.43	-0.02	-0.12	0.06	0.48	0.96	0.66	1.00	0.63	0.24	0.22	0.11	0.10	0.05
Value Bdg (10y)	0.32	0.25	0.46	0.28	0.48	0.02	-0.05	0.06	0.38	0.64	0.95	0.63	1.00	0.13	0.08	0.08	0.05	0.05
Inc (all)	0.20	0.24	0.26	0.20	0.24	0.07	0.13	-0.01	0.37	0.29	0.21	0.24	0.13	1.00	0.85	0.54	0.39	0.33
Inc (earned)	0.17	0.21	0.26	0.24	0.21	0.13	0.16	0.03	0.24	0.21	0.11	0.22	0.08	0.85	1.00	0.06	0.02	0.26
Inc (family)	0.02	0.05	-0.01	-0.03	0.01	-0.05	0.02	-0.07	0.30	0.22	0.20	0.11	0.08	0.54	0.06	1.00	0.76	0.22
Family Support	0.04	0.07	0.03	-0.01	0.06	-0.04	-0.01	-0.03	0.32	0.24	0.22	0.10	0.05	0.39	0.02	0.76	1.00	0.19
HH head edn	0.02	0.05	0.06	0.07	0.03	0.12	0.19	0.00	0.36	0.10	0.11	0.05	0.05	0.33	0.26	0.22	0.19	1.00

Table 2.6. Correlation of household variables (Beayop)
Variables showing a correlation of 0.5 or greater are shaded. Variables as for Table 2.2.

	No. peop fract	No. peop (int)	No. prodv Ad.	No. prodv M.	No. prodv F.	Prop Ad	Prop. M	Prop. F	WR	FW	FW (10y)	Value Bdg	Value Bdgs (10y)	Inc (all)	Inc. (earnd)	Inc. (fam)	Fam. Support	HH head edn
No. peop (fract)	1.00	0.90	0.77	0.40	0.76	-0.33	-0.23	-0.14	0.00	0.28	0.31	0.24	0.23	0.10	0.13	-0.06	0.06	0.10
No. peop (int)	0.90	1.00	0.62	0.31	0.63	-0.33	-0.20	-0.18	-0.02	0.26	0.21	0.21	0.12	0.05	0.14	-0.13	-0.03	0.13
No. prodv Ad.	0.77	0.62	1.00	0.71	0.82	0.19	0.09	0.14	0.14	0.55	0.51	0.48	0.39	0.23	0.24	0.00	0.18	0.22
No. prodv M.	0.40	0.31	0.71	1.00	0.19	0.33	0.56	-0.25	0.02	0.44	0.38	0.37	0.28	0.16	0.26	-0.08	0.03	0.18
No. prodv F.	0.76	0.63	0.82	0.19	1.00	0.00	-0.33	0.40	0.18	0.42	0.40	0.38	0.32	0.19	0.13	0.07	0.23	0.16
Prop. Ad	-0.33	-0.33	0.19	0.33	0.00	1.00	0.67	0.47	0.17	0.17	0.17	0.09	0.08	0.15	0.15	0.07	0.11	0.27
Prop. M	-0.23	-0.20	0.09	0.56	-0.33	0.67	1.00	-0.34	0.00	0.10	0.08	0.00	-0.03	0.10	0.22	-0.09	-0.08	0.18
Prop. F	-0.14	-0.18	0.14	-0.25	0.40	0.47	-0.34	1.00	0.22	0.10	0.13	0.11	0.14	0.08	-0.06	0.20	0.24	0.13
WR	0.00	-0.02	0.14	0.02	0.18	0.17	0.00	0.22	1.00	0.32	0.35	0.20	0.20	0.50	0.44	0.23	0.30	0.48
FW	0.28	0.26	0.55	0.44	0.42	0.17	0.10	0.10	0.32	1.00	0.79	0.94	0.63	0.32	0.22	0.14	0.18	0.19
FW (10y)	0.31	0.21	0.51	0.38	0.40	0.17	0.08	0.13	0.35	0.79	1.00	0.73	0.92	0.26	0.21	0.10	0.15	0.19
Value Bdg	0.24	0.21	0.48	0.37	0.38	0.09	0.00	0.11	0.20	0.94	0.73	1.00	0.69	0.18	0.05	0.13	0.15	0.17
Value Bdg (10y)	0.23	0.12	0.39	0.28	0.32	0.08	-0.03	0.14	0.20	0.63	0.92	0.69	1.00	0.10	0.04	0.07	0.09	0.16
Inc (all)	0.10	0.05	0.23	0.16	0.19	0.15	0.10	0.08	0.50	0.32	0.26	0.18	0.10	1.00	0.65	0.67	0.58	0.07
Inc (earned)	0.13	0.14	0.24	0.26	0.13	0.15	0.22	-0.06	0.44	0.22	0.21	0.05	0.04	0.65	1.00	-0.12	-0.13	0.17
Inc (family)	-0.06	-0.13	0.00	-0.08	0.07	0.07	-0.09	0.20	0.23	0.14	0.10	0.13	0.07	0.67	-0.12	1.00	0.88	-0.10
Family Support	0.06	-0.03	0.18	0.03	0.23	0.11	-0.08	0.24	0.30	0.18	0.15	0.15	0.09	0.58	-0.13	0.88	1.00	0.06
HH head edn	0.10	0.13	0.22	0.18	0.16	0.27	0.18	0.13	0.48	0.19	0.19	0.17	0.16	0.07	0.17	-0.10	0.06	1.00

Chapter 3.
The consumption of wild foods

3.1 Abstract

To assess the dependence on forest products, I begin with an analysis of the contribution of wild foods to energy and protein consumption in two study villages. People in Teguete, the more rural village, consumed more wild foods. Of these, bushmeat, followed by wild plants were more important than wild fish. Wild foods in general were more important for protein consumption than calorie intake, particularly because households obtained a lower proportion of their protein from household production (agricultural and forest harvests), than calories. There was some increase in bushmeat consumption with wealth, particularly for Beayop where consumption of bushmeat was generally lower. The increased consumption of wild plants during the lean season may compensate for lower calorie and protein consumption from agricultural harvests during this period in Teguete, but there was no evidence of this in Beayop. The loss of wild food products to communities is therefore most likely to impact protein consumption of the poorest households.

3.2 Introduction

The use of wildlife products is extremely widespread (Prescott-Allen & Prescott-Allen 1982; Falconer 1990; de Beer & McDermott 1996), and traditionally the view has been that their primary use is in the provision of food to local people. Consequently, in investigating the dependence of people on wild foods, I begin with an analysis of the contribution of wild foods to the diet; how often people eat different foods (wild and otherwise) and the contribution of these foods to energy and protein consumption. I investigate differences in food sources (i.e. where and how households have directly obtained foods) and in food types (i.e. agricultural, wild, coastal or imported foods: the original source of these products) to give a thorough examination of the importance of wild foods for macronutrients both directly (as households harvest foods from the forest themselves), and indirectly (as determined by the amounts of wild foods eaten, regardless of how obtained) in the two study villages.

3.2.1 Wild meat and fish

Wild meat and fish are most often cited as an important source of protein, as opposed to other nutrients. Many people living in, or close to, tropical forests use meat as a major source of protein (Bennett & Robinson 2000) and wildlife often supplies this meat and is the primary source of protein for rural and urban households in many forested regions of poor nations (Redford & Kent 1993; Chardonnet et al. 1995; Juste et al. 1995; Ntiamoa-Baidu 1997), as well as being a source of income. However, the consumption of all meat and fish, as well as wild meat and fish varies

considerably between country even within west and central Africa (Table 3.1), and between rural and urban consumers, with the former often consuming more wild meat and fish than their urban counterparts.

Table 3.1 Meat and fish consumption (including from wild sources) in west and central Africa, as reported in previous studies.
Daily recommended amount of protein is 52g/ AME/day (FAO & WHO 1985).

Country	Study population	Meat and fish consumption	Wild meat & fish consumption	Reference
Cameroon	Three rural communities	271-306g /AME/day	70-88% protein (and almost all meat and fish consumption)	(Koppert et al. 1993)
Equatorial Guinea	Urban consumers	385g /AME/day	20% protein (bushmeat only)	(Albrechtsen et al. 2005)
Equatorial Guinea	Total supply to capital city	2129.6 t/yr	1.5% protein	(Albrechtsen et al. 2005)
Ghana	Rural		33g/person/day (bushmeat only)	(Cowlishaw et al. 2007)
Ghana	Urban		46g/person/day (bushmeat only)	(Cowlishaw et al. 2007)
Gabon	Rural		268g/AME/day (bushmeat only) (16% of total value of consumed foods)	(Starkey 2004)
Central Africa	Rural		130g/ person/day (bushmeat only)	(Wilkie & Carpenter 1999)
Central Africa	Urban		13g/person/day (bushmeat only)	(Wilkie & Carpenter 1999)
Central African Republic		38% protein		(Périssé 1966; Pondi et al. 1989), reported in (Koppert et al. 1993)
Cameroon	Rural, southern Cameroon	70-88% protein		as above
Cameroon	Urban	27-57% protein		as above
Côte d'Ivoire		25% protein		as above
Congo		43% protein		as above
Togo		20% protein		as above
Gabon		59% protein		as above
Uganda		9% protein		as above
Nigeria		4% protein		as above

Why people eat bushmeat, and how this varies across individuals, is still not well understood. Some studies state it to be a luxury product that consumers will pay a premium for, noting its role in ceremonies and as a reminder of village life for urban families (Chardonnet et al. 1995; Njiforti 1996). Other studies have tried to gauge a taste preference for different animal types, but have shown only an inconsistent preference for bushmeat (only rural consumers consistently chose bushmeat over domestic alternatives, Schenck et al. 2006), or a preference for fresh meat and fish of all types (including bushmeat, but with fish being most preferred, East et al. 2005). There is other evidence showing that most consumers respond to price, typically choosing the most affordable meat or fish available (Bowen-Jones 1998; Wilkie & Carpenter 1999; Wilkie & Godoy 2000). Consequently, the amount and proportion of different animal products eaten often varies with household income, but again this differs between country, region and community (Table 3.2). This may in part reflect differences in the range of wealth categories of the surveys in question, as well as the price of, and preference for, each meat and fish type.

Table 3.2 Variation in meat and fish consumption (including from wild sources) with household wealth, as reported in previous studies.

Country/Region	Study population	Wealthier consumers consume:	Reference
Equatorial Guinea	Rural	More meat and fish (all types) No effect on bushmeat consumption	(Kümpel 2006)
Equatorial Guinea	Urban (Bata)	More bushmeat (possibly because it was the only fresh meat commonly available) More fresh fish	(East et al. 2005)
Equatorial Guinea	Urban (Malabo)	More fresh livestock Less bushmeat No effect on overall meat and fish consumption	(Fa et al. 2006)
DR Congo		More fresh fish	(de Merode et al. 2004)
South America		Less bushmeat Less fish	(Wilkie & Godoy 2001)
Gabon	Rural	More bushmeat (although peaked with the third highest income quartile)	(Starkey 2004)
Gabon		More meat (all types) More fresh fish	(Wilkie et al. 2005)

Meat and fish state may also affect consumer preference and price, and consequently consumption. In Equatorial Guinea, frozen meat and fish were shown to be the cheapest animal meat types (excluding smoked fish), but were least preferred, with consumption decreasing with increasing income (East et al. 2005, and see Chapter 6). Smoking meat or fish can also affect price and preference, and in Equatorial Guinea, smoked bushmeat is significantly cheaper than fresh meat and

smoked fish is the cheapest animal source all of (see Chapter 6), and is sometimes referred to as 'poor man's food' (Kümpel 2006). In contrast, smoked bushmeat in Ghana commands a higher price than fresh counterparts (Cowlishaw et al. 2005), probably due to the cost in time and money (i.e. the cost of fuel) of smoking meat and the greater storage time of meat once smoked.

Evidence indicating that fish and bushmeat can be substitutes for each other in some regions is mounting. In central and west Africa, fresh fish was preferred (East et al. 2005), and consumption increased with income (see Table 3.2). In addition, Brashares *et al* (2004) show that bushmeat consumption varies with fish availability and price in Ghana, while Wilkie *et al* (2005) show an increase in fish consumption with increasing bushmeat prices in Gabon. In contrast, in South America, fish is apparently an inferior good, with consumption decreasing with income (Wilkie & Godoy 2001).

Other predictors of bushmeat, domestic meat and fish consumption and preference include ethnic group (Fa et al. 2002; Kümpel 2006), with groups such as the Fang in Equatorial Guinea, having stronger preferences for bushmeat; household size (Fa et al. 2006), with larger households eating less total meat per AME in Malabo; gender (Koppert et al. 1993), with men generally eating proportionally more meat and fish (as grams per total calories consumed), while women and children eat proportionally more roots and tubers; and perhaps a weak variation in total calories consumed with season (Koppert et al. 1993), with a decrease in calorie intake towards the end of the main rainy season shown for one population in south Cameroon, but no differences in two other populations, and no clear seasonal patterns over all. Another study gave stronger evidence for a seasonal variation in bushmeat and fish consumption, with households eating more of these during the lean season (de Merode et al. 2004).

Research therefore shows that the consumption of different categories of meat and fish can vary due to price, preference (individual or cultural) and wealth of the consumer. In Equatorial Guinea at least, consumers may differentiate between food state (i.e. whether fresh, frozen or smoked) far more than they do between food categories (i.e. whether bushmeat, livestock, or fish). Understanding the relationships between these may be further confounded by differences between rural and urban areas, and by consumers preferring what they have grown used to.

3.2.2 Wild plants

The consumption of wild plants has often been overlooked in previous studies, and until relatively recently has been given little consideration. Approximately 1,500 species of wild plants are collected for consumption in central and west Africa (Chege 1994), and research, particularly under the 'Non-timber Forest Products' (NTFP) label, has now shown their importance. Wild plants are now viewed by many to be important for the dietary and medical needs of poor forest people, and are particularly thought of as a safety net or reserve food for times of hardship, during lean seasons (Ogoye-Ndegwa & Aagaard-Hansen 2003; de Merode et al. 2004), as a 'famine food' (Senaratne et al. 2003; Shackleton & Shackleton 2004; Delacote 2007), in times of conflict (e.g. 'night spinach' Jamiya et al. 2007) and even as a response to disease epidemics (Balee 1992), most recently HIV/AIDS (UNAIDS 1999). In other areas, wild plants are regularly consumed and harvested all year round, and play a substantial role in diet and nutrition (Bhattacharya & Patra 2007; Bikoue & Essomba 2007), particularly for women (Jimoh & Haruna 2007), as well as for income and livelihoods (see Chapter 4). In addition, some have reported a positive link between health and wild food consumption (Dounias & Colfer 2008), and in one case the bush mango, caused a decrease in obesity and cholesterol in obese patients (Oben et al. 2008). Indeed, the role of NTFPs in Central Africa has recently been highlighted by the FAO project "Enhancing food security through Non-Wood Forest Products in Central Africa".

There have been virtually no studies on the consumption of wild plants in Equatorial Guinea. A preliminary market survey documents some of the species commonly traded (Sunderland & Obama 1998) and Cogels (1997) lists only a few wild food plants collected: palm nut (*Elaeis guineensis*), palm wine (from various palm species), bush mango (*Irvingia gabonensis),* and wild fruit species such as "metom" (*Dacyodes macrophylia*); as well as non-food plants: raffia, bamboo and unspecified medicines, none of which appear to be sold. Significantly, Dounias (1993) noted that wild plant harvest practices in neighbouring Cameroon were not observed in similar villages in Equatorial Guinea, even in the Campo area, near to the Cameroon border, concluding that traditional practices of forest plant product harvesting may have been lost in Equatorial Guinea. Koppert *et al* (1996), however, showed a relatively low consumption of non-animal forest products in Cameroon, mainly made up of mushrooms, wild yams, and some nuts and grains such as bush mango, with the latter only present in July-August. They attribute this low value to the already stretched time budget of women, who spend much of the day in the fields and kitchen. They do note that men use more wild foods when on hunting trips and that these plants are mainly used for flavouring rather than making a significant nutritional contribution, but that they add more protein than calories.

This study has not examined the role of wild foods to micronutrition (i.e. the provision of vitamins and minerals), but their contribution to consumption of micronutrients such as vitamins A and C, iron, and dietary diversity in general has been noted, particularly for fruits and leafy greens (Hoskins 1990; Ogden 1990), in urban as well as rural areas (Gockowski et al. 2003), and for people living with HIV/AIDS (Barany et al. 2004). To highlight the importance that some ascribe to wild plants, there is concern that exotic introductions of alternative leafy vegetables (e.g. *Brassica spp.*) and the subsequent reduction in native, wild plants, may cause a loss in nutritional intake, particularly among the poor, if introduced species have lower nutritional values, cause a narrowing of harvests or a loss of local knowledge for harvest and production of these vegetables (FAO 1988; Udosen 1995; Okafor 1997; Future-Harvest 2001).

Fuelwood may actually be one of the most important NTFPs for household nutrition. Fuelwood makes up 61-86% of the primary energy consumption in some regions of Africa, of which 74-97% is used by households (Amous 2000). Fuel availability can determine the nutritional value of meals (Egal et al. 2000), as cooking releases nutrients in grains and fibrous roots, and some staples such as cassava can be toxic without such processing.

3.2.3 Wild invertebrates and herpetiles

The consumption of edible insects such as caterpillars, larvae and crickets, snails, other invertebrates, and small herpetiles such as frogs has been studied in many cases, although again is often neglected by studies and particularly by regulatory frameworks and development assistance (de Foliart 1999; Vantomme et al. 2004; Nasi et al. 2008). Insects are a popular food source in many countries, whether for regular consumption, as an occasional delicacy, or as a safety net eaten in times of food shortages, and estimates suggest that more than 1,000 species of terrestrial invertebrates are consumed by people (de Foliart 1992; Marconi et al. 2002; Vantomme et al. 2004). Studies have shown that insects can contribute significantly to the diets of the rural poor, for daily fat, protein, vitamin and mineral requirements (de Foliart 1992; Illgner & Nel 2000). Marconi *et al* (2002) showed that consumption of 100g of invertebrates contributed 1.2-9.4% of daily fat requirements and 6-144% of daily protein requirements in Amazonia. Other research has shown that caterpillars have higher protein and fat content than meat or fish (Malaisse 1997) and that some species are very rich in vitamins and/or minerals (de Foliart 1992). Indeed, de Foliart (1992) showed that 100g of caterpillars could provide 100% of the daily requirements of the contained vitamins and minerals.

3.2.4 Food sources and food types

There are few data on the actual origin of bushmeat consumed in households, so it is difficult to know how much is directly harvested by households, and how much is traded within villages and in informal markets. In Equatorial Guinea, one study in urban Malabo showed that 97% of bushmeat consumed was bought and 3% received as gifts (Albrechtsen et al. 2005), while in a rural village, over half of bushmeat consumed was captured by the household itself (Kümpel 2006).

In this chapter, I assess the contribution of different **food types** by dividing foods into categories, regardless of how they were obtained by the household (i.e. all foods originally gained from the forest, foods imported into the country, agricultural foods, etc.) to examine the contribution of these foods to the community as a whole, as well as the differences in consumption patterns between individuals and communities in both villages. In a different set of analyses, I assess the contribution of different **food sources** by categorising foods consumed according to how they were obtained by the household (i.e. wild foods obtained from the forest by the household in question, items bought, food received as a gift, and food produced in the fields), to determine the direct contribution of the forest for individuals and households. Given previous research outlined above, I hypothesise that:

1) More remote communities (i.e. Teguete) will consume more wild foods;
2) Medium or wealthier households will consume more meat and fish in general, and specifically more bushmeat and wild fish;
3) Poorer households and women will consume more wild plants;
4) Poorer households will consume more items directly sourced themselves (either from forest or agriculture), while richer households will consume more bought items;
5) The consumption of wild products will be highest in the hungry season.

3.3 Methods

3.3.1 Data Collection

During the regular household interviews (see Chapter 2), households in each village were visited approximately every fortnight. All adults in the household were asked about their food consumption during the previous day and the consumption by children in the household, and an interview was deemed invalid if any household member over 18 could not be found or their answers not recorded. The household member who had cooked was asked about the ingredients of any food prepared, and all respondents asked a series of questions taking them through the day's consumption (i.e. asking what they ate first thing, then what they ate, etc.), and including food and drinks eaten in the house,

in other peoples houses, in the fields, bought in the street or in bars, and who was present for each eating event (including guests), following methods laid out by Swindale & Ohri-Vachaspati (1999). For each food item, questions were asked on how many times it was eaten the previous day, how the food was obtained (bought, received as a present, harvested from the fields, trapped or hunted, etc.), where obtained from (bought in a bar in the village, an urban market or wholesalers, a local fisherman, etc), in what state it was obtained (fresh, smoked, frozen, rotten), when obtained, what quantity obtained, and for what price. Fang or local names of forest animals, fish and wild plants were used to avoid misidentification.

Respondents were asked about the quantity of food consumed using local units, and the weight of the same amount of food measured using the same container where possible. Additional data was also collected on the weights of different food types of different states in different local units wherever possible. Common units included: handful (amount filling one palm), double handful (amount filling two palms), wicker dish (locally made), small, medium and large saucepans, locally made wicker baskets used to transport food harvested from fields, and entire unit of something (e.g. a whole banana). When weighing items, care was taken to note the state of the food (i.e. raw, cooked, smoked, etc.), whether or not it was peeled or skinned, which household it was weighed in, and to note any equivalent units (i.e. the number of entire avocados in one basket). For foods that were prepared and eaten over more than one day (e.g. when a pot of food was cooked and then half of it eaten one evening, and the remainder eaten for the following breakfast or lunch), the amount consumed for the sample day alone was estimated from the total quantity, based on the number of times it was eaten over both days and the number of people eating at each event.

Where a food item was weighed during the interview, that weight was used in all calculations. Where food was not weighed during an interview, the average weight for that food, state and unit for that household was taken. Where these data were not available, the average weight of that food, state and unit for the village was taken. Where possible, the estimated calorie and protein amounts per kilo of foods were taken from Cooperacion Sanitaria Española con Guinea Ecuatorial (1991) which contains country-specific values of common and local foods. Otherwise nutritional values were taken from various sources, including FAO (1997).

Daily food consumption per household was taken by adding the estimated calorie and protein amounts for each food item and amount eaten that day. To calculate individual consumption, the amounts of food items that were eaten from a shared pot were proportioned according to the Adult Male Equivalent (AME) of all the people eating that food and the values added for each person.

AME values were taken from the scale used for poverty line calculations as reported in (Pedersen & Lockwood 2001), based on information on recommended dietary allowances (WHO 1989), Table 3.3.

Table 3.3 AME values for different age and sex groups.
*Taken as 0 ≥ age > 0.5; § Taken as 0.5 ≥ age > 1; ‡ Taken as 1 ≥ age > 4. Age boundaries for all other population groups are specified in the same way, unless otherwise indicated. Taken from Pedersen & Lockwood (2001).

Population group	AME
Infant 0 - 0.5 *	0.22
Infant 0.5 – 1 §	0.29
Child 1 – 3 ‡	0.45
Child 4 – 6	0.62
Child 7 – 10	0.69
Male 11 – 14	0.83
Male 15 – 18	0.98
Male 19 – 50	1
Male 51+	0.79
Female 11 – 14	0.72
Female 15 – 18	0.74
Female 19 – 50	0.76
Female 51+	0.66

3.3.2 Data Analysis

Variation in total food consumption

Food consumption was measured on an individual level (calories and grams of protein consumed/individual/day) and at the household level (calories and grams of protein consumed/household/day).

The variation in daily individual calorie intake from all food types was analysed using a linear mixed model with a normal error structure (IID) in the following way[1]:

- Calories consumed/individual/day ~ Village + HH Income + Season + Sex + Age + (1|Village/HH/Individual), offset = AME)

[1] For simplicity, not all explanatory variables are shown in these equations. For a full list, see text and section 2.4.1 Explanatory variables).

The individual quantities of food eaten in the shared pot were estimated by dividing the total pot amount by the number people eating it, proportionally to their Adult Male Equivalent (AME; see Table 3.3 for AME values used). Given that the majority of food was consumed by the entire household from a shared pot, there was only a small amount of variation between individual household members, mainly made up of any snacks eaten outside of the home. Differences in consumption from within the shared pot were not possible to detect with the data collected, and given the communal nature of peoples' eating habits (people often eat literally from the same pot or dish), this may only be possible using extremely labour intense and intrusive methods such as direct observation. Condiments and small food items contributing minimally to nutrition (e.g. salt, chilli, stock cubes and garlic) were not included in any analyses. Similarly, children under 2.5 were excluded from all analyses.

Differences in calorie consumption with individual and household variables, season and village were analysed. Household level variables were: household (HH) income, HH fixed wealth, HH wealth rank, HH size, number of productive adults (aged 18-65 and not including the chronically ill), number of productive females, presence/absence of productive males, proportion of productive adults to total household size, proportion of productive females, education level of the HH head, and gender of the HH head (see Chapter 2 for details). Individual level variables were: education, sex and age. All variables were tested for normality and transformed where necessary.

Individuals nested within households, nested within villages (1|Village/HH/Individual) were specified as random effects for analyses of individual consumption. Individual consumption was offset by AME (adult Male Equivalent), effectively analysing differences in daily consumption per AME. In other words, the calorie consumption per individual is measured against the expected calorie consumption for that individual, according to their sex and age (see Table 3.3 for AME values used).

The model was simplified to obtain the minimum adequate model (MAM) by fitting the saturated (unrestrained) model and then comparing models with progressively simplified fixed effects using change in deviance tests. Significance was taken as $p<0.05$.

Variation in protein consumption from all food types was analysed in the same way[2]:

- Protein consumed/individual/day ~ Village + HH income + Season + Sex + Age + (1|Village/HH/Individual), offset = AME)

In order to ensure that any differences at the household level were still detectable without the need to use figures derived from estimates based on AME and the distribution of a shared pot., variations

in household level calorie and protein consumption were similarly analysed, but with no offset for AME and the random effects were specified as household nested with village (1|Village/HH) [2]:

- Calories consumed/HH/day ~ Village + HH income + Season + No. Adults eating + No. children eating + (1|Village/HH), offset = AME)
- Protein consumed/HH/day ~ Village + HH income + Season + No. Adults eating + No. children eating + (1|Village/HH), offset = AME)

In these analyses, individual level variables were not included and the number of adults and number of children eating at that household at that day were specified as addition explanatory variables, to account for differences in household size.

Variation in consumption of different food types and from different food sources

Food consumption was then divided into categories of food type and food source. **Food type** was taken as the supply origin of that food type, and used to assess the contribution of different food supplies to the community as a whole. **Food source** was taken as the means by which each food item was obtained by the household, to analyse specifically how households obtain food. So, a bar of cassava bought by a household would have food type 'agriculture', but food source 'bought'.

Food type was divided into these categories:

- **Agriculture** – agricultural food items produced in the country, including cassava, peanuts and almost all fresh fruit and vegetables
- **Imports** – food mainly imported into the country, including all processed foods (no processing is done in Equatorial Guinea except one brand of beer not found in either village), such as all tinned and packaged goods, frozen fish and meat, and agricultural goods not grown in Equatorial Guinea (e.g. rice)
- **Coastal** – marine fish from the Rio Muni coast (and so part of the country's food production). All marine fish in the village was smoked.
- **Wild** – all non-cultivated species harvested from the forest, farm-fallow or agricultural land. These were further split for additional analysis into:
  - **animal –** terrestrial and bird wild animals (bushmeat)
  - **fish –** all wild freshwater fish
  - **plant –** forest plant products

[2] For simplicity, not all explanatory variables are shown in these equations. For a full list, see section 2.4.1 Explanatory variables).

These categories also reflect the geographical origins of the food types, with virtually all agricultural and wild food being harvested locally, so if it was purchased it was almost always from another household within the village. Some food items at times fell into either of two groups. The most problematic of these was palm oil and other palm products, which were both cultivated in fields and collected from wild growing trees in the forest. Although no oil palm plantations exist, when a new field is cleared, if the area contains a palm tree it is usually left to grow and the palm fruits harvested accordingly. Consequently, although a large proportion of oil products was recorded as being harvested from the forest (~40%), a greater proportion was recorded as coming from agricultural land (~60%), and so all palm products were classified as food type agriculture, leading to a potential over estimation of the contribution of agricultural products and underestimation of wild products[3]. Similarly difficult products to define were two classes of fish. The fang words 'bifaka' and 'celele' are generic terms for small and smaller fish. These small fish make up the majority of the small smoked fish brought from the coast, but small locally caught fish can also be called by these terms, and if smoked, there is no way to know if they came from the coast or were locally caught. To err on the side of caution, all smoked *bifaka* and *celele* were classified as coastal, while fresh *bifaka* and *celele* were classified as wild (no fresh fish came from Bata). Other locally caught fish had fang names specific to fresh water species, so there were no problems in classifying these.

The calorie and protein contribution to consumption from each of these food types was analysed against the explanatory variables above. Individual variation in daily calories consumed from produced food as a proportion of the total calories consumed was analysed as above, using a mixed model with a normal error structure, maximum likelihood method and offset by individual AME. The proportion of calories from produced food was transformed by an arc sin transformation and analysed against the explanatory variables above, transformed where necessary. Due to the large number of zeros in the data and the consequent lack of a normal distribution, only days where some of the food source in question was consumed were analysed, thus analysing the relationship of the proportion of energy from a source only when it was being consumed. Variation in individual protein consumption from produced food was analysed in the same way. The proportion of calories or protein consumed was taken as the dependent variable rather than the absolute amounts consumed, to give a greater reflection of the contribution to current diets, and to avoid distortions caused by the large differences in activity levels and subsequent energy needs between different groups (particularly between wealth categories).

[3] The food source of palm products was still taken as the actual origin from which households had obtained it, so included both 'agriculture' and 'forest' categories.

Food source was divided into these categories:

- **Bought** – food bought by a member of the household
- **Agriculture** – food produced by a member of the household, including food harvested from fields by household members and any domestic animals eaten
- **Gift** – food received by household members as a gift
- **Forest** – food hunted, fished or gathered by household members. This included all non-cultivated species collected from forests, fallow land and agricultural land. This group was further split into:
  - **animals** – all terrestrial and bird forest animals
  - **fish** – wild caught fish (there were no reared fish or aquaculture in either village)
  - **plants** – all forest plant foods

The frequency of consumption from each of these sources was separately analysed, with daily presence or absence of each food source for each individual on each sample day given as a binomial variable, using a mixed model with a binomial error structure, against the explanatory variables above (transformed where necessary). In order to ascertain the different contributions of food harvested from the forest, these were further divided into terrestrial animals, fish and plants.

As above, calorie and protein consumption from each of these food sources was analysed individually against the explanatory variables. As with food types, the proportion of calories and protein consumed from agricultural products was treated as a continuous variable, but due to data limitations, the consumption of imported, coastal and wild foods on any sample day was treated as a binary variable, followed by analysis of the proportion of calories and protein only for days where that food type was consumed. All data were analysed in R, version 2.6.2 (R Development Core Team 2007), using the lme4 library (Bates & Sarkar 2007).

3.4 Results

3.4.1 Total food consumption

People ate an average of 1534 calories per AME in Beayop and 1325 in Teguete which is lower than the daily recommended amounts of 2000[4]. Conversely, an average 66g of protein per day per AME was consumed in Beayop and 61g in Teguete, which is higher than the daily recommended

[4] Extreme caution should be shown when using daily recommended amounts of food intake, as people's needs vary so greatly. In addition, any estimates of food intake are likely to be underestimates.

amount of 52g/AME/day (FAO & WHO 1985). There is no significant difference in food consumption between males and females (Figure 3.1, Figure 3.2), although females have slightly higher calorie consumption per AME (although still a lower absolute calorie consumption).

As we would hope, the models at household and individual levels show very similar results, suggesting that they reflect genuine differences between groups, as opposed to being an artefact of AME calculations (Table 3.4). Individual calorie consumption, and household and individual protein consumption, are significantly higher in Beayop (Figure 3.1, Figure 3.2). Household and individual consumption of calories and protein increases significantly with wealth, as represented by HH income or fixed wealth, and oppositely consumption of calories and protein decreases significantly with household size. Individual consumption of calories and protein per AME increases significantly with the proportion of productive females in the household and increases significantly with age (Table 3.4), reflected in a higher recorded consumption of calories and protein in over 18 year-olds (Figure 3.1, Figure 3.2). Seasonally, calorie consumption was lowest in the 3rd season, followed closely by the 2nd season, and protein consumption was lowest in the 2nd and 3rd seasons. Consumption of both calories and protein was highest in the 4th season.

Figure 3.1 Daily calorie consumption per AME for adults and children by gender and village

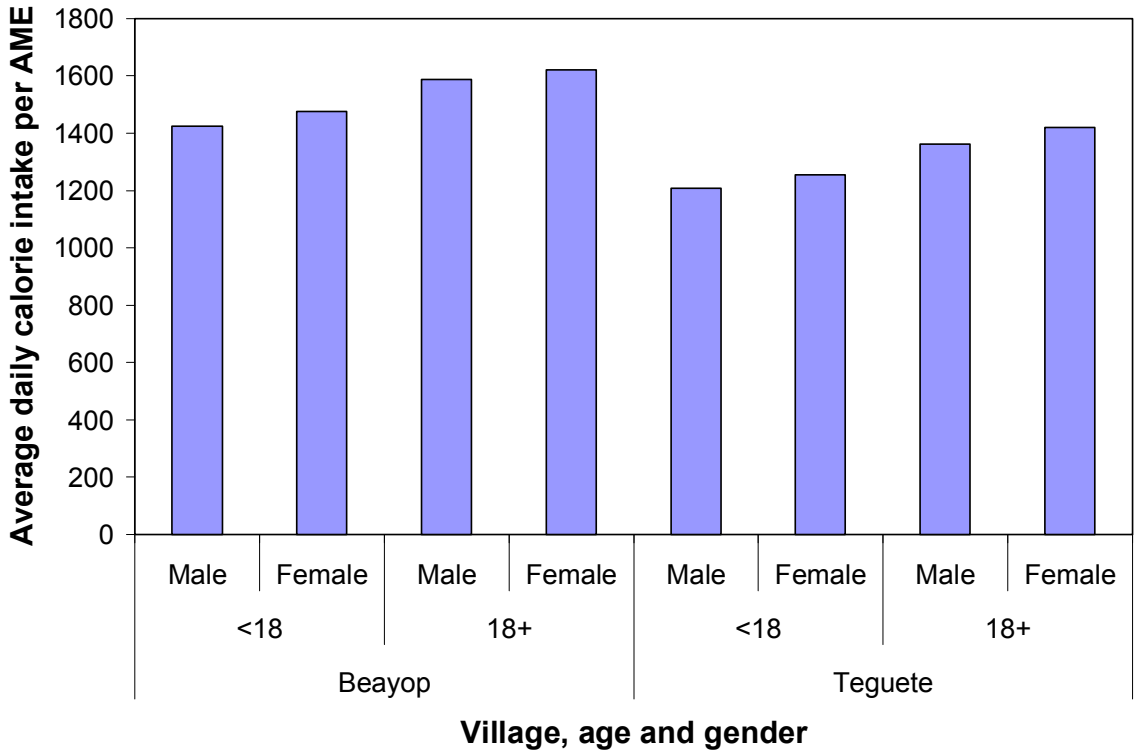


Figure 3.2 Daily protein consumption per AME for adults and children by gender and village

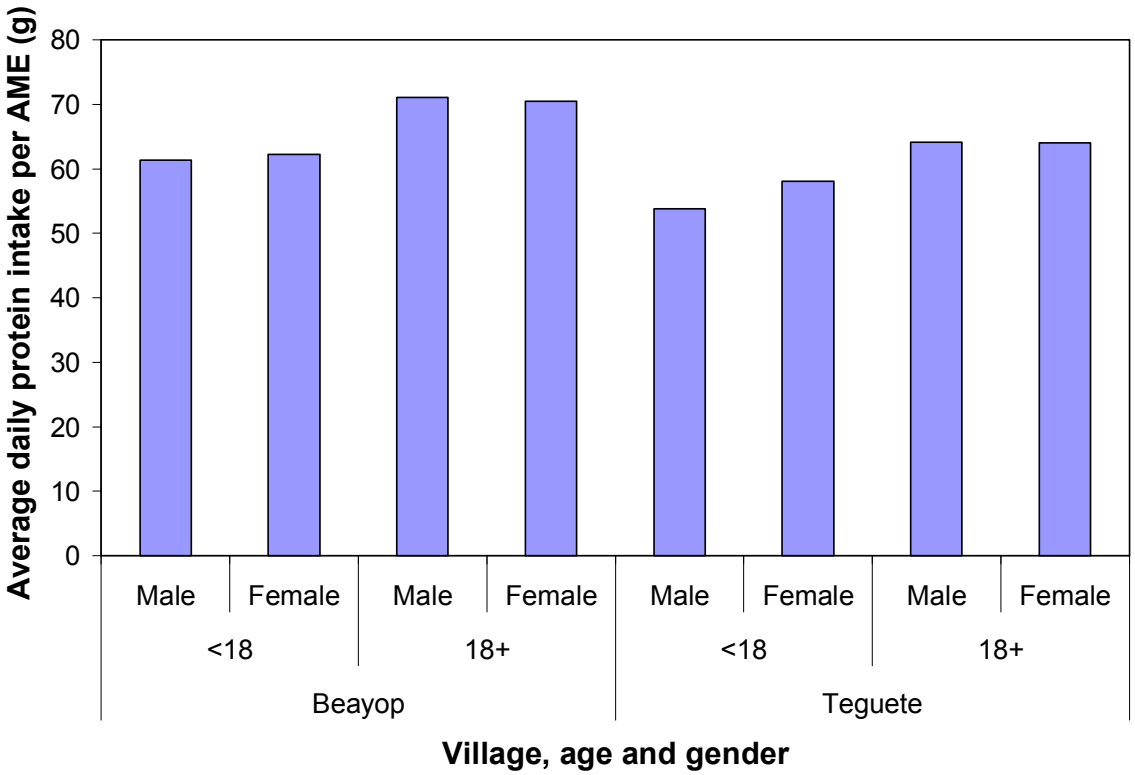


Table 3.4 Results of GLMMs – total energy and protein consumption from all foods.
Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, differences between levels are indicated by symbols. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 5.1, Table A 5.2, Table A 5.3 and Table A 5.4 for details.

Variable	Level	HH calorie consumption	Individual calorie consumption	HH protein consumption	Individual protein consumption
Season	1Small Dry 2 First Wet 3 Big Dry 4 Second Wet	+ - - ++	+ - - - +	+ - - ++	+ - - +
Village	Beayop Teguete		+ -	+ -	+ -
HH Income			+		+
HH Fixed Wealth		+++	+++	+++	+++
HH size		- - -	- - -	- -	- -
Proportion productive females			+++		+
Age		NA	+++	NA	+++

3.4.2 The contribution of food types to consumption

General description of food types

Agriculture

Few livestock animals were reared in either village (see Chapter 4 for numbers), and even fewer consumed (recorded consumed on less than 10 HH survey days), tending to be reserved for special occasions, so virtually all produced foods were arable agricultural crops. Aside from food staples such as cassava and plantains, the two main crops are peanuts and calabaza. Both are good sources of protein and are used as a sauce eaten with meat, fish or greens, or as a meal in their own right, as opposed to an accompaniment. However, plant-based protein is generally regarded as inferior, and there is a strong preference for meat and fish, together with a belief that meat and fish are better for the health.

Imported foods

The large amount of relatively cheap frozen meat and fish found in Bata does get transported to some rural villages, either by enterprising village shop owners (as is the case in Beayop), although a freezer and electricity generator are necessary for this, or may be sent in small quantities (usually only for special occasions) to villages by family members living in the cities. The lack of a way to store frozen food means that smaller or more remote villages do not usually have a regular supply of frozen fish and domestic meat, and this is the case in Teguete.

Coastal

Small, smoked marine fish seem to reach virtually all rural villages in Río Muni, and this is true of Beayop and Teguete. Most of this fish is caught off the shore of Río Muni, the bulk coming from Cogo and the coastline between the southern border with Gabon and Bata, where it is usually smoked and then transported to Bata. Village traders and other villagers visiting Bata or other cities often buy (or get given) a plastic bag full of smoked fish and this can be stored in the village for regular consumption or for sale in small portions of two to four fish to other villagers. This was the cheapest animal protein available in either village.

Wild foods (forest foods)

Although no urban traders visited Beayop or Teguete specifically, hunters in both villages did sometimes sell their products to other villagers, as well as to passing cars or traders, so a sizeable proportion of bushmeat consumed was not directly captured by the household. Some hunters also chopped up their catch, selling smaller, more affordable, portions of fresh bushmeat for around 500cfa. Wild fish and plants were also sold within the village, but on a far lower scale.

Community differences in consumption from different food types

In both villages, agricultural products were consumed virtually every day (Figure 3.3) and overall provided the greatest proportion of calories of all food types (60% and 68% for Beayop and Teguete respectively, Table 3.5). They were more important in Teguete, providing a significantly higher proportion of protein and calories to households (Table 3.7). Households ate imported goods significantly more often in Beayop, and these provided the highest proportion of protein of all food types (41%). In Teguete forest products provided the majority of protein (53%), and were consumed significantly more often and provided a significantly higher proportion of energy and protein when they were consumed (Figure 3.3 and Table 3.7). Within forest products, bushmeat was most important for protein provision in both villages, although it provided on average over twice the protein to people in Teguete than in Beayop (Table 3.5), and was eaten significantly more often in Teguete (Table 3.8). Wild plants provided the greatest overall proportion of calories of all forest products in Teguete, and were eaten more often and provided a greater proportion of calories when they were consumed. Forest fish provided a relatively small proportion of calories and protein to households, but of this, it was more important in Beayop, providing a significantly higher proportion of protein when it was consumed. Coastal food was eaten more frequently and provided more energy and protein to households in Beayop, but this was lowest contributor of all food types.

Large proportions of the agricultural and forest products consumed were harvested directly by the household, and in these cases the food type reflects the food source. For example, of the average 920 cal/AME/day gained from all agricultural products in Beayop, and 891cal/AME/day in Teguete (Table 3.5), an average 773 cal/AME/day and 741 cal/AME/day respectively were obtained from agricultural sources (

Table 3.9), giving an estimated 84% and 83% of agricultural products consumed in the household that are harvested directly by the household in question (Table 3.6). In this way, the results show that while a greater proportion of forest products consumed were harvested by the household in Teguete, households were marginally more likely to buy or receive bushmeat as a gift in Teguete than in Beayop (Table 3.6). The majority of forest fish and plants consumed in Teguete were harvested directly by the household, while in Beayop most wild fish and plants consumed were bought or received as a gift.

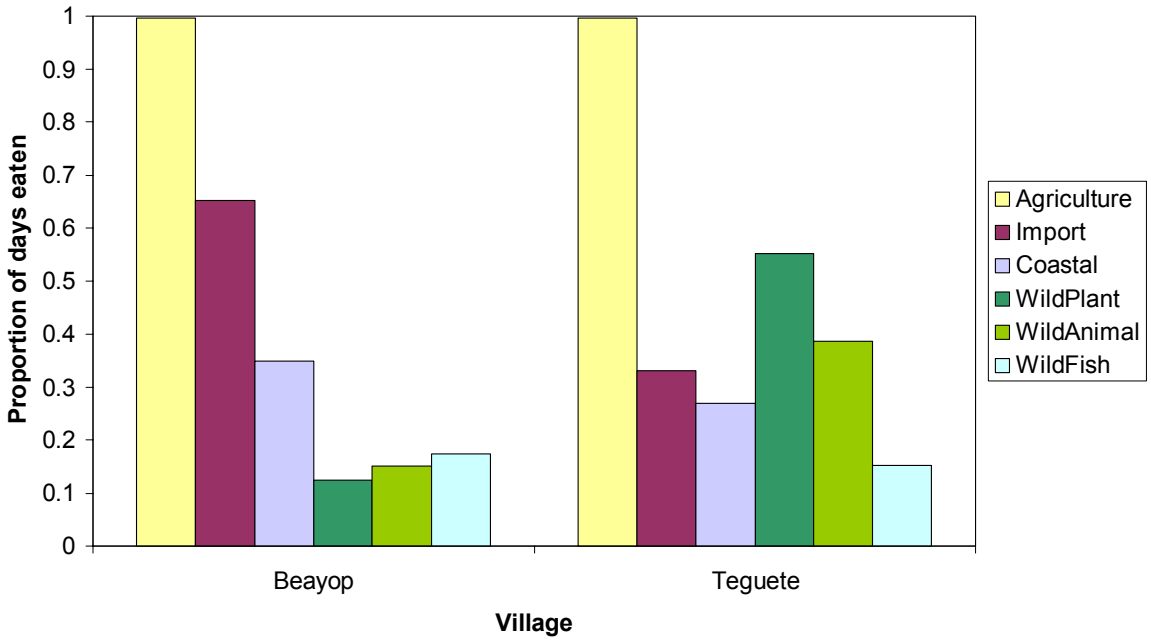
Table 3.5 Average contribution to calories and protein by different food types.

Food type	Average calories/AME/day		% total calories		Average g protein/AME		% total protein consumption	
	Beayop	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*
Agriculture	919.7	891.0	59.9	67.5	17.6	18.7	26.0	31.9
Import	474.0	135.3	30.9	10.3	28.0	6.3	41.3	10.8
Coastal	28.3	15.8	1.8	1.2	4.8	2.7	7.1	4.6
Forest products	112.3	277.8	7.3	21.0	17.4	30.9	25.7	52.7
Forest animals	*61.8*	*123.9*	*4.0*	*9.4*	*12.3*	*25.0*	*18.1*	*42.7*
Forest fish	*27.5*	*7.1*	*1.8*	*0.5*	*4.5*	*1.4*	*6.6*	*2.4*
Forest plants	*23.0*	*146.8*	*1.5*	*11.1*	*0.6*	*4.5*	*0.9*	*7.7*

Table 3.6 Average percentage of agricultural and forest foods consumed that were harvested directly by the household for each village.
Figures were estimated using the average number of calories obtained of that food source, as a proportion of all calories of that food type consumed.

Food type	Beayop	Teguete
Agriculture	84.1 %	83.2 %
Forest (all)	51.7 %	71.0 %
Forest animals	*65.1 %*	*56.7 %*
Forest fish	*26.8 %*	*76.6 %*
Forest plants	*45.7 %*	*82.8 %*

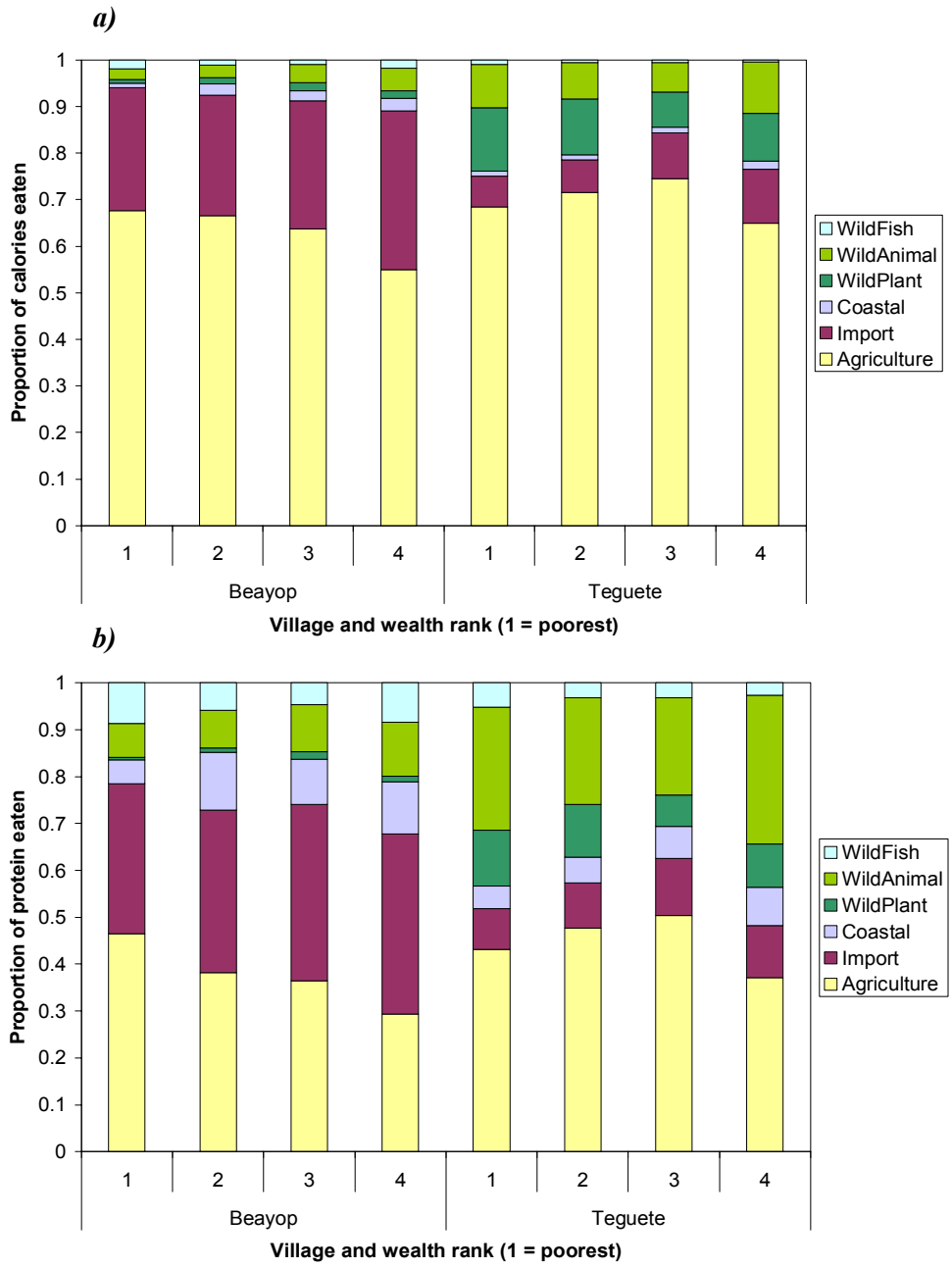
Figure 3.3 Frequency of consumption of different food types



Household variation in consumption from different food types

Individuals from wealthier households gained significantly lower proportions of energy and protein from agriculture in both villages (Figure 3.4 and Table 3.7). Instead, wealthier households gained more calories and protein from imported foods, and ate these significantly more frequently, as did households with better educated household heads (Table 3.7). Wealthier households gained slightly more protein and calories from coastal foods, and these were eaten most frequently by households with a higher proportion of productive females, and with the most educated household heads. In Beayop, wealthier households gained a higher proportion of calories and protein from forest foods, while in Teguete, the poorest and wealthiest gained most from forest foods, driven by a significantly greater frequency of consumption among the 1st and 4th wealth ranks. This increased frequency of forest product consumption at the wealth extremes was probably due to wealthier households eating wild plants most often in Beayop and poorer households eating them most often in Teguete. Larger households also ate bushmeat significantly more often.

Figure 3.4 Average proportion of a) calories and b) protein for food types with wealth rank and village.



Seasonal variation in consumption from different food types

In both villages, agriculture provided the lowest proportions of calories from agriculture in the 2nd season, and the lowest proportion of protein in the 2nd and 3rd seasons (Figure 3.5 and Table 3.7). In compensation, the forest provided significantly higher proportions of calories and protein in the 2nd and 3rd seasons in Teguete due to a higher frequency of consumption and higher proportion of calories when they were consumed. Of these, forest plants were consumed most often and provided the highest proportion of calories and protein in the 2nd and 3rd seasons in Teguete (Figure 3.5 and Table 3.8), but bushmeat was consumed the least frequently, providing the lowest proportion of

protein in the 2nd season. Seasonal differences in consumption of forest products in Beayop were less varied, except for wild fish which were eaten most frequently and provided most protein in the 4th season.

Figure 3.5 Graphs showing average proportions of a) protein and b) calories consumed from food types with village and season.

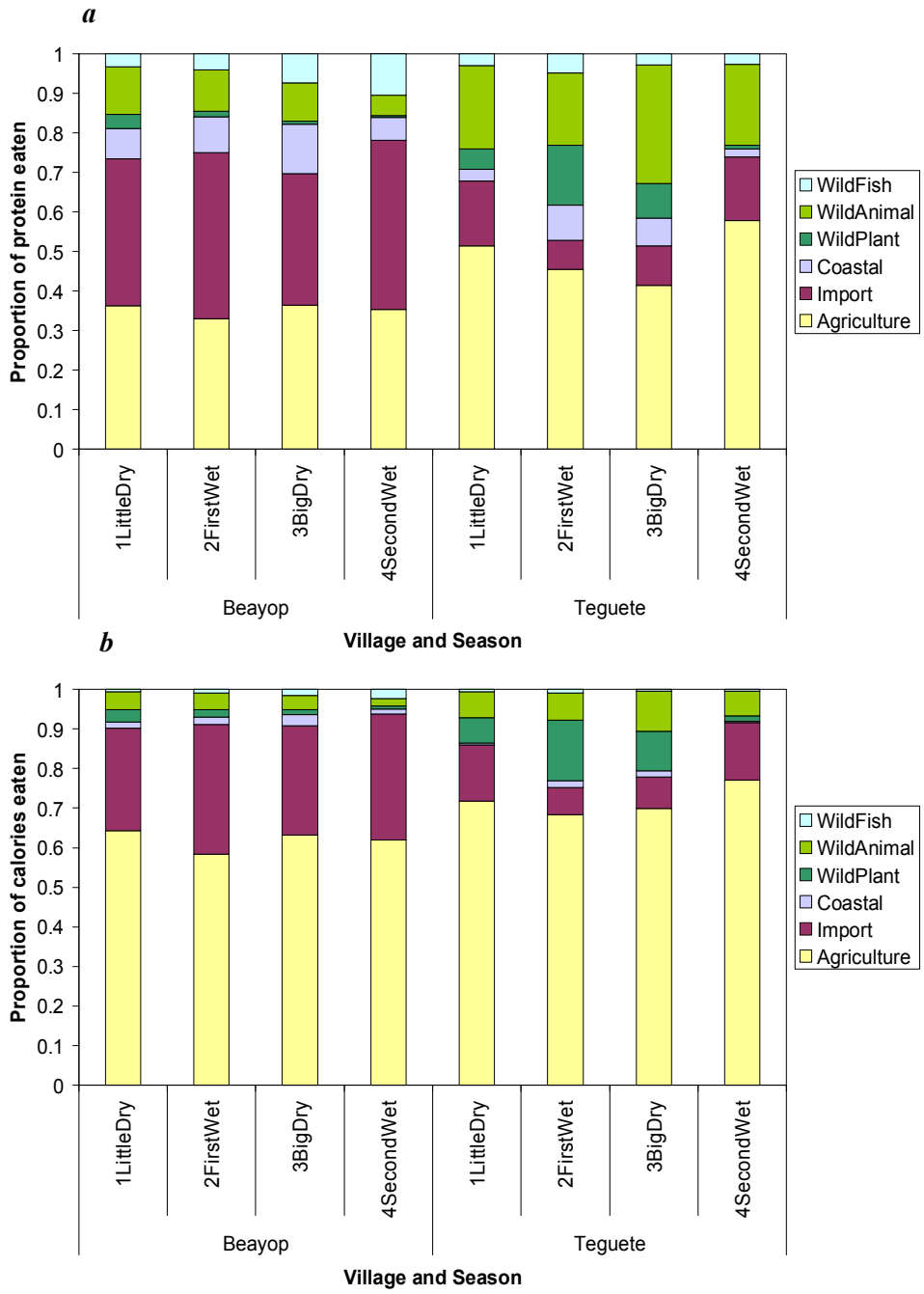


Table 3.7 Results of GLMMs of consumption from different food types against all explanatory variables.
Models show effects on the frequency (freq.) of consumption and the proportion (prop.) of protein or calories provided by different food types on the days consumed. The frequency of consumption of agricultural products was not analysed as they were eaten virtually every day. The proportion of calories from coastal foods was not analysed, as these products were more important for protein consumption. The proportions of protein and calories from imported gifted foods were not analysed due to the wide variation of products that this group consisted of. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables and variables with significant interactions, differences between levels are indicated by symbols. Explanatory variables that were not significant for any of the tested parameters were not included in the table. For a breakdown of forest sources into animal, fish and plant products, see Table 3.12. See Table A 5.18, Table A 5.19, Table A 5.20, Table A 5.21, Table A 5.22, Table A 5.23, Table A 5.24 and Table A 5.25 for analysis details.

Variable (food types)	Level	Agriculture, prop. calories		Agriculture, prop. protein		Coastal, freq. eaten		Coastal, prop. protein		Import freq. eaten	Forest, freq. eaten		Forest, prop. calories		Forest, prop. protein
Season		Beay	Teg	Beay	Teg	Beay	Teg	Beay	Teg		Beay	Teg	Beay	Teg	
	1Small Dry	-	+	-	++	-	+	++	-	+	-	++	+	+	-
	2 First Wet	- -	++	- -	+	+	++	++	+	- -	- -	+++	-	++	-
	3 Big Dry	-	++	-	-	+++	+	++	+	- -	- -	+++	-	++	++
	4 Second Wet	- -	+++	-	+++	+	- -	+	-	++	- -	+	- -	-	+
Village	Beayop	-		-				+		++	- - -		- -		-
	Teguete	+		+				-		- -	+++		++		+
Money		- - -		-						++					
Wealth rank	1	+		++				-			++				
	2	+		+				+			+				
	3	+		+				++			-				
	4	-		-				++			++				
HH size											++				
No. prod. females								- -					-		
Prop. prod. females						+		++							
HH head education	None					+				-					
	Primary					+				-					
	Secondary					-				+					
	Higher					++				+					

Table 3.8 Results of GLMMs of consumption from different forest food types against all explanatory variables.
Models show effects on the frequency (freq.) of consumption and the proportion (prop.) of protein or calories provided by different food types on the days consumed. Only the proportion protein from forest animals and fish were analysed as these products were more important to protein consumption than calorie consumption. Similarly, wild plants were more important for energy consumption, so proportion of calories was analysed instead. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables and variables with significant interactions, differences between levels are indicated by symbols. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 5.26, Table A 5.27, Table A 5.28, Table A 5.29, Table A 5.30 and Table A 5.31 for result details.

Variable	Level	Animal, freq. eaten		Animal, prop. protein		Fish, freq. eaten		Fish, prop. protein		Plant freq. eaten		Plant, prop. calories	
Season	1 Small Dry 2 First wet 3 Big Dry 4 Second Wet	Beay. - - - - - - - -	Teg. ++ + ++ ++	Beay. + ++ + -	Teg. - + + -	Beay. - + ++ ++	Teg. ++ + ++ -	Beay. + - + ++	Teg. - - - - - - - ++	Beay. + - - - - - -	Teg. ++ +++ +++ +	Beay. - - - +	Teg. - ++ + -
Village	Beayop Teguete	- - ++						++ - -		- - - +++		- +	
HH Income								-					
Wealth rank	1 2 3 4									Beay. - - - + +	Teg. ++ ++ + ++		
HH size		+++										- - -	

3.4.3 The contribution of food sources to consumption

Community differences in consumption from different food sources

The frequency and proportion of foods from different sources varied significantly between villages. People in Teguete consumed greater amounts of calories and protein from foods harvested directly from the forest, and these made up a greater proportion of their total consumption and provided the most protein overall (

Table 3.9). Of these, bushmeat was most important for protein, followed by forest plants and fish. In Beayop, bushmeat again provided the most protein, but this was followed by fish, then wild plants. The greater overall consumption of forest products in Teguete was due to a significantly higher frequency per person of eating wild animals, fish and plants compared to people in Beayop (Table 3.11 and Table 3.8), with people eating forest plants on average 50% of days (Figure 3.6) and a higher proportion of calories coming from forest products when they are consumed (Table 3.11).

There were no significant differences in agricultural consumption between villages. Individuals in Beayop and Teguete consumed agricultural foods harvested by the household almost every day (Figure 3.6) and these provided the majority of calories and nearly a quarter of protein consumed (

Table 3.9). Similarly, there were no significant differences in consumption of foods received as a gift. Individuals in Beayop consumed a significantly greater proportion of calories and protein from bought foods (including nearly half of all protein), and this was due to a significantly higher frequency of consumption of bought foods (Table 3.11).

Figure 3.6 Frequency of consumption from all food sources by village.

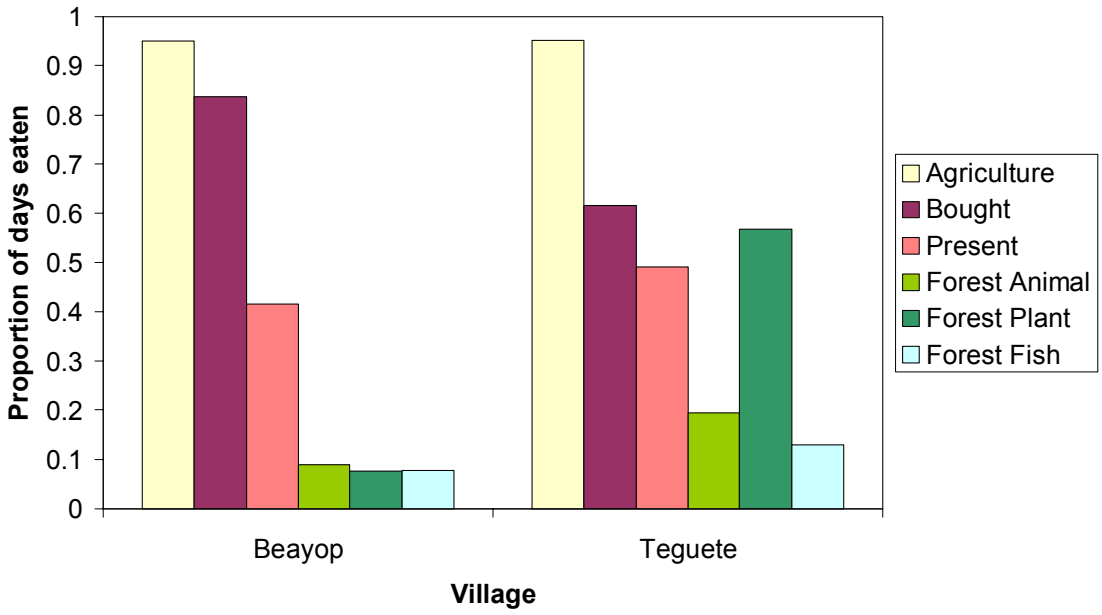


Table 3.9 Average contribution to calories and protein by different food sources.

Food source	Average calories/AME/day		% total calories		Average g protein/AME		% total protein consumption	
	Beayop	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*
Agriculture	773.38	741.25	50.7	56.3	14.86	14.27	21.9	24.6
Bought	526.28	187.87	34.5	14.3	33.13	14.12	48.9	24.2
Present	168.32	189.78	11.0	14.4	9.56	11.37	14.1	19.6
Forest products	58.14	197.21	3.8	15.0	10.26	18.36	15.1	31.6
Forest animals	*40.24*	*70.27*	*2.6*	*5.3*	*7.92*	*13.68*	*11.7*	*23.5*
Forest fish	*7.38*	*5.44*	*0.5*	*0.4*	*2.19*	*1.08*	*3.2*	*1.9*
Forest plants	*10.52*	*121.50*	*0.7*	*9.2*	*0.15*	*3.60*	*0.2*	*6.2*

Household variation in consumption from different food sources

People from medium wealth ranks gained a significantly higher proportion of calories from agriculture in both villages, and a higher proportion of protein in Teguete (Figure 3.7 and Table 3.11). However, poorer households in Beayop consumed agricultural products more frequently, and gained a greater proportion of protein from agriculture (Table 3.11), which is reflected in a higher proportion of protein consumption in the poorest wealth rank. Larger households also ate harvested agricultural foods significantly more often, as did households with a higher proportion of productive females.

Households with a lower income ate forest products significantly more frequently (Table 3.11) and this is due to a higher frequency of consumption of forest fish among poorer households and of forest plants among the second wealth rank (Table 3.8). Similarly, households in medium wealth ranks, particularly the second wealth rank, consumed bushmeat most frequently, as did households with higher income. Larger households consumed all forest foods more frequently, and male-headed households ate bushmeat significantly more often and gained a greater proportion of protein from forest products when they did consume them.

Wealthier households gained a higher proportion of calories and protein from bought foods (Figure 3.7), and ate bought foods significantly more frequently (Table 3.11), as did households with more productive adults and containing a productive male. Younger people were also significantly more likely to eat bought foods. The poorest and wealthiest households in both villages gained the most

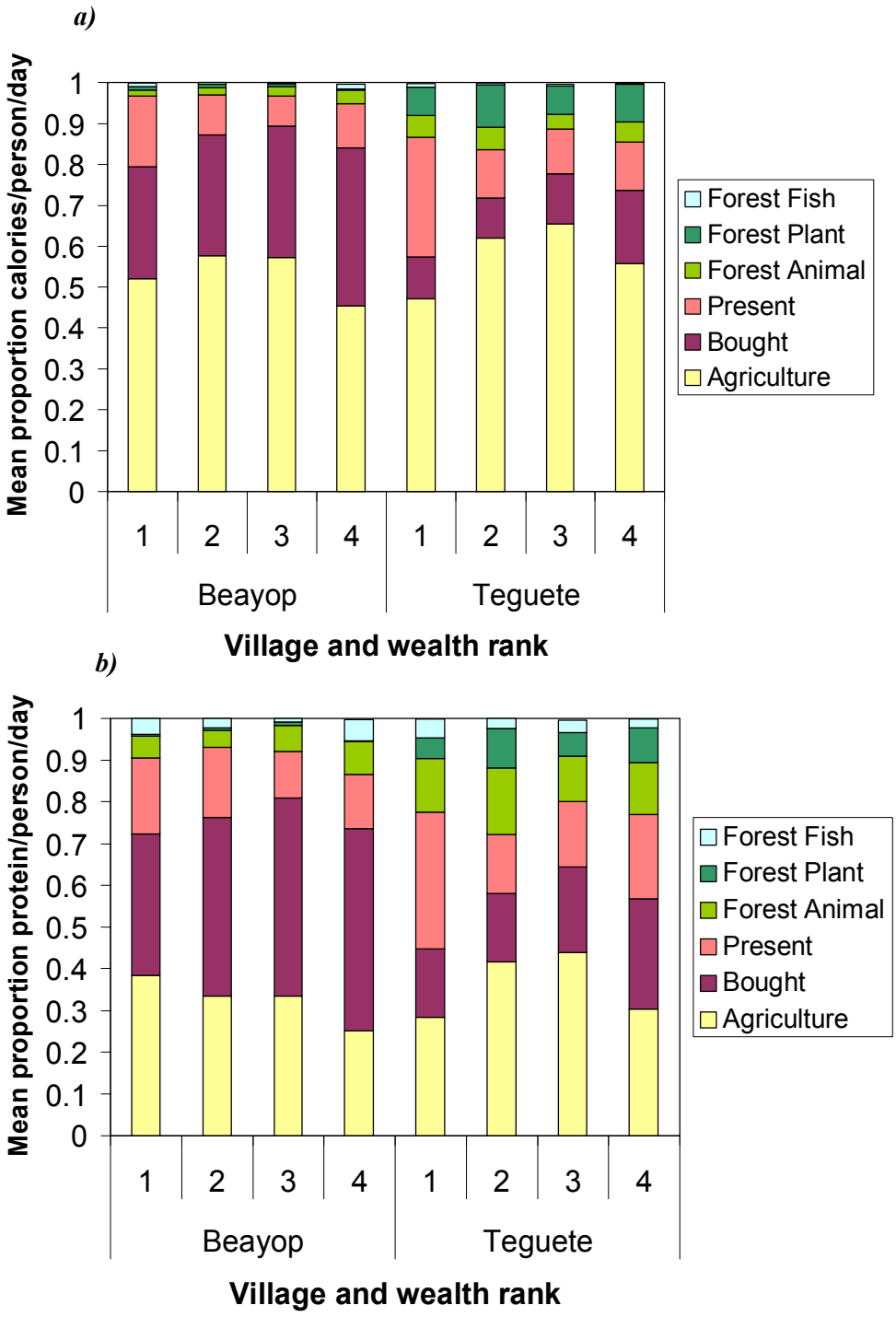
calories and protein from gifts of food (Figure 3.7), and these households ate food gifts significantly more often (Table 3.7). Smaller households also ate food gifts more often.

Medium wealth ranks generally consumed greater proportions of calories and protein that they had produced themselves (as opposed to bought or received as a gift, Table 3.10). The exception were the poorest households in Beayop who produced the greatest proportion of protein for consumption within the household.

Table 3.10 Average proportion of calories and protein produced by HHs in each wealth rank and village. Produced goods are those cultivated (i.e. agricultural crops and livestock) and captured or harvested from the forest.

Village	Wealth rank (1=poorest)	Percentage calories produced by the HH	Percentage protein produced by the HH
Beayop	1	55.1	48.0
	2	60.1	40.4
	3	59.5	40.1
	4	50.6	38.9
Teguete	1	60.7	50.9
	2	78.4	69.2
	3	77.7	63.8
	4	69.0	52.3

Figure 3.7 Average proportion of a) calories and b) protein for wealth ranks in each village.



Seasonal variation in consumption from different food sources

Overall, people in Teguete gained the highest proportion of calories and protein from forest products in the 2nd and 3rd seasons (Figure 3.8 and Table 3.11), and this was largely driven by a higher frequency of forest plant consumption and a higher proportion of protein from forest animals when they are consumed in these seasons in Teguete. Conversely, total proportion of calories and protein from forest products in Beayop is lowest in the 2nd and 3rd seasons, and this is due to harvesting all forest products, and animals and plants specifically, less often in these seasons (Table 3.7 and (Table 3.8). Fish is eaten most often in seasons 2 and 4.

People in Beayop gained the lowest proportion of calories and protein from agriculture in the 2nd and 4th seasons while people in Teguete gained the lowest proportion of protein from agriculture in the 2nd and 3rd seasons (Figure 3.8). Households harvested and ate agricultural foods most often and gained the greatest proportion of calories from agriculture in the 3rd season (Table 3.11). Households in Teguete gained a higher proportion of calories from gifts in the 1st and 4th seasons, and ate gift food significantly more often in the 1st season. There were no discernable seasonal differences in consumption of bought food.

Figure 3.8 Graphs showing average proportion a) calories and b) protein for different seasons and villages.

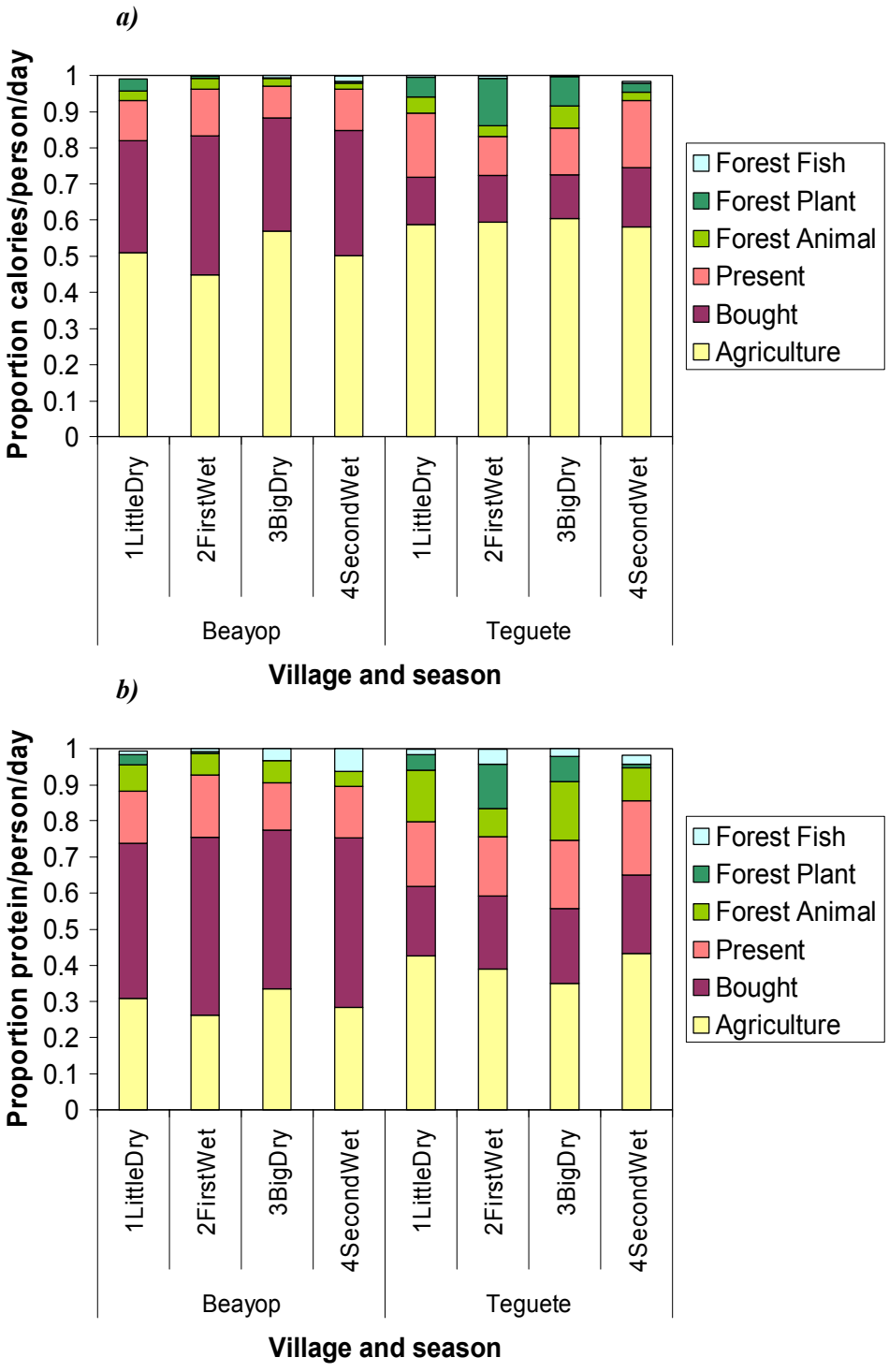


Table 3.11 Results of GLMMs of consumption from different food sources.
Models show effects on the frequency (freq.) of consumption and the proportion (prop.) of protein or calories provided by different food sources on the days consumed. The proportions of protein and calories from bought and gifted foods were not analysed due to the wide variation of products that these groups consisted of. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables and variables with significant interactions, differences between levels are indicated by symbols. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 5.5, Table A 5.6, Table A 5.7, Table A 5.8, Table A 5.9, Table A 5.10, Table A 5.11 and Table A 5.12 for more details. See Table 3.8 for a breakdown of forest sources into animal, fish and plant products.

Variable	Level	Agriculture freq. eaten	Agriculture, prop. calories	Agriculture prop. protein	Bought freq. eaten	Gift, freq. eaten	Forest, freq. eaten		Forest, prop. protein		Forest, prop. calories
Season	1Small Dry 2 First Wet 3 Big Dry 4 Secnd Wet	- - ++ +	+ - ++ -			+ - - - - -	Beay + - - ++	Teg - + ++ -	Beay - ++ +++ - -	Teg + + + +	- ++ + - -
Village	Beayop Teguete			- +	+ + - -		- - + +				- +
Income				- - -	+ +		- - -				
Wealth rank	1 2 3 4 5	++ + + - - -	+ ++ ++ - - -			++ - - - - - ++					
HH size		+++				- - -	+++				
No. productive adults					++						
Productive males	Yes No				++ - -						
Proportion productive females		+									
Age					- -						
HH head sex	Male Female								++ - -		

Table 3.12. Table showing results of GLMMs of consumption from forest food sources against all explanatory variables.
Models show effects on the frequency of consumption and the proportion of protein provided by forest terrestrial animals (bushmeat) and fish on the days consumed. Protein contribution (as opposed to calorie) was analysed because these products were more important for overall protein consumption. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables and variables with significant interactions, differences between levels are indicated by symbols. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 5.13, Table A 5.14, Table A 5.15, Table A 5.16 and Table A 5.17 for details.

Variable	Level	Forest animal, frequency eaten	Forest animal, proportion protein		Forest fish, frequency eaten	Forest fish, proportion protein	Forest plant, frequency eaten	
Season			Beay.	Teg.			Beay.	Teg.
	1Small Dry	++	-	-	-	-	-	++
	2 First Wet	- -	+++	-	++	+	- -	+++
	3 Big Dry	+	-	++	- -	+	- - -	+++
	4 Second Wet	-	+	- -	+	++	-	+
Village	Beayop	- -			- - -		- -	
	Teguete	++			+++		++	
Income		+++			-			
Wealth rank	1	-					-	
	2	++					++	
	3	+					+	
	4	- -					- -	
HH size		++			+++		+++	
HH head sex	Male	+++						
	Female	- - -						

3.5 Discussion

This study provides some evidence with which to examine the hypotheses laid out in the introduction, although not all as expected:

1. More remote communities consume more wild foods

As expected, people in the more remote community of Teguete consumed significantly more wild foods and gained a significantly higher proportion of macronutrients from them.

2. Inconclusive evidence that wealthier households eat more bushmeat

There was some evidence to support the hypothesis that wealthier households eat more bushmeat. Wealthier people in both villages ate more protein in general, and the higher wealth ranks in both villages ate the most bushmeat, both hunted by the household and in general. In addition, middle wealth ranks ate bushmeat produced by the household more often than poorer or wealthier ranked households. However, there were no significant relationships between wealth and the frequency or proportion of bushmeat consumption, and the poorer wealth ranks as well as wealthier ranking households also gained a high proportion of protein from bushmeat in Teguete. This, and the lack of discernable differences in wild fish consumption, mean that these results support those found by Kümpel (2006) and suggest that the increased protein consumption by wealthier households is due to higher quantities of meat and fish consumption in general, but that this does not particularly consist of wild meat or fish.

3. No clear relationship between wild plant consumption and wealth

Wild plants were eaten most in Teguete, arguably the poorer village, and there, wild plants were eaten most often by poorer households, although wealthier households still showed high consumption of these products. In contrast, wild plants were eaten most often by wealthier households in Beayop, and I suggest that this disparity is due to the different status and desirability of various wild plants. Some wild plants, such as forest-harvested leafy greens, could be considered 'food of the poor', and households may eat these greens when there are no other foods available (see Chapter 5, and reported by Jamiya (2007) in other countries). Other wild foods are perhaps a substitute for equivalent or preferred bought products, and this includes palm oil (as opposed to vegetable oil) and palm wine (as opposed to purchased, imported beer, wine or spirits)[5], and so are

[5] Palm products were considered a forest food source when they were harvested directly from the forest.

also foods of the poor. A third category of wild plant products are preferred and are widely traded in other countries. In particular, this includes the bush mango, which is twice the price of peanuts (by volume) and for which demand is high enough to have provoked domestication programmes in other countries (Atangana et al. 2002). Bush mango is less widely harvested in Beayop, so may be consumed more often by wealthier households that can afford to buy it.

4. Poorer households consume more products directly sourced by the household

The second poorest wealth ranks produced ate the greatest proportion of protein and calories produced by the household. The poorest wealth ranks were often unable to produce much food, either due to low labour availability in the household (reflected in low proportions of active adults and recognised as a characteristic of poorer households during the wealth ranking exercise – see Chapter 2), and so relied on gifts of food more than other households. The exception was for the poorest households in Beayop, who produced the greatest proportion of protein themselves than other households in the village, and the results suggest that this is made up of increased protein from agricultural products, as opposed to animal or fish products. This may be because where people are more likely to give gifts of food they have produced themselves (rather than bought), in a village where less bushmeat is hunted (and so less animal protein produced by the village), the gifts received by the poor are less likely to be meat.

5. Wild foods, particularly plants, contribute more to consumption in the 'hungry' season in Teguete, but not in Beayop

Focus groups identified the second season as the 'hungry' season, mainly due to the reduced agricultural harvest and increased agricultural labour during this period (Chapter 2) and this is supported by additional evidence in Chapter 5. Households in Teguete consumed the greatest proportion of calories and protein from wild products in seasons 2 and 3, and overall proportion consumption from wild plants was particularly high in the second season, when wild plants are eaten more often. This suggests that wild plants are important for both protein and calorie consumption during the lean season in rural villages. However, households in Beayop do not show increased consumption of wild foods during the lean season, and this may be due to reduced access to forest foods, or increased access to alternative food sources (and livelihoods – see Chapter 4).

3.5.1 Additional observations

Average calorie and protein consumption levels recorded are lower than the daily recommended amounts. However, this may be the result of consistent under-estimation of food quantities and so it

it is difficult to draw any real conclusions as to whether overall consumption needs are being met, particularly because activity levels (and so actual energy requirements) have not been reported. However, any under-reporting is likely to be consistent across groups, and so we can still have confidence in comparisons between individuals and households.

The results also suggest that households are more able to produce food to meet energy needs than protein requirements, as reflected in the higher proportion of calories eaten from food produced by the household, than protein. This difficultly in obtaining protein may be greater in areas with lower forest offtake, such as Beayop. People in countries such as Equatorial Guinea, where there is a heavy reliance on carbohydrate staples that are very low in protein (such as cassava) are most likely to consume inadequate protein, even when energy consumption is sufficient (Svedberg 2000), and an inability to produce enough protein to fulfil consumption needs affects poor households more than wealthier households, who are able to purchase food from other sources. These results suggest that the poorest households in communities with lower access to forests are more at risk from deficiencies in the diet protein than the poorest households in more rural villages, who can access forest protein resources.

One major limitation of this study is the inability to detect differences in individual consumption within households. Evidence shows that intrahousehold allocation of resources, including food, can vary significantly, particularly between genders and age groups (Haddad et al. 1996). The communal nature of food consumption in this study, with households commonly sharing food from an actual shared pot, made it impossible to accurately assess differences in food consumption within households with the resources available, so I was unable to test these hypotheses.

In conclusion, the data do show that wild foods can play an important role in diets, and this is particularly true of bushmeat and wild plants, and of more rural communities. Wild plants may be particularly important during the lean season, and the loss of wild food products in communities with less forest access is most likely to impact protein and calorie consumption of the poorest households.

Chapter 4.
The contribution of wildlife to livelihoods

4.1 Abstract

Recent studies have shown that forest products can be more important for income than for consumption, and so in this chapter I aim to quantify the production and income from forest products compared to other income sources. I show that poorer households harvest the most forest products, and of these, bushmeat is the most important. Income per hunter increases with wealth, but averaged over all people, bushmeat provides most income to the poor. Poorer households earn less income from other livelihood activities such as trade and paid work, and may be less able to compensate during the 2nd and 3rd seasons when agricultural productivity is lowest. Gender divisions between livelihood activities remain strong, with men generally hunting, and women cultivating agricultural food staples. The collection of forest plant products is also divided by gender, with men harvesting more valuable, generally non-edible wild plants, and women harvesting low value wild plant foods that are not widely traded in Equatorial Guinea.

4.2 Introduction

In the past, harvesting non-timber forest products in tropical regions has often been considered as primarily a subsistence activity, with all products being consumed in the home. Evidence now shows that harvesting wildlife can play a key role in the livelihood activities of poor, rural populations (Pimentel et al. 1997; Mainka & Trivedi 2002) and some have estimated that wildlife makes up a significant and direct part of the livelihoods of up to 150 million people (Bennett & Robinson 2000). Forest products can contribute considerable revenue to households (Juste et al. 1995) and indeed, income from wildlife sales can be more important than its value as a food resource (Godoy et al. 1995; de Merode et al. 2004). Despite this, many forest products do not appear on countries' balance sheets or development frameworks (Bird & Dickson 2007), and trade in these products is often not part of the formal economy. As a result, their value for income generation is consistently underestimated, and the cost to rural households of replacing these products with bought items even more so (Narendran et al. 2001; Delang 2006). Wildlife can be important in providing a supplementary income (UNDP 2005), with households gaining 40-60% of income from NTFPs, and as high as 80% where alternative income sources do not exist. Another study in Cameroon put income from forest activities at over half of local incomes (Chege 1994).

Of all tropical forest products, bushmeat is thought to be of particular value in many areas. Meat generally has a higher value per unit weight or volume than other forest products, can be relatively easily stored and transported, and may be the only source of ready cash in a subsistence economy.

In sub-Saharan African, bushmeat hunting is a common component of household economies (Asibey 1977; ma Mbalele 1978; Martin 1983; Anadu et al. 1988; Geist 1988; King 1994; Juste et al. 1995) and in some cases, hunters and traders earn higher than average annual earnings (Dethier 1995; Ngnegueu & Fotso 1996). Even as a supplementary income, hunting was shown to be essential to farmers in a number of African countries (Bissonette & Krausman 1995) albeit on a small scale, with farmers hunting during the agricultural low season, when there are lower labour requirements. In Equatorial Guinea, studies have shown that hunting may be more important for income than food, and in two hunter villages studied, hunting was both widespread and a major income source, rivalling salaries for some individuals (Kümpel 2006; Rist 2007). Other studies have shown bushmeat to be sold and consumed across much of Río Muni (Albrechtsen 2007).

The contribution of wild insects and other invertebrates to income can be significant. In Botswana, the sale of the caterpillar *Imbrasia belina* was the third biggest source of income after the sales of poles and livestock, contributing 13% of total household monetary income (Zitzmann 1999). In Central Africa, there is a strong trade in insects, with insects being widely available in village markets, and even some city markets and restaurants (de Foliart 1992). There also appears to be significant international trade, both within the central African region, and to other countries in Africa and Europe. Tabuna (2000) reports that 5 and 3 tonnes of dried *Imbrasia spp.* are imported annually to France and Belgium respectively from DRC, valued at US$ 41,500 in the case of Belgium.

Inland wild fisheries are less often studied, but studies have shown that inland water systems can be particularly important for poorer people at a community and country-wide scale (DFID 2002). Inland fisheries are often more accessible than marine fisheries; using simple, low-cost technologies, not requiring regular labour inputs (so they can be fitted around a season's agricultural labour requirements) and with the division of labour less strict than for marine fisheries (where men commonly fish, and women process and trade), meaning that women and children are more likely to be involved with small-scale inland fishing (DFID 2002). However, it is widely believed that inland fisheries are greatly underreported (Revenga & Cassar 2002), particularly because the production of fish for household consumption, and the production of other aquatic organisms such as crustaceans and molluscs, are not included (FAO 2006). In addition, the characteristics of inland fisheries – often informally dispersed and with diverse types of fishing equipment and methods – mean that conventional data collection methods derived from marine fisheries are less suitable.

In Asia, inland fisheries have been ranked by resource users as the second most important NTFP (Foppes & Ketphanh 1997) and studies have shown them to be the second biggest earner of income from NTFPs (Foppes & Dechaineux 2000). Africa has a particularly high rate of per capita inland fish production amongst its developing countries, and of the global top 10 countries with the highest inland fisheries capture production per capita, seven are in Africa (in order – Uganda, Tanzania, Chad, Mali, Gabon, DRC and Zambia, FAO 2006). Although the large lakes present in Uganda, Tanzania and Chad are predominantly responsible for the high inland fish harvests in these countries, the importance of inland fisheries in Gabon suggests that it could be important in neighbouring Equatorial Guinea, but very few data are available. One study by Cogels (1997) reported that reported that 15% of men fished in certain seasons, and that this provided 42% of the income in a village situated less than 5km from a broad part of the large river Campo in Equatorial Guinea. Similarly, Cayuela Serrano *et al* (2000) show that wild fish accounted for 12% total income in a village 2km from the river Wele, with 29% of all catch sold, but don't report any income from fishing for the other two villages studied. Little else is known about inland fishing in Equatorial Guinea.

Wild plants have been shown to be important for income, as well as consumption (Delang 2006; Delang 2006), and may be particularly important for poor and marginalised households and women (Neumann & Hirsch 2000; Kaimowitz 2003; Shackleton & Shackleton 2006). There are usually fewer barriers to entry for the harvesting of plant NTFPs than for bushmeat hunting – many people already have the skills and knowledge to harvest the products, raw products can often be harvested at little or no cost (except labour), and if there is a market, minimal capital is required to begin trading. Income from plant NTFPs is often low but can vary considerably, with some producers and traders gaining income rivalling that of teachers' salaries in west and central Africa (Awono et al. 2002; Ndoye & Awono 2005) and even earning enough to raise their standard of living (Shackleton 2005). Although this may not be enough to lift households out of poverty, income from the local NTFP trade can have an equalising effect, lowering disparities between households (Fisher 2004). Some forest plants are even exported from central Africa to Europe (Mialoundama 1993). Not all studies have shown NTFPs to be important for livelihoods. Ambrose-Oji (2003) found NTFPs made up at most 6% of income in a forest migrant community in Cameroon, and that it was the wealthier households that were more likely to earn this. There is little information on the role of wild plants for livelihoods in Equatorial Guinea, beyond one study showing wild plants for sale in Bata markets (Sunderland & Obama 1998). However, of the plant NTFP species shown to be of value in the central African region, some are commonly harvested in Equatorial Guinea. These

include the African plum (*Dacryodes edulis)* for which commercial production in Cameroon alone was estimated at US$7.5 million in 1997 (Awono et al. 2002) and is the third most important fruit crop (after banana and kola). In Cameroon, Bush mango (*Irvingia gabonensis*) was estimated as worth US$80-90/year (Ayuk et al. 1999), and there is also a significant trade in Nigeria (Schreckenberg et al. 2006). Non-food wild plants such as rattan are also important for livelihoods (Bi & Kouakou 2004), including in Equatorial Guinea (Sunderland et al. 2004).

To determine dependence on forest products we must consider the contribution of wildlife to income, as well as to consumption. In this chapter, I analyse the income earned and the total value (including non-sold items) from forest products and to compare this to income and total value gained from other livelihood activities. Neither study village is specifically a 'hunter village' in that they are not at the end of a road, and are not the closest villages to the forest in the surrounding area. In addition, both are significantly larger than villages previously studied, are not specifically visited by traders (although traders do pass through these villages), and Beayop at least is relatively accessible to urban markets. Consequently, they are more likely to be representative of villages across Rio Muni than the "specialist" hunting villages previously studied. For these reasons, I would expect a lower average income from forest products, and bushmeat in particular, in both Teguete and Beayop, than that seen in previous studies. The greater diversity of livelihood strategies and trade opportunities afforded by the greater access to urban areas in Beayop means that I would expect higher incomes in Beayop than Teguete, and for wildlife to make up a lower proportion of that income.

Previous studies have shown hunting to be predominantly a male occupation (e.g. LeBreton et al. 2006), while women generally dominate the harvest of wild plant foods (Ford Foundation 1998; Ndoye et al. 1998), although this is not always the case. Studies have shown that households may vary significantly in the income gained from wild foods according to household wealth. In Sulawesi, Indonesia, income from wildlife (mainly plants and invertebrates) decreased with wealth (Pilgrim et al. 2007). De Merode *et al* (2004) found that income from bushmeat and fish increased with wealth, but that income from wild plants decreased with wealth in rural households in Democratic Republic of Congo. A similar pattern was seen in Gabon, where income from bushmeat increased with wealth, as well as with 'remoteness' of a community (Starkey 2004), although income from hunting as a proportion of total income was highest for medium wealth households. This has been attributed in part to the fact that wealthier households within these poor rural areas are often more likely to have healthy, working aged men, and so are more likely to hunt. Given that the poorest households in this study are likely to lack productive adults (Chapter 2), I would expect

to see a similar result, with medium households gaining more income from bushmeat, at least in Teguete.

4.3 Methods

Throughout this chapter, I distinguish between the value of production and the income from each livelihood activity. I take value to be the monetary equivalent of all goods produced or harvested (regardless of whether they were for sale or consumption) as well as the income or value of any paid work (i.e. including the value of goods paid in-kind) and the net income from any goods traded. I take income to be only the cash income from these sources, calculated from what people have actually sold or earned.

4.3.1 Data Collection

Data were collected on all livelihood activities, including goods produced or harvested, money or goods earned, and goods traded (including how they were obtained and at what price) in Beayop and Teguete during regular household interviews with all household members of 18 or over. For detailed methods and description of the study sites, see Chapter 2.

For forest and agricultural activities, for each sample day the amount (in local units) and value of all goods produced (including those brought into the house, or consumed or sold before reaching the house), were recorded as reported by the interviewee. If the respondent could not put a monetary value on the item, the average value of that item and quantity in that village was used, giving a monetary value for all goods. Goods that were never sold in either village were not included in the analyses, and this included water, firewood and the leaves used to wrap cassava. The value of any forest or agricultural goods actually sold on the sample day (regardless of whether they were collected on that day) was recorded as actual income. For the two main agricultural harvests, peanut and calabaza[6], the entire crop was often harvested in a matter of days, and so for these products all households and field owners were questioned at the end of each harvest, and again at the end of the survey, as to the total number of sacks harvested and sold from each field of these products. Where possible (and once the crop had had sufficient time to dry), the sacks were weighed and the weights recorded. The total value of the harvest was estimated using the average price per sack for that household, or where none had been sold, for that village. The mean value per day for peanuts and calabaza was taken as the total value of that season's harvest divided by the number of days of the

[6] Calabaza is the local Spanish name for Cucurbitaceae oilseeds (also known as Egusi)

season which it was harvested. Similarly, the mean income per day was taken as the total income divided by the number of days of the season in which it was sold. Any peanuts or calabaza recorded in the daily surveys were not included in the calculations, to avoid double counting.

Hunter offtake surveys were done in both villages for the final 7 months of the survey. Each weekend, from Saturday afternoon to Sunday evening when all hunters had usually returned to the village, I and/or a trained research assistant visited all hunters in the village, and asked questions on all hunting trips for that week. Data were collected on all hunting trips and carcasses captured for that week, including on which days they had been hunting, the time leaving and returning to the village, what methods were used on the trip (i.e. trapping, gun, dogs, or a combination of these), and details of any animals caught, what they did with it (i.e. consumed at home, consumed in the forest, sold, gave to someone, abandoned in the forest), and if sold, how much for and who to.

For traded goods, the actual income was recorded as being the price it was sold for, minus the production costs and the initial cost of the item where appropriate. In some cases it was necessary to estimate the production costs, and where necessary, a case study was done of the activity in question. For example, this included a calculation of the cost of cooking doughnuts, where women in each village were observed cooking the doughnuts, with the amount and cost of each ingredient observed, and the number of doughnuts produced counted, to give an estimated production cost per doughnut, from which net income could be calculated. In the case of village shops and bars, on survey days shop owners were asked how much total money they had taken that day. Every two months, an inventory of each village shop was made, to record the prices of all goods for sale, and count the amount of stock. Where possible, when bars were restocked, we recorded the amounts of each good bought, where it was bought from, how much it cost and the estimated travel costs. This allowed calculation of the mean mark-up on each product for each bar. The weighted average mark-up for each village shop was calculated using the proportion of goods bought to restock each bar. Thus, the average mark-up for each bar was calculated, permitting estimation of the net profit given the total money taken for each survey day.

Respondents with jobs and salaries were initially asked what their monthly salary was, and after that were only asked in the regular questionnaire if they had received any bonuses in the previous two weeks. The salary amounts were verified at the end of the study, and any changes made accordingly. The one respondent who was uncomfortable with answering this question was instead asked to point to a category on a piece of paper, and the middle value of this range was taken as an

estimate of his income. Details of any casual work were recorded; including type of work, amount earned, and number of days worked where possible.

To ascertain the differences in livelihood activities between individuals and households, data were also collected and calculated on household characteristics including household (HH) income, HH fixed wealth, wealth rank, HH size, number of productive adults (age 18-65 and not chronically ill), number of productive females, the presence/absence of productive males, proportion of productive adults (to whole HH size), proportion of productive females, gender of the household head and education level of the household head. In addition, data on individual age, sex and education levels were collected, and village and season recorded. See Chapter 2 for methods and details.

4.3.2 Data Analysis

Summary of different income sources

For each livelihood activity, the characteristics of people engaging in that activity (i.e. recorded as producing anything from that activity) were detailed, including the number of males and females in each village, the age range, average age, average value/day, average income/day, average value/year, range of income, average hours/day, average days/week, assets required (e.g. equipment, land, skills, etc.) and the cost of those assets. For all livelihood activities except hunting, these data were taken from the regular household surveys. Where appropriate, the major value and income sources within each category were listed. For hunting, these data were taken from hunter surveys, as these had a greater number of sample days. Where people engaged in more than one livelihood activity, they were included in the analysis for all activities in which they participated. This excluded people who were participating in an activity that they did not usually do (i.e. children helping in their parents' fields were not included). For trade, where one person bought, produced or processed a good (e.g. harvested and then cooked bars of cassava) but another person physically sold it, this income was attributed to the owner of the good – the person who kept the money. This commonly applied to older children selling goods at the side of the road that had been grown or processed by adult family members. In these cases, the interviewee was asked both who physically sold the good, and who earned the money.

The determinants of income and potential income from different sources

Livelihood activities were split into four categories:

- **Forest:** Any activity harvesting goods non-cultivated products from the forest, farm-fallow or agricultural land. This was further broken down into the harvesting of animal, fish and

plant products and includes goods that require further processing in the village (i.e. the production of artisanal products made from rattan, or palm oil harvested from the forest) or in the forest (i.e. the production of palm wine).

- **Agriculture:** Activities associated with the production of all agricultural goods and livestock. Again, this includes goods requiring processing in the village such as the production of bars of cassava, sales of banana doughnuts, and production of palm oil (if that oil has been harvested from the fields).
- **Trade:** Any activity involving the buying and subsequent selling of goods. This was further divided into goods that were sold with no processing/value added (i.e. the majority of bar products), and goods that were resold after processing (e.g. doughnuts and bread made in the village with purchased wheat flour, and meat and fish that had been bought from hunters and fishers in the village and cooked to sell in single portions along the side of the road).
- **Paid:** Any activity where the person was paid for their work by another person. This included salaried work and casual work such as carpentry and payments for clearing fields).

As virtually no domestic animals were recorded as sold during the entire survey, these were not included in the analyses (except for calculating total household income). For products that were both cultivated and harvested from the forest (e.g. African plums, oil palms, avocados) the produce was counted as agricultural if the tree was 'owned' by a particular household or growing in a field. Goods were counted as forest offtake if grown in the forest.

The average daily value and daily income per person per season for each livelihood activity type was calculated for all people over 18 by taking the average value and income from all sample days that a person had been interviewed within each season.

Factors affecting who engages in each type of livelihood activity

For each person in each season, whether or not they had harvested 'forest' products (i.e. wild products) was recorded as a binomial variable. This was used to assess the factors affecting who in each community engaged in 'forest' category livelihood activities according to individual and household characteristics, village and season (see list above) using a generalised linear mixed model (GLMM) using the lme4 library (Bates & Sarkar 2007):

- Whether or not a person produced 'forest' products ~ Village + HH Income + Season + Sex + (1|Village/HH/Individual), offset = AME) [7]

Individual nested within household nested within village were specified as random effects. Explanatory variables were transformed to give normal distributions where appropriate. Analyses were done in the same way to assess the factors affecting who gains income from forest products, and this was repeated for each category of livelihood activity (forest, agriculture, trade and paid activities) using the following dependent variables:

- Whether or not a person gained income from 'forest' products
- Whether or not a person produced 'agricultural' products
- Whether or not a person gained income from 'agricultural'
- Whether or not a person gained income from 'trade'
- Whether or not a person gained income from 'paid' work

All people who traded or had paid worked gained monetary income, so value produced was the same as income:

Further analyses were done in the same way to assess the factors affecting wither or not individuals harvested different types of forest[8] products (animal, fish and plant) using the following dependent variables:

- Whether or not a person produced 'forest animal' products
- Whether or not a person produced 'forest fish' products
- Whether or not a person produced 'forest plant' products
- Whether or not a person gained income from 'forest animal' products
- Whether or not a person gained income from 'forest fish' products
- Whether or not a person gained income from 'forest plant' products

Factors affecting amount of value and income gained for each type of livelihood activity among resource users

To assess the variations in the value of forest products produced, a further analysis was done using only data for people who had harvested forest products (i.e. the resource users or 'producers'). The

[7] For simplicity, not all explanatory variables are shown in these equations. For a full list, see text and section 2.3.1.

[8] As specified above, 'forest' products refers to all non-cultivated products harvested from the forest, farm-fallow or agricultural land.

log of the average daily value gained from forest products per person per season was analysed using a linear mixed model (LMM) in the lme4 library (Bates & Sarkar 2007) to assess variations in the value of forest products harvested, with explanatory variables as above. Again, individual nested within household within village were specified as random effects and explanatory variables transformed where necessary:

- Value of 'forest' products harvested ~ Village + HH Income + Season + Sex + (1|Village/HH/Individual)) [9]

The analyses were repeated in the same way for income from forest products, for each type of livelihood activity, and for individual forest products using the following dependent variables:

- Income from 'forest' products
- Value of 'agricultural' products harvested
- Income from 'agricultural' products
- Income from 'trade'
- Income from 'paid' work
- Value of 'forest animal' products harvested
- Value of 'forest fish' products harvested
- Value of 'forest plant' products harvested
- Income from 'forest animal' products
- Income from 'forest fish' products
- Income from 'forest plant' products

It was not possible to analyse the amount of income earned by all people for an activity, as for any given activity a large number of people would have gained no income or value, creating many 'true-zeros' in the data set (Martin et al. 2005). This

All data were analysed in R, version 2.6.2 (R Development Core Team 2007). Models were simplified to obtain the minimum adequate model by fitting the saturated model and then comparing models with progressively simplified fixed effects using change in deviance tests. Significance was taken as $p<0.05$.

[9] For simplicity, not all explanatory variables are shown in this equations. For a full list, see text and section 2.3.1.

4.4 Results

4.4.1 General characteristics of livelihoods

Agriculture

Virtually all households maintained at least one field a year of mixed crops (see Table 4.1 for all details). Fields are planted with peanuts or calabaza and then intercropped with staples such as cassava, plantains, bananas and sugar cane, with the proportions of each crop varying between field, household and village. Also cultivated are (in no particular order): leafy greens, maize, onion, tomatoes, yam, cocoyam, wild peppers and sweet potatoes. Many households also have patches of cultivated land near the house, where papayas, some leafy greens, bread fruit, chilli peppers and coconut may be grown. African plums (*Dacryodes edulis*) and palm fruits were also harvested, and this was counted as agricultural produce where the trees were owned by a particular household. This commonly occurred for trees growing close to the village (particularly for African plums) or trees growing within households' fields (particularly for oil palms, where in land being cleared for planting, the tree would be left to remain in the field).

With the exception of two men in Teguete, both of whom were over 60 and lived by themselves, no men had mixed crop fields or grew these dietary staples. Instead, they usually helped clear new fields, leaving women to cultivate the land for the rest of the year. Some men did help out in their wives' or mother's fields, particularly during times of heavy work, or if the female in question was heavily pregnant or had a small child. However, this was very infrequent, and more often it was female relatives or friends who would offer support to women temporarily unable to cultivate their fields. Where men had fields, they were generally semi-permanent fields including trees such as mangoes, oranges, avocados, African plums or oil palms, with established pineapple plants growing in between, and consequently did not require as much labour (and certainly not planting or clearing).

Table 4.1 General characteristics of agriculture

	Beayop		Teguete	
	Female	*Male*	*Female*	*Male*
Field owner (no. people)	74	2	86	3
Field owner, age range	20 - 80	46 – 65	19 – 82	61 – 92
Field owner, average age	44	56	53	69
Average value/day (cfa)	704	315	356	185
Average income/day (cfa)	805	77	354	117
Average value/year (field owners only) (cfa)	109,925	35,000	60,697	21,667
Average income/year (field owners) (cfa)	21,771	2,500	11,705	9,167
Labour required:				
Physical intensity of work	Clearing fields is particularly labour-intensive, and usually done by men. However, despite the fact that some women continue to have fields into their 70s and even 80s, all the field work requires physical strength. This is particularly true given that all work is done by hand with a machete (i.e. no mechanisation at all) and because all harvests are carried by basket whose weight is support on the forehead (via a strap) and the back.			
Assets required:				
Property/land	Land (see Box 4.1)			
Equipment: Machete File (to sharpen machete)	2500 cfa (replaced every 6 months) 1000 cfa (replaced every 3 months)			
Other start-up costs Clearing land:	Seeds or tubers to plant (these are usually saved from previous fields to plant in new fields. They are rarely bought, and most people borrow or receive them as gifts). Male family members often clear the land for burning for a new field using an axe or chain saw (if available), but more commonly using a machete. If a woman doesn't have anyone she can call on to do this, she may pay someone instead (12,000 – 25,000cfa per field).			
Social resources	For land rights As buffer during illness/pregnancy To help with field clearing			
Natural resources	Variation in soil quality Differences in climate and the quantity of crop pests (greater in Teguete) meant that Calabaza was grown on a greater scale in Teguete, and sugar cane on a greater scale in Beayop. Peanuts planted in both.			
Skills/knowledge education	Without ever being formally taught, most women and some men learn agricultural skills, usually from older female (often mothers-in-law) relatives as they help out in the fields as adolescents, or when first married.			
Seasonality:	Peanuts are mainly harvested in the 1st and 3rd seasons. Calabaza is harvested in the 4th season.			
Barriers to entry:	A large amount of time needed, physically demanding, and either money or social capital necessary to start-up (to get help clearing fields, and 'borrow' or buy seeds and tubers to plant).			
Crops giving greatest total value (in order)	Peanuts, cassava, sugar cane (made into Malamba), plantain, calabaza		Cassava, peanuts, calabaza, banana, pineapple	

Although a fair amount of livestock was recorded as owned (Table 4.2), only two animals (a pig in Beayop and a goat in Teguete) were recorded as sold in the entire year. Consumption of livestock is generally restricted to events such as fiestas, weddings and for witch doctor ceremonies (when a goat or chicken may be required), and animals are usually taken from the household's own stocks or received as gifts for these events, rather than being bought.

Table 4.2. Total number of livestock animals owned (adult animals only).
It is forbidden (by the village council) to own pigs in Teguete, due to the damage to crops. For 83 households in Beayop, and 80 in Teguete.

	Beayop	Teguete
Pigs	44	0
Goats	50	129
Chickens	540	431
Ducks	52	62
Sheep	0	25

Forest livelihoods

Most hunting was done by wire traps (84% and 86% in Beayop and Teguete respectively) or guns (Table 4.3 and

Table 4.4). In addition, one male in each village went hunting with dogs, but neither caught anything, and both abandoned it as being unprofitable. Of the women with traps, without exception all were traps around their fields and were checked most days when working in those fields. All of these had initially been set by a male family member, but (especially if that male was no longer in the village) the female responsible would re-set the traps when necessary, and consume or sell any animals that were caught.

Fishing was not done as a main livelihood activity by any households, and was mainly a supplementary activity. Hunters sleeping in the forest commonly took a line and hooks with them, and would fish for food to consume while in the forest. Some female-headed households and older households had a fish trap that they would check every morning and these mainly caught small freshwater crabs and small fish. Young boys sometimes went fishing with a hook and line (although were often unsuccessful) and in the long dry season (the 3rd season), women sometimes collected a local plant ('esia') and used it to poison fish in certain portions of the river, while the water level was low. Only in Beayop did two men commonly fish and sell their catch, but even this was secondary to trading in terms of income and value produced.

The most important wild edible plants in terms of income were (in order): bush mango, palm oil, palm wine, avocado, forest fruit "nsuin" and African plum. These were mainly collected by women, with the exception of palm wine which was collected by men. Men commonly harvested non-edible forest plants, and the most important of these were (in order): rattan, palm fronds (for making into roofs), bamboo, other larger vines (for making baskets) and smaller vines (for tying rattan and larger vines). In both villages, rattan and other vines were mainly used by older men to make bowls, baskets and fish traps, that were time consuming to make and sold for a small amounts of money (i.e. the average bowl cost 300 cfa, and the average basket 2000 cfa). Bamboo was used to make cheap beds such as those in every kitchen that were often the only seating available, and were usually made by members of the household as a house was constructed. In Beayop only, two brothers regularly harvested rattan, and used this to make furniture such as chairs and coffee tables that they sold in Bata. However, they reported having to walk further into the forest to harvest the rattan than had previously been necessary, and were not keen on others in the village following suit.

Table 4.3. General characteristics of gun-hunting.

	Beayop		Teguete	
	Female	*Male*	*Female*	*Male*

People	No. gun-hunters (including those borrowing other peoples guns)	0	8 [10]	0	14
	Age range (all people gun-hunting)	NA	20 – 55	NA	19 – 75
	Average age (all people gun-hunting)	NA	34	NA	35
Profitability	Average value/trip (cfa)	NA	4660	NA	6417
	Range value/trip (cfa)	NA	0 – 9000	NA	0 – 62667
	Average income/trip (cfa)	NA	4100	NA	4596
	Range income/trip (cfa)	NA	0 - 9000	NA	0 – 47000
	Average value/trip, gun & traps (cfa) [11]	NA	NA	NA	4440
	Range value/trip, gun & traps (cfa) [3]	NA	NA	NA	0 – 19500
	Average income/trip, gun & traps (cfa) [3]	NA	NA	NA	3031
	Range income/trip, gun & traps (cfa) [3]	NA	NA	NA	0 – 19500
	Average annual income, gun (cfa)	NA	490,360	NA	360,878
Labour required	Physical intensity of work	Medium			
	Average hours per day	NA	4.0	NA	7.57
	Average days/week	NA	2.3	NA	1.51
	Night hunting (No. people)	0	2	0	1 [12]
	Night hunting (av. No hours)	NA	8.9	NA	5
Costs	*Equipment* Gun: No. of owners No. households with a gun Average cost per gun (cfa)	 5 4 156,666		 8 4 148,000	
	Other running costs Average cost per cartridge (cfa) Torch and batteries (night-hunting only) Gun hire	600 Some hunters borrow guns from others in the village, and usually pay them back with a portion of their catch rather than money			
Resources	Social resources	No formal permission required, but see Box 4.1.			
	Natural resources	Forest and wildlife			

[10] Three 12 year old boys also took out a gun one time to practice, but they didn't catch anything, and are not included in these calculations

[11] In Teguete, some hunters took their guns with them when they checked their traps, and the average value and income for these combined trips are shown here.

[12] The one hunter in Teguete that went night hunting, went only once, whereas the two in Beayop were regular night hunters

	Skills/knowledge education	It does take skill and practice to be a good shot, and (particularly given the cost of guns and cartridges), this is something that many people don't have. Skills tend to be passed on within males of the same family, and for that reason the guns and gun-hunters are relatively concentrated within a few households in each village.
	Barriers to entry:	Limited access to skills and high start up costs (gun)

Table 4.4. General characteristics of trapping.

		Beayop		Teguete	
		Female	*Male*	*Female*	*Male*
People	No. people (having traps)	4	37	2	83
	Age range	18 – 50	11 – 90	40 – 57	11 – 92
	Average age	35	39	49	42
Profitability	Average value/trip (cfa)	667	1445	48	1477
	Range value/trip (cfa)	0 - 5500	0 – 18000	0 - 921	0 – 25323
	Average income/trip (cfa)	304	782	7	696
	Range income/trip (cfa)	0 - 5500	0 – 18000	0 - 400	0 – 25000
	Average annual income (cfa)	37,939	109,793	1,929	72,384
Labour	Physical intensity of work	Medium			
	Average hours per day	0.7	5.2	0.8	7.4
	Average days/week	2.4	2.7	5.3	2.0
	Sleeping away from the village (no. people)	0	0	0	13
	Sleeping away from the village (av. no. nights)	NA	NA	NA	2.9
Costs	Equipment Wire (average cost, cfa)	200/m		275/m	
	Other start-up costs	None			
	Other running costs	None			
Resources	Social resources	No formal access or permission is required, but see Box 4.1.			
	Natural resources	Forest and wildlife			
	Skills/knowledge education	It does take skill and practice to set traps successfully, but most boys learn to do this to some degree, usually from older male family members.			

Trade

In each village there were a number of small shops/bars, and these were where most trade was done. In addition, items such as cassava bars, local doughnuts, meat and fish (cooked and sold with cassava), bread and fruits were commonly sold on the side of the road.

Paid work

In Teguete, the only jobs with salaries were those of the four teachers and the one health centre worker. In Beayop, in addition to the teachers and health centre worker, a few men had paid jobs with a road building company, but the company soon moved, and the men moved with it. There was also one bar/restaurant large enough to employ someone full time. Aside from salaried jobs, the

only paid work was mainly done by the one or two carpenters in each village (sometimes employed to build people's houses), or by men paid by (often female headed) households to clear fields. Despite a national minimum wage of 90,000 cfa/month, teachers and health centre workers reported wages of 75,000 – 120,000 per month, while the one man working in the bar earned 50,000cfa/month.

Box 4.1. Access to land

Agriculture

Access to land is relatively informal, but varies between the two villages. In Beayop (a more densely populated area), land around the village is divided among the households according to historical use of particular areas. These unmarked boundaries remain even during the fields' fallow periods, and generally a household's plots of land are relatively close to their own house. As the village has expanded, existing households have moved further away from the village and cleared new patches of forest to create more land that is officially theirs. This is limited by strict boundaries between villages, so that villagers in Beayop cannot create a field in new land that 'belongs' to neighbouring villages. However, the village is bounded only on three sides, while on the fourth side there are no villages for a considerable distance, so boundaries here are less strictly upheld, if at all. In practice, virtually no mature forest has been cleared in the last decade, as almost all the land in the area surrounding the village is secondary forest, having been converted to plantations during the colonial period[13]. New families moving to the village may take over land of family members in the village, or may appeal to the village council. The village council will then discuss the matter and generally can resolve it by asking other families who have more land than they can cultivate (including fallow land) to let the new family use that land. There are very few disputes, but those arising are resolved by the village council – a group of elders (mainly men) who discuss the issue. However, the people in Beayop are aware that land can be an issue, and count themselves lucky that they still have enough. Many know friends of relatives in village closer to Ebibeyin, where there are more conflicts over land, due to a much higher population density. In Teguete, the situation is fairly similar, except that the boundaries are less well known, and neighbouring villages are far enough away that there are no official limits between villages.

Hunting

As for agriculture, there are clearer restrictions on hunting in Beayop than in Teguete, with the same village boundaries existing for hunting as for agriculture. However, these boundaries are less enforceable for hunting, and while a trapper may sabotage the traps of someone he doesn't recognise (or doesn't know who they belong to), a trapper is unlikely to chance upon many foreign traps without concerted effort. Enforcing land boundaries on gun-hunters is virtually impossible, unless the hunter enters the forest from the village (which is highly unlikely). Between households, there are virtually no limitations, although particularly close

[13] Equatorial Guinea is unusual in that land covered by forest has actually increased in the last 30 years, as land converted to plantations returned to secondary forest.

to the village hunters tend to know along which paths other people's traps are, and will avoid them to find un-trapped pathways.

Teguete is closer to uninhabited parts of the forest, and consequently there are no boundaries between villages. Men from other villages pass through the village to go trapping, and there are some pathways leading off the road some way away from the village that are commonly known to be trapped by people from particular villages. However, these are loose associations, rather than strict rules, and people say that there are no problems between villagers or households over hunting land. Between households within Teguete, very few people know where the traps of another person are, beyond a general direction, and this information is guarded quite strongly. The exception to this is that pairs or groups of three men may trap together, and they will know the whereabouts of the other group members' traps (and may check them for each other if one is ill or unavailable). Gun hunters from the village and surrounding villages are similarly not restricted in access, but the very infrequent (maybe one a year) 'leisure' gun hunters from the city have been known to be charged by the village president. Soldiers from the military post inside the village or elsewhere are not charged, and some have shot a considerable number of animals. However, these were not monitored, and varied with the individuals involved (who rotated every three months).

4.4.2 Determinants of production and income

Overall production/income

Production and income from all sources combined was higher in Beayop (Table 4.5 and Figure 4.2, Table A 6.1). In both villages, production and likelihood of income per household were lowest in season 2, while income varied differently between seasons, depending village (Table A 6.1 and Table A 6.2). In addition, male-headed households, and households with a higher proportion of productive females produced more per AME per household, and men in general produced more and earned higher incomes than women (Figure 4.2).

Community differences in production and income

Across all people, forest products combined provided over half of total livelihood production in Teguete and nearly a quarter in Beayop, including 25% and 12% from bushmeat (Table 4.5). People harvesting forest products produced more in general, and specifically more wild plants per season, and people in Teguete were significantly more likely to get income from forest products as a whole (Table 4.7 , Table 4.8), and bushmeat specifically (Table 4.9). In contrast, people in Beayop gained nearly twice the production and three times the income from agriculture across the whole village,

and this accounted for a greater proportion of production and income (Table 4.5). Amongst people that sold agricultural products, average income per day was also significantly higher in Beayop (Table 4.10). There were no significant differences in income from trade between villages (
Table **4.11**), but people in Beayop did earn substantially more from processed traded goods (Table 4.5).

With only five or six regularly employed people in each village, no analyses were done on the determinants of paid work. However, with the exception of the man working at the restaurant in Beayop, all wage earners in both villages had higher education and qualifications for their jobs, and were mainly men (one or two female teachers were employed in each village, but were nursery or infant school teachers with lower salaries). Similarly, very little fish was recorded harvested or sold in either village, and because of this no statistically significant differences in fish harvests or sales were found.

Trade contributed the greatest total amount of income in Beayop – significantly more than in Teguete. In particular, people in Beayop earned more from value-added products sold at the side of the road, while income from products with no value-added (e.g. most bar products) was only slightly less in Teguete (Figure 4.1).

Table 4.5 Summary average production values and income per person for livelihood types in both villages. Mean value produced/day for the whole village is the mean value per person of all goods from each livelihood type, for all people (including those not producing that good). Similarly for mean income/day.

Livelihood type	Mean value produced/day (cfa), whole village		Mean income/day (cfa), whole village		Percentage production, whole village		Percentage income, whole village	
	Beayop	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*	*Beayop*	*Teguete*
Agriculture	269.0	138.2	101.0	29.1	39.6%	27.7%	24.6%	15.0%
Paid Salary	91.7	42.4	91.7	42.4	13.5%	8.5%	22.4%	21.8%
Paid Casual	13.6	5.9	13.6	5.9	2.0%	1.2%	3.3%	3.1%
Trade VA	84.2	6.0	84.2	6.0	12.4%	1.2%	20.5%	3.1%
Trade VNA	63.4	37.5	63.4	37.5	9.3%	7.5%	15.5%	19.3%
Forest (all)	157.3	269.7	56.3	73.3	24.5%	57.6%	13.7%	39.4%
Forest animal	*79.3*	*126.7*	*29.1*	*65.1*	*11.7%*	*25.4%*	*7.1%*	*33.5%*
Forest fish	*37.1*	*21.8*	*15.5*	*0.2*	*5.5%*	*4.4%*	*3.8%*	*0.1%*
Forest plant	*40.9*	*121.2*	*11.7*	*7.9*	*6.0%*	*24.3%*	*2.8%*	*4.1%*

Table 4.6 Percentage of production sold (of the total value produced), and mean income per day (earners only) for livelihood types in each village.

Livelihood Type	Mean percentage of production sold, whole village		Mean income/day (cfa), earners only	
	Beayop	*Teguete*	*Beayop*	*Teguete*
Agriculture	37.53%	21.1%	943.36	358.51
Paid Salary	NA	NA	1370.31	1511.74
Paid Casual	NA	NA	580.79	235.78
Trade VA	NA	NA	1094.10	266.76
Trade VNA	NA	NA	758.18	405.67
Forest (all)	33.83%	26.6%	841.32	666.57
Forest animal	*36.72%*	*51.4%*	*725.69*	*930.04*
Forest fish	*41.75%*	*1.06%*	*1158.33*	*83.33*
Forest plant	*28.50%*	*6.54%*	*686.94*	*202.13*

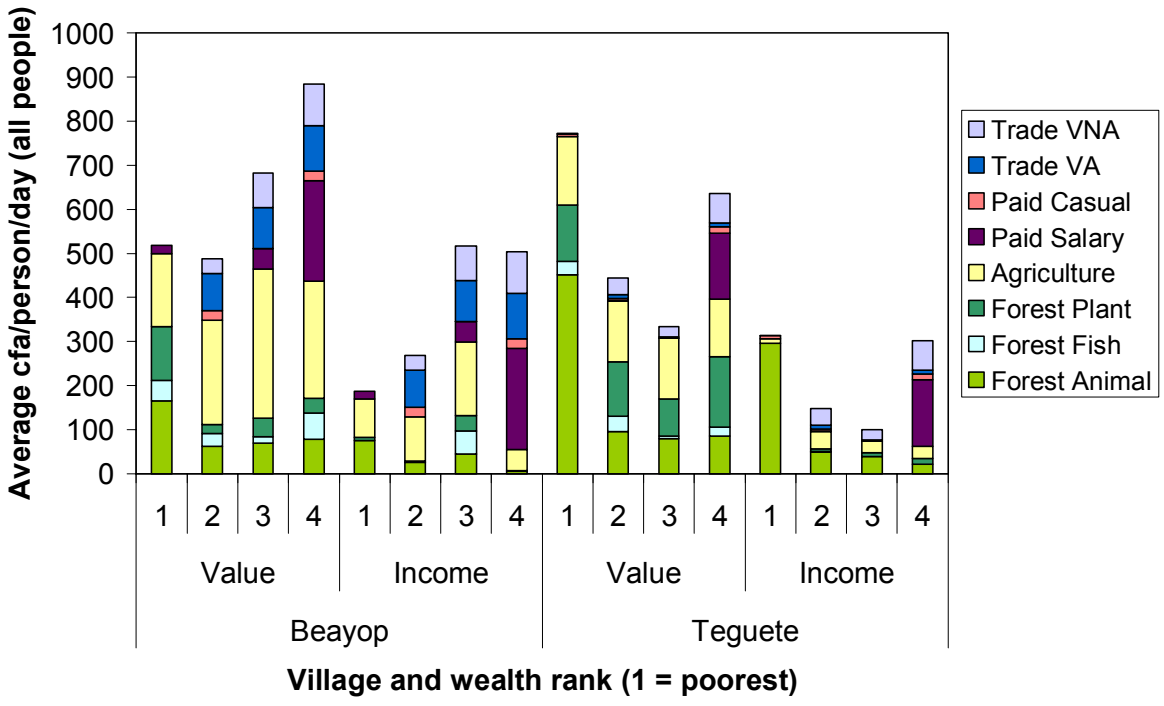
Household and individual differences in livelihoods

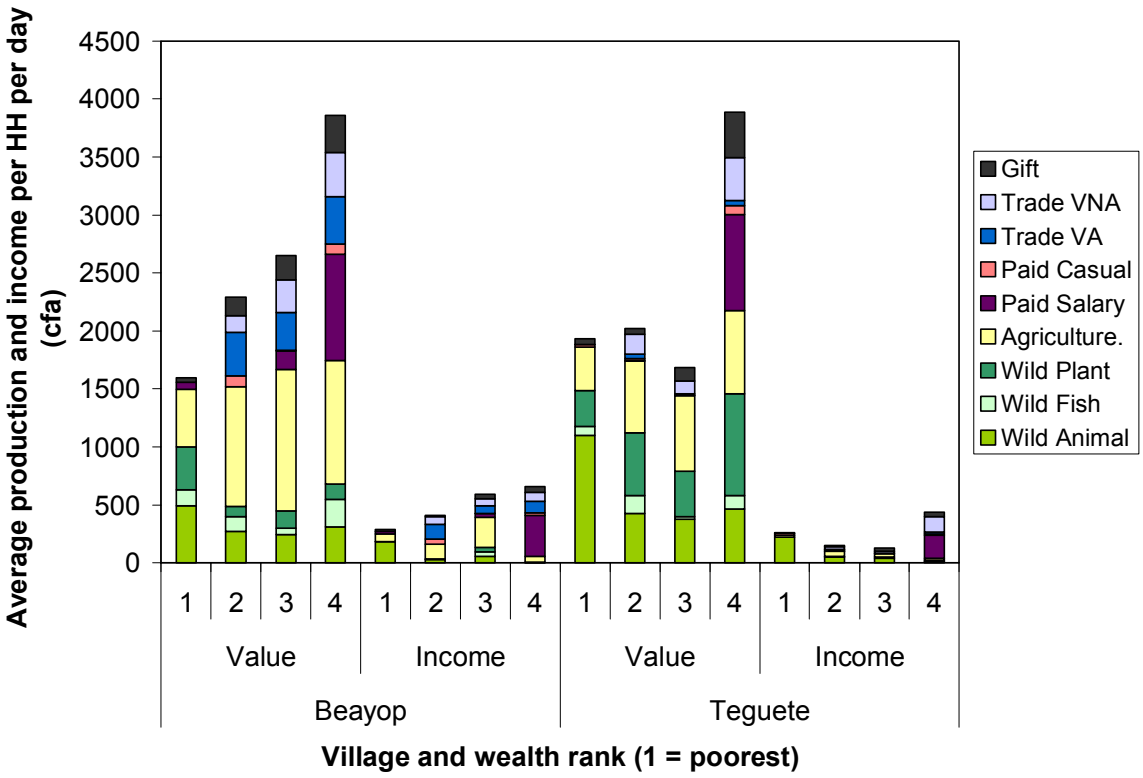
Across wealth groups as a whole, forest products provided the most value and income to the poorest wealth ranks (Figure 4.1), although it was more important to the poorest wealth rank for production in Beayop, and for income in Teguete. Within individuals harvesting forest products, those from poorer households harvested significantly more per day on average, although wealthier households harvested the second highest amounts (

Table 4.7). In contrast, among bushmeat hunters, those from wealthier households gained the highest amount and income per day (Table 4.9). People in the poorest wealth ranks were most likely to gain income from bushmeat sales, but within these ranks, wealthier people were more likely to sell bushmeat (Table 4.9).

The middle wealth ranks were significantly more likely to sell agricultural products, and in Beayop produced and sold most across the group (Figure 4.1 and Table 4.10). Wealthier households on average gained more from trade than poorer households, were more likely to trade, and wealthier traders gained significantly more income per trader (
Table **4.11**). People in households where the household head had a higher level of education were significantly more likely to trade, as were people from female-headed households (Table 4.11). People with salaries were overwhelmingly in wealthier households (Figure 4.1).

Figure 4.1 The value and income from all livelihood sources, for wealth ranks and villages.





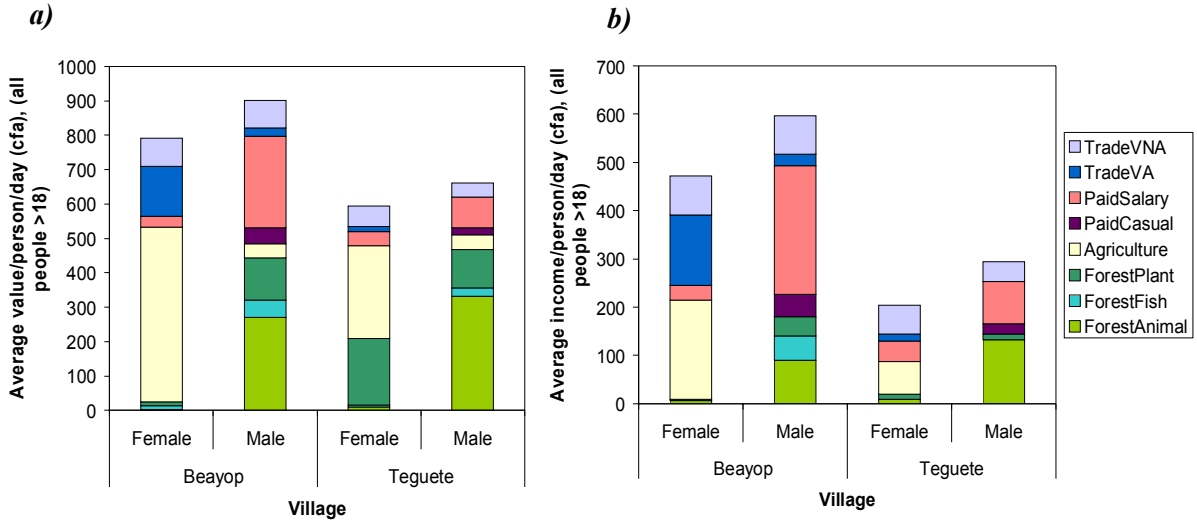
In both villages, men produced and sold more forest products as a whole (Figure 4.2) and the majority of this was bushmeat. Men were significantly more likely to hunt and sell bushmeat than women, and produced more when they did (Table 4.8 and Table 4.9). However, women harvested all forest products significantly more often than men and in Teguete produced more when they did (

Table 4.7). On average, women produced more wild plants than men in Teguete, but the opposite was true in Beayop (Figure 4.2). Of the small amounts of wild fish that were harvested and sold, most was by men.

Women harvested and sold the vast majority of agricultural products (Figure 4.2), and were more likely to harvest and sell them, and produced and sold higher quantities when they did (Table 4.10). Women in male-headed households were also more likely to produce agricultural goods. On average, women in Beayop gained more from trade than men, largely due to increased trade of processed goods (Figure 4.2), and younger traders in both villages earned significantly more from trade than did older traders (Table 4.11). but the same was not true in Teguete. In both villages, women gained far less on average from paid work (Figure 4.2).

Older respondents in both villages were still comparatively economically active. People between the ages of 50 – 65 were most likely to produce and sell agricultural products, but women over 65 years old were second most likely to farm, and agricultural harvest among farmers increased with age (Table 4.10). Similarly, 50 – 65 year olds were most likely to harvest forest products and older people more likely to harvest forest plants (Table 4.8). However, amongst those harvesting forest products, younger people produced and earned more (Table 4.7).

Figure 4.2 Graph showing average a) value and b) income per person per day from all livelihoods. TradeVNA = Trade Value Not Added (i.e. goods were not processed); TradeVA = Trade Value Added (i.e. goods were processed).



Seasonal differences in livelihoods

In Teguete, individuals earned and produced the least overall in the 2nd and 3rd seasons (Figure 4.3), while in Beayop individuals produced least in the 2nd and 3rd seasons, but earned least in the 2nd and 4th seasons. Total production from forests was highest in Teguete in the 1st season (Figure 4.3), and this was largely due to an increased frequency and amounts of wild plants harvested in Teguete in this season (Table 4.8). The very low income from sales of wild plants in Teguete meant that the same patterns were not so apparent for income from forests, although forest income was also highest in the 1st season. There were less seasonal changes in forest production and income in Beayop, but generally both were higher in the 2nd and 3rd seasons. Total production from agriculture was lowest in the 2nd and 3rd seasons (Figure 4.3), and the likelihood of agricultural production and income, and amounts produced by farmers were significantly lower in the 2nd season for both villages (Table 4.10).

Figure 4.3. Value and income from all livelihoods for village and seasons

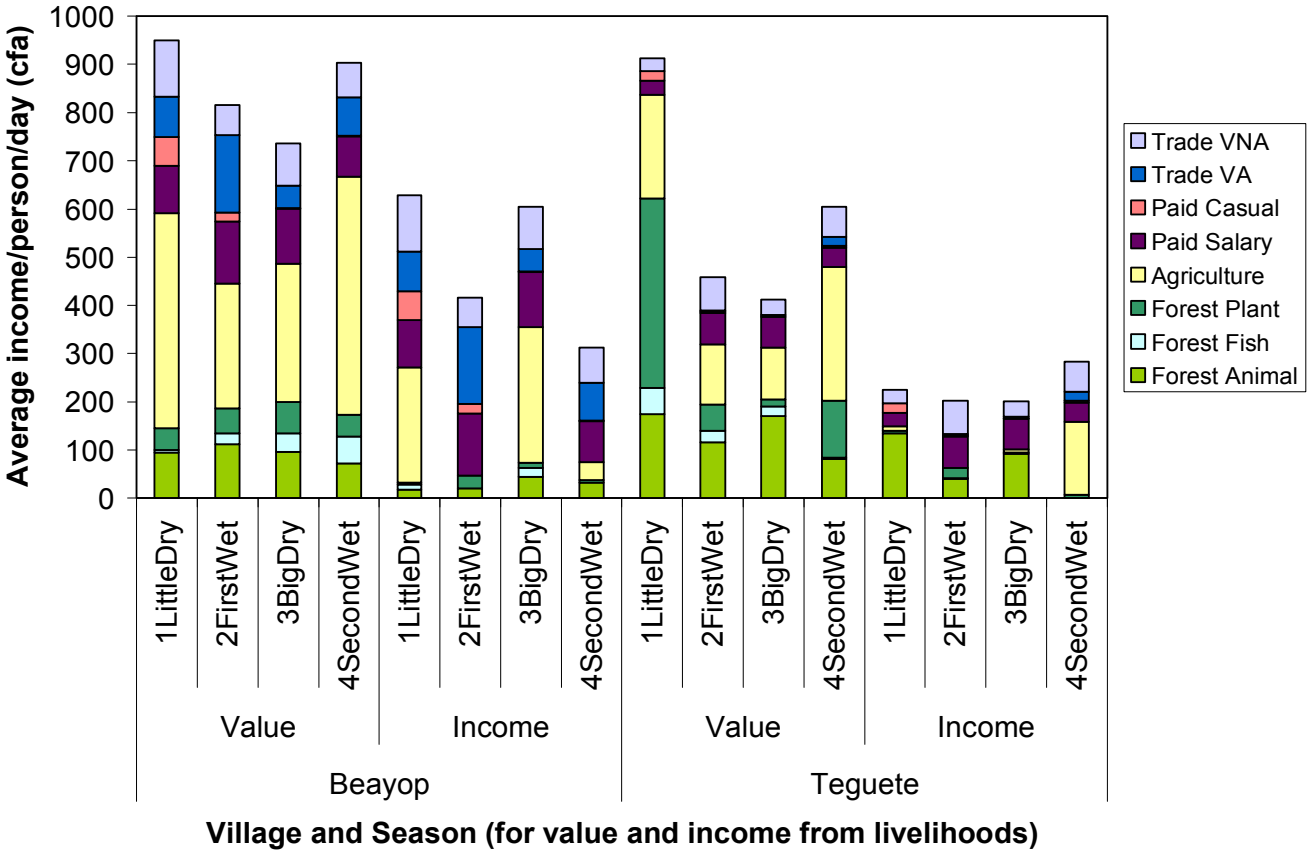


Table 4.7. Results from GLMMs on the determinants of value and income from all forest products combined. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, the parameter estimates relative to the first level (i.e. season 1, wealth rank 1, etc.) are also given. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. The relationship between age and the likelihood of forest production was not linear, so age was analysed as a categorical variable. For all other analyses, the relationship was linear or not significant. See Table A 6.1, Table A 6.4 , Table A 6.5, Table A 6.6 and for full results.

Variable		All forest production, likelihood of production	All forest products, amount of production	All forest products, likelihood of sale	All forest products, amount of income
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	++ - + +	++ + - - -	+ - ++ -	
Village	Beayop Teguete		 +	 +	
HH Wealth rank	1 2 3 4		++ - - - +		
HH Income					++
Sex	Female Male	+++	 +++	 +++	
Age	18 – 30 30 – 50 50 – 65 65+	- ++ ++ +	- - *(continuous)*		- - *(continuous)*
HH Income: Sex	Income: Female Income: Male	 +			
Village: Sex	Teguete: Female Teguete: Male		+++		

Table 4.8. Results from GLMMs showing the likelihood of harvest and the value of those harvests for forest products.
Forest products are divided into animals (bushmeat), fish and wild plants. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, the parameter estimates relative to the first level are also given. Where there is a significant interaction between variables, the parameter estimate for both variables combined is shown. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 6.8, Table A 6.9, Table A 6.10, Table A 6.11 and Table A 6.12 for full results.

Variable	Parameter levels	Animal: likelihood of harvest	Animal: amount harvest	Fish: likelihood of harvest	Plant: likelihood of harvest		Plant: amount harvest	
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	+ - ++ - -	++ ++ - +	*No significant differences*	Beay. - - - ++ +	Teg. +++ - - - - - +	Beay. - ++ - - +	Teg. +++ ++ - ++
Village	Beayop Teguete						++	
HH Income			+					
Sex	Female Male	+++	++				+++	
Age					+++			

Table 4.9. Results from GLMMs showing the likelihood of income and the amount of income for forest products. Forest products are divided into animals (bushmeat), fish and wild plants.
Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, the parameter estimates relative to the first level are also given. Where there is a significant interaction between variables, the parameter estimate for both variables combined is shown. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 6.13, Table A 6.14, and Table A 6.15 for full results.

Variable	Parameter levels	Animal: likelihood of income	Animal: amount of income	Fish: likelihood of income	Plant: likelihood of income
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	+ - ++ - -		*Not analysed (n < 20 selling)*	*No significant differences*
Village	Beayop Teguete	+			
HH Income		+	+		
HH Wealth rank	1 2 3 4	++ + - - -			
Sex	Female Male	+++			

Table 4.10. Results from GLMMs showing determinants of value and income from agricultural harvest. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, the parameter estimates relative to the first level are also given. Where there is a significant interaction between variables, the parameter estimate for both variables combined is shown. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 6.16, Table A 6.17, Table A 6.18 and Table A 6.19 for details.

Variable	Level	Likelihood of production	Amount of harvest		Likelihood of income		Amount of income	
Season			Beay.	Teg.	Beay.	Teg.	Beay.	Teg.
	1 Small Dry	+	+	+	+	-	+++	- -
	2 First Wet	- -	-	- -	- - -	- - -	++	- - -
	3 Big Dry	++	++	-	+++	- - -	+	- - -
	4 Second Wet	++	+	++	- -	++	-	-
Village	Beayop Teguete						+	
Wealth Rank	1 2 3 4				- + ++ - -			
HH head sex	Female Male	+						
Age	18-30 30-50 50-65 65+	- + ++ +	+++ *(continuous)*		- - ++ ++ +			
Sex	Female Male	+++	+++		+++		+	

Table 4.11. Results from GLMMs showing determinants of likelihood and amount of income from trade. Significance and direction of trends are indicated by symbols: 1 symbol = $p < 0.05$; 2 symbols = $p < 0.01$; 3 symbols = $p < 0.001$. For significant multilevel categorical variables, the parameter estimates relative to the first level are also given. A blank cell indicates no significant relationship. Explanatory variables that were not significant for any of the tested parameters were not included in the table. See Table A 6.20 and Table A 6.21 for details.

Variable	Level	Likelihood of trade	Amount income from trade
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet		+ ++ - +
HH income		+	+++
HH head education	None Primary Secondary Higher	- - - + ++	
HH head sex	Female Male	+	
Age			-

4.5 Discussion

Forest products contribute a significant value and income to many people in both villages. Between the two communities, as expected and reflecting differences in other studies (e.g. Starkey 2004), people in the more remote Teguete earned less in total, and more from forest livelihoods, of which income from bushmeat was the most important. The greater accessibility to markets and traders mean that producers and village traders in Beayop can command higher prices than in Teguete, and have more opportunities to sell processed goods, generating higher incomes from trade and agriculture. Greater prices and sales opportunities for agricultural goods in Beayop may also drive the higher agricultural production seen in that village.

Despite the higher total bushmeat hunting levels, hunter offtake per week, and access to forest resources in Teguete, the higher prices for bushmeat and access to traders in Beayop mean that both trappers and gun-hunters earned higher average annual incomes in Beayop. This is to be expected – in a village with higher average incomes, and more access to alternative incomes, the income from hunting should be higher to make it an economically attractive activity. The data do reflect that these villages are not specifically hunter villages, and the average annual incomes from hunting (gun-hunters and trappers in both villages (US$510 in Beayop and $440 in Teguete) are far less than those reported by Kümpel (2006) in a hunter village (Sendje) two years earlier, where hunters earned a mean annual income of $1019 (my currency conversion using 2008 exchange rates). Given the higher percentage of people hunting in Sendje, the total contribution of hunting income to villages shows an even greater gap (~$700/person/year in Sendje for all people in the village, compared to $315 in Beayop and $482 in Teguete). These differences must also be due to the low transport costs to Bata from Sendje. All these wages are far below the Equato-Guinean annual minimum wage of $2130/year, but in Teguete and Beayop are equivalent to the $400-700/year reported earned by trappers in Central Africa Republic, the difference being that in CAR this is similar to the minimum wage (Noss 1998). Income from gun hunting was significantly higher than that from trapping, and this is likely to be due to higher value species being killed, preferred species being targeted and carcasses less likely to be rotten (see chapter 6). Other studies have found guns to be the hunter method of choice for hunters selling a large proportion of their catch (Dethier 1995; Auzel & Wilkie 2000).

Average annual wages earned from wild fish and plants are much lower than this. Unsurprisingly, potential and actual income from wild fish is probably correlated to proximity of water sources in Equatorial Guinea. The regular incomes from fishing reported previously (Cogels 1997; Cayuela

Serrano et al. 2000) must be in part due to the close proximity of large rivers at these sites, something that neither Beayop of Teguete have (although Beayop has a medium sized river). The large income and trade in edible wild plants reported in other parts of west and central Africa (Ndoye et al. 1998), are not reflected in this study. The two wild fruit species most commonly reported in other countries, bush mango and African plum, are both are harvested (although not cultivated) in both villages, and both are sold in urban markets in Bata and Ebibeyin. However, extremely few are sold in the study villages, and those that are, are sold and consumed locally. This disparity reflects a general lack of entrepreneurship in the country (as reported in Kümpel 2006), possibly due to low education levels and investment power in many rural areas. This is also associated with falling agricultural production, and consequently agricultural incomes, over the last 30 years. The trade in non-edible wild plants of low value is common across men in both villages. However, without significant changes in production, these have little potential for increasing incomes substantially. The production of rattan furniture gains high incomes for the two men who produce it, but they are already reporting a visible reduction in rattan available in the forest, an observation mirrored in villages closer to Bata (Sunderland et al. 2004). The production of small artisanal items by the (particularly elderly) men in the village is vital to this group who often have no other income, but the average income earned and market for goods are both very low. However, palm wine (also usually produced by men), has more potential. There is a large demand in the village as it is the cheapest alcohol available, is widely liked, and other countries, such as DRC, have shown that traders can earn significant incomes from palm wine trade (traders earned US$166/month, above the gross national product per capita in DRC, Ndoye & Awono (2005).

In both villages, there are large differences in the production and income gained by males and females, but particularly between the income of men and women in Teguete. Women in Teguete on average earn only 56% of the average male income, despite producing 88% of livelihood value. In Beayop women earn 84% of the average male income, and produce 90% of the production value. This is chiefly due to the maintenance of a strict gender divide in the livelihood activities commonly followed, whereby females cultivate all staples for the family, while men pursue livelihoods which often have more earning potential. Paid work is also more likely to go to men, and this is probably mainly due to lower education levels for females, in part because of the cost of education beyond primary level (children have to be sent to larger urban areas to live with relatives). The exception is in the trade of processed goods, and where there is a market for these goods (such as in Beayop), women can make a reasonable profit, earning nearly half their average incomes from trade, compared to men who earn 17% of average income from trade. In comparison, women earn an

average 37% of income from trade in Teguete, and men 11%, but the absolute incomes are much lower in Teguete.

The positive relationship between household wealth and bushmeat harvest reported elsewhere (de Merode et al. 2004), is also seen in this study. Wealthier hunters gain more income per hunter from bushmeat in both villages, probably due to harvesting a higher amount of bushmeat per trip, and being more likely to sell bushmeat when they do catch it. However, averaged across all people within a wealth rank, bushmeat provides the greatest income for the poorest households. The evidence shows that this is probably made up of a large number of poor hunters harvesting small amounts of bushmeat that they are more likely to consume at home. In addition, poorer households are less likely to earn money from any other livelihood (particularly trade and paid work), so income from the forest is a greater proportion of their total income, and makes up over 90% of the income earned by the poorest households in Teguete (compared to 39% for the population as a whole) and 44% in Beayop (compared to 14%), and this is virtually all from bushmeat.

Seasonally, total production is least in the 2nd and 3rd seasons, known as the 'hungry season' and the long dry season respectively, and this is reflected in a lower income in Teguete. Much of this difference is due to a lower agricultural production in the 2nd season (when none of the major peanut or calabaza crops are harvested) and the 3rd season (when the 2nd, smaller, peanut crop is harvested), coupled with a high production of forest plants in the 1st season (when most of the forest fruit trees are in season). It is not clear if these deficits are compensated for by other livelihoods, although men may have less opportunity to pursue other livelihoods such as hunting in the 2nd season, due to the need to clear fields at this time. As with previously, results on the seasonal differences in production and income should be treated with caution as they reflect only differences occurring during the study year. Without additional data, it is difficult to say whether these are useful predictors for other years, as annual variation in seasonality could affect livelihoods.

Due to the fact that some forest products are currently never sold in either community, and were consequently not given a monetary value, this study may underestimate the value of forest products. Products not valued include firewood which is a valuable NTFP in other central Africa countries (Biloso & Lejoly 2006).

In summary, it seems clear that the forest is providing valuable services to livelihoods in both villages. Women in the rural village of Teguete gain around half of the value of all goods produced from the forest and although very little of this is sold, it is contributing greatly to household

production. For all people, poorer households gain a lower income, but of this a greater amount and a greater proportion is from forest goods, with bushmeat providing almost all income to the poorest people in Teguete and nearly half in Beayop. Given that neither village 'specialises' in hunting, and that Beayop at least is has access to urban areas and is not considered to be adjacent to any particularly wildlife-dense forests, the large income by the poorest people has large implications for the rest of Río Muni. Teguete and Beayop between them represent a reasonably large part of the spectrum of forest and market access by villages. Consequently we must assume that the poorest households in many other villages in Río Muni may also be earning 45-95% of their income from bushmeat hunting.

Chapter 5.
Evaluating dependence on wildlife for vulnerable people and at vulnerable times

5.1 Abstract

To assess dependence on forest products, as opposed to simply the use of wildlife for consumption and income, the proportion of consumption, production and income from different sources was quantified for the most vulnerable households and seasons, and compared to the rest of the community and to other seasons. In this chapter, I assess the food security of households in both study villages, by measuring the frequency of use and the severity of household coping mechanisms. Vulnerable households are identified as being the least food secure, and these are also the poorest households, with the lowest ratio of productive adults to dependents. Vulnerable households are also less livelihood secure in that they have a lower diversity of livelihoods and fewer income sources. The most vulnerable season is shown to be the second season when data from previous chapters demonstrates that consumption and income are among their lowest, and when children under five are most likely to weigh proportionally less. The poorest and least food secure households gain a significantly greater proportion of income and production from forest products than other households, but do not consume significantly different sources of food. Agricultural income is significantly lower during the lean season and although households do not show a significant difference in other livelihood activities during this season, this reduction may impact poorer households the most, both in total income and in their ability to earn money from alternative sources. Thus, this chapter provides strong evidence that the most vulnerable households are more dependent on forest products for both income and livelihoods.

5.2 Introduction

In this chapter, I move beyond the measurement of wildlife use for consumption and income as described in chapters 3 and 4, to broader indicators of food and livelihood security in order to assess the use of wildlife resources as a safety net, providing food and livelihoods to the most vulnerable households, and in the most vulnerable seasons. I assess the proportion of food, production and income provided by forest products compared to other resource types, and evaluate which resources are most important to the most insecure groups and at the most vulnerable times of year.

5.2.1 Beyond food consumption and income

As demonstrated in chapters 3 and 4, the use of wildlife resources for consumption and livelihoods is extensive in both Teguete and Beayop. However, it is through the evaluation of the use of wild foods as a safety net that we begin to assess people's dependence on wildlife products. Wildlife

resources may act as a safety net in a number of ways, including through their potential to provide food or income during times of stress.

To assess the ability of wildlife to reduce vulnerability to food shortages, we have to look beyond simply food consumption, to the role of wildlife in food security. Wild foods can contribute to food security by providing a 'back-up' supply of food when people most need it, so protecting individuals, households or communities from extreme fluctuations in consumption. This may be during a lean season (Fleuret 1979; Chambers et al. 1981), during times of stress such as famine, conflict or disease epidemics, (Vaughan 1987; de Waal 1988; Sullivan 1998; Draulans & Van Krunkelsven 2002; Jamiya et al. 2007) or during times of financial hardship – i.e. for the poorest households (Shackleton & Shackleton 2006). For example, in the Democratic Republic of Congo (DRC), consumption of wildlife increased by 75% on average during the hungry season (de Merode et al. 2004). In addition, wild food consumption can lead to a healthier diet, providing access to valuable nutrients that people may not otherwise have adequate access to, leading to a positive link between health and wild food consumption (Dounias & Colfer 2008). Others have highlighted the importance of bushmeat to regional protein supplies and predicted large decreases in availability in the future (Fa et al. 2003), or shown links with other sources of protein at a regional level, namely similarly threatened marine fish supplies (Brashares et al. 2004; Rowcliffe et al. 2005).

Similarly, as we look beyond consumption when assessing the value of wild foods to food security, we need to look beyond total income generation if we are to understand the role of forest products to sustainable livelihoods. Consequently we need to look at the potential of wild resources to provide income in times of hardship, and their contribution to diversifying income and production. A livelihood is considered 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' (Scoones 1998), and people are more likely to have a sustainable livelihood portfolio when they gain income from a range of livelihood sources. Initial results show that wildlife resources may be important in contributing to livelihood diversification and safety nets (Shackleton & Shackleton 2004), particularly for poorer groups (Vedeld et al. 2007). Rural households may turn to wildlife sales in response to agricultural shortfalls (Loibooki et al. 2002) and to complement agricultural production in the lean season or between two crops (Chardonnet et al. 1995; Crookes et al. 2007). Livelihood diversification is an important strategy in reducing an individual or households vulnerability to shocks such as crop failure, illness, job loss, or extreme climatic events; with a greater number or diversity or income sources, the chances of all income sources failing at the same

time is very low. The poorest people tend to have less diverse income sources and so are more at risk to periods of very income and unexpected income (Vedeld et al. 2007).

Some institutions have pointed to the similar values of food security and livelihoods approaches, including a recognition of the temporal nature of food security (shown in the distinctions made between chronic food insecurity and transitory food insecurity) and livelihoods (shown in the emphasis on sustainable livelihoods) and the importance of vulnerability in both approaches. Devereux *et al* (2004) have reported in detail on the usefulness of livelihoods approaches for food security monitoring and others have explicitly included livelihoods strategies as one aspect affecting food security, in a conceptual framework of the latter (Wolfe & Frongillo 2001). Consequently, a study of the dependence on wild foods should include an investigation of importance of wild foods in the (albeit overlapping) provisioning of food security and sustainable livelihoods.

Warner (1995) proposed that the degree of dependence of a community on wildlife products is due to the condition of the resource, its proximity to the community, access rights and restrictions, local and external demand, and income earning options. For a forest community, this translates to the condition of the forest and prey populations, distance to the forest, access rights (cost of permits or fines), local and larger market demand and consequently price of wild resources and alternatives (which depends a lot on the presence of traders in more isolated villages), alternative livelihoods available, and different individual, cultural and community attitudes to wildlife, attitudes to work and food preferences. The greater access to relatively less exploited forests in Teguete, coupled with the lower availability of alternative livelihoods suggests that people in Teguete are more likely to depend on wildlife than those in Beayop. In addition, although bushmeat is most commonly referred to in the context of food security and livelihoods, it is wild plants (de Merode et al. 2004) and fish (FAO 2006) that are often more important to the extreme poor or food insecure, particularly for women and children, so we might expect a greater dependence on forest plants than bushmeat.

5.2.2 Food security indices

Given the multi-faceted nature of food security, it is difficult to measure using a single metric, and a recent international symposium concluded that a suite of indicators was needed to cover different dimensions of food insecurity (IFPRI 2002; FAO/FIVIMS 2003). These methods include traditional measurements such as nutritional intake and child growth data, as well as other indicators such as identifying the presence and common use of 'household coping mechanisms' (Corbett 1988) and the similar rapid 'comparator indicator questionnaires', as well as famine vulnerability assessments.

This broadening of the suite of indices addresses the widely argued necessity for qualitative and/or more rapid measures of hunger and food security. I use elements of all these measurements except famine vulnerability assessments, which were deemed not appropriate due to the regional scale of these assessments (and so beyond the scope of this study) and due to the very low likelihood of extreme shortages of food supplies in the study site.

The measurement of food coping strategies as an indicator of food security is based on the principle that a that a simple set of questions, representing the most common coping behaviours relied on by people in the community when there is insufficient food or money to buy food, can be determined by focus groups. These coping strategies can then be ranked or weighted and the frequency that each strategy was used assessed for each household or community. The combination of the severity and frequency of use for each strategy, summed across all strategies, then results in a quantitative score that allows identification of vulnerable households, or monitoring over time (Maxwell 1996; Maxwell et al. 1999). Subsequent studies have used variations on this type of indicator, usually including questions on one or more of the following types of strategies:

- **dietary change strategies**, such as consumption of less expensive and/or less preferred foods;
- **food-seeking strategies**, including increasing in the amount of food available in the short term (e.g. by borrowing food or money, foraging for different types of food, harvesting immature crops, etc.);
- **rationing strategies**, such as eating less often or smaller amounts, to prioritise feeding of certain family members (e.g. vulnerable members such as children, 'maternal buffering'; or working members of the family), or to even pass entire days without eating;
- **household structure strategies**, such as action to decrease the number of people to be fed in the short term (e.g. by migration, or sending children to live with relatives).

Questions on all four types of strategy were combined in the Coping Strategies Index developed by the FAO (Maxwell et al. 2003) as a quick and easy tool for food security assessment, particularly in Africa. Other studies have used the measurement of coping strategies in a range of countries and situations, including in South Africa (Oldewage-Theron et al. 2006), as an assessment of food security among households with HIV/AIDS (Senefeld & Polsky 2006), Bangladesh (Frongillo et al. 2003; Park 2006), Malasia (Zalilah Mohd & Khor 2004), Sri Lanka (Senaratna 2006) and Kenya (Malleret-King 2000). Rapid comparator indicator questionnaires such as the widely used FAST system developed in the USA (Wolfe & Frongillo 2001; Hall 2004), adapted questionnaires in

Bangladesh (Coates et al. 2003; del Ninno & Dorosh 2003) and the more recently developed food access measurement (Coates et al. 2007) incorporate questions from some of these strategy groups, namely dietary change and rationing strategies, with additional questions on hunger and perceptions of vulnerability and anxiety. Other studies have found dietary diversity a useful indicator of micronutrient deficiencies, particularly in vulnerable groups such as women of a reproductive age (Arimond et al. 2008). The assessment of short and long-term accumulation strategies, using similar methodologies, has been used to provide additional information in some studies (Malleret-King 2000; Senaratna 2006).

5.2.3 Anthropometric measures

In this chapter, to identify the most vulnerable season, I use infant (under-fives) anthropometric data collected over five years in Teguete. The use of child nutritional indicators such as weight, height and age ratios is one of a suite of traditional measures often used to measure food security (Shetty 2002). Low weights and heights are often a sign of malnutrition, with wasting (thinness or a low weight-for-height) being particularly associated with acute hunger, while stunting (shortness or a low height-for-age) is commonly associated with chronic hunger. Being underweight (low weight-for-age) can be due to wasting or stunting and is a reflection of general malnutrition.

The use of child nutritional indicators less useful as a food security measure at the individual level because low weight or malnutrition can be due to a number of reasons, particularly illness and poor health-care practices, as well as poor food consumption. Indeed, health, wealth and food consumption all influence, and are influenced by, each other. Poor families are less likely to be able to afford health care and food, and so are more likely to become ill. In turn, sick adults are less able to work and so provide food or money to the household, and sick children require care, preventing adults from working. People with inadequate diets are less able to work, and are more vulnerable to disease and illness. An additional consideration is that weaker members of a household are often buffered by other household members (mothers may particularly buffer young infant consumption), so minor food shortages may not impact young children and therefore an absence of low child weights does not imply that all members of the household are equally well nourished. Finally, low infant weight is usually a reflection of poor food consumption, rather than a cause of it, so anthropometric data is not very useful as a diagnostic tool for the causes of food insecurity. However, in this case, we are only looking for reflections of changes in food insecurity between different seasons. With a large sample size (as used here) and repeated measurements of the same

individuals across different years, consistently relatively lower child weights within a particular season are likely to represent a vulnerable season for all members of the community.

5.2.4 Vulnerable seasons and households

Previous chapters have indicated the second season, and to some extent the third season as being when households are potentially at greater risk from food and income shortages. Focus groups discussing the agricultural calendar identified the second season as being the 'hungry' season, although this was as much to do with the large amounts of work needed to be done in the fields, as the lack of foods being harvested. It is also the time when stores of protein staples such as peanuts are most likely to run dry (Chapter 2). Total food consumption was lowest in the second and third seasons (Chapter 3) and in Teguete at least, total production and income were again lowest in the second season, followed closely by the third season (Chapter 4). Production and income in Beayop were less consistent, but the second season did show the lowest production (albeit with very little variation between seasons) and the second lowest average income (Chapter 4). Consequently, if people do depend on wildlife resources as a seasonal safety, we would expect them to use it in greater proportions during the second or third seasons.

In this chapter, I identify the most vulnerable households as those using food coping strategies most frequently. I identify which season is most likely to be vulnerable to lower food and income supplies by analysing data on child weights and ages to assess when children are most likely to weigh relatively less. Having ascertained the most food insecure households and seasons as far as the data allow, I then analyse which food sources and livelihoods provide the greater proportion of food, production and income for the most vulnerable quartile of households compared to the rest of the community. Finally, I analyse which food and livelihood sources provide the greatest proportion of food production and income in the most vulnerable season, compared to other seasons.

5.3 Methods

To identify the most vulnerable households within each study village, I quantified the use and severity of food coping strategies within the household as an indicator of food security, taking food insecurity as a more accurate measure of vulnerability than simply low food consumption. This was followed by an analysis of the characteristics of the least food secure quartile of households in each village, which is used both as an indicator of the validity of the approach (i.e. food security is consistently, but not solely, related to household wealth measures in most studies), and as a descriptor to characterise the least food secure households (e.g. for assessment of any demographic

correlates of food security). Wealth rank is used as a second indicator of household vulnerability, and it is assumed that a community's perception of household wealth is likely to consider a wide range of factors beyond income alone (see Chapter 2 for discussion). Finally, I assess one aspect of livelihood security, namely income diversity, to examine whether the households identified as the poorest and least food insecure are also livelihood insecure.

5.3.3 Data Collection

Food Coping Strategies

The frequency of use of a range of food coping strategies was assessed twice: once in April 2005 (the 2nd season) and once in February 2006 (the 1st season). In 2005, focus group discussions were held beforehand to identify the commonly used coping strategies, and then questionnaires were conducted at each household to ask how frequently they had used this strategy over the previous two months, and how severely they ranked those strategies that they had used.

In 2006, the focus group discussions were repeated, but this time in greater depth, to investigate some of the ideas behind different coping mechanisms, and to get a consensus on the order of severity of the various strategies. In each discussion group, the coping strategies were written on a card (with pictures also illustrating the strategy, for those who couldn't read). The four female respondenets were asked to review the strategies and new ones were added where appropriate. They were then asked to put the strategies in order of which strategy was the least serious (i.e. what they would do first in times of food and money shortages), up to the most serious strategy (i.e. the last resort) that they would only do if all other options had been investigated. Discussions were held until the four women in each group arrived at an agreed order, and repeated three times in each village. Focus groups also discussed long term coping strategies, but all strategies that were discussed (such as migration, selling house, etc.) were deemed not possible (in the case of house sales), or not appropriate by respondents. For example, the closest to migration anyone got was moving from the city and back to the village, when the search for a job in the city had failed, so for some people, living in the village was already a coping strategy.

Questionnaires were then conducted with all households, this time asking only questions on the frequency of strategy use (and not severity). Data were collected on accumulation strategies, both within the focus groups and questionnaires, but the results were found to be more an indicator of wealth, and didn't add any real information to the study, so these results have not been reported.

Questionnaires also included a question on the frequency of anxiety over food supplies, in line with previous food security questionnaires (see introduction).

The timings of the two food security questionnaires were somewhat borne out of necessity but also choosen to reflect different seasons within the year, including the season identified as the 'hungry' season by agricultural focus groups. Given that not all seasons were assessed (and only one score used), data from the food security questions were used only to distinguish between households, not between seasons.

Food security score

The frequency of use of each strategy (as represented by the proportion of days on which it was used over the previous two months) was multiplied by the severity of that strategy (as given by the consensus in the 2006 focus groups, a high score being more severe), to give one number per strategy. These were summed, to give one score per household per survey. This score is referred to as the food security score for each year, with a higher value denoting a less food secure household. The score for 2006 was used in data analysis as it was considered more accurate, due to a revision of the questions.

Anthropometric measurements

In both villages, all members of the village that desired were weighed and measured in February 2006, according to standard protocols, as described by de Onis (2004). Children under 16 were only measured with parental consent and presence. Children under five were weighed and measured by local health care workers, with parental consent and presence. In addition, permission to use Teguete health centre records was obtained. These records contain the monthly weights and ages of most under-fives in the village for the period 1996-2000. After this date, the records are incomplete or non-existent, due to illness of the health worker at the time. Individuals were identified by name and by household code in the health centre records (their coding). Date of birth was recorded with weight, and these were checked against other health centre records, for consistency, as well as with our own records where the individual could be identified as someone living in the village. Height was not measured for many of the health centre records, partly due to a lack of a measuring rule (and so the inability to measure supine length) and for this reason weight-for-age data is used here. This is also the most widely used metric in developing countries, and although it cannot distinguish between wasting and stunting, it does represent a combination of both these aspects, and has a high positive predictive value as an indicator for child malnutrition in developing countries (WHO 1995). WHO Anthro 2005 software (WHO Anthro 2005 Beta version 2006) was used to convert

weight and age data into a weight-for-age z-score (WAZ). The z-score expresses values as a number of standard deviations above or below the reference mean, giving a linear scale with a mean of 0 and standard deviation of 1. The reference mean used by the programme is taken from data collected from breast-fed infants across six countries in five continents between 1997 and 2003.

Individual and household level variables

Village, household income, household fixed wealth, wealth rank, number of productive adults (defined as healthy adults aged 18-65), number of productive females, presence of productive males (yes/no), number of people in the household (household size), proportion of productive adults in the household, proportion of productive females in the household, sex of household head, education level of household head, sex, age, education and season were used as household and individual-level explanatory variables, and analysed with respect to food security scores. See Chapter 2 for data collection and analysis methods.

Food consumption

The number of calories consumed from different food sources was recorded from 24 food recall questionnaires, across the year. Food sources were split into four categories: agriculture, forest, bought, and gifts, according to where or how the household obtained that particular food item. The proportion of calories consumed from each source was calculated for each household for each sample day, and these proportions were averaged for the year and for each season separately. See Chapter 3 for details.

Income and production

The value of all products and income produced or earned from different sources was recorded from 24 food recall questionnaires, across the year. Income and product sources were split into four categories: agriculture ('produced'), forest, trade and paid work, according to where or how the household obtained that particular product or income. The value of all products was taken as the value of anything earned, produced or harvested. Income was taken as the value only of those products actually sold (or the profit made on those items that were traded) or income. The proportion of product value and income from each source was calculated for each household for each sample day, and these proportions were averaged for each season, and then for the year. See Chapter 4 for details.

5.3.4 Data Analysis

All data were analysed in R, version 2.6.2 (R Development Core Team 2007). Models were simplified to obtain the minimum adequate model by fitting the saturated model and then comparing models with progressively simplified fixed effects using anova. Significance was taken as $p<0.05$.

The variation in food security score with household characteristics was analysed with a linear mixed model using the lme4 library (Bates & Sarkar 2007). The household food security scores from both 2005 and 2006 were used where available. Year and household nested within village were specified as random effects. Fixed effects were all the household level variables (as detailed above), as well as season, year (2005 or 2006) and village. Explanatory variables were transformed to give Normal distributions where appropriate (see Chapter 2 for details).

The variation in WAZ score was analysed in two sets of data. The first included only the data for which the individual was currently in the village and could be identified, and so household level variables could be assigned, as well as individual variables (sex and age), year of measurement and season of measurement. The second analysis included all WAZ scores, and only individual variables, year and season. For this second set of data, individuals and households were identified and coded from the health centre records, allowing individual and households to be fitted as random effects, despite not knowing exactly which household the health centre code referred to. In this way, year and individual nested within household were specified as random effects in all analyses. Only data from Teguete were used, so it was not necessary to specify village as a random effect.

In order to analyse the difference between the food sources of the most food insecure and other households, the households in each village in the least food secure quartile (as measured by food security score) were identified. The proportion of calories from each of the four sources (agriculture, forest, bought, gifts) was averaged across the whole year for each household. The composition of the food sources for the least food secure households was compared to the composition of the food sources for the rest of the population using compositional data analysis, and the library 'compositions' in R (van den Boogart et al. 2006). Data were put into the vector class "acomp", the centred log ratio transformation taken (using the "clr" function) and analysed with a multivariate analysis of variance (manova) to show the significance of food security quartile and village. This was done using a two level factor - quartile 4 (the least food secure) and quartiles 1-3 lumped together. The same was done to compare the most vulnerable season with other seasons.

To analyse the difference between the livelihood and income sources of the most food insecure households, the average proportion of production value from each livelihood source (forest, agriculture, paid work and trade) was calculated for each household in each season, and the average value per household taken as the average across all four seasons. The composition of the proportion of value from all livelihoods for the least food secure quartile of households in each village was compared to the composition of the production sources for the rest of the population in the same way as for the food consumption data. The same was done to compare the most vulnerable season with other seasons. The process was repeated for income from each livelihood source, and to analyse the poorest households (as identified by the bottom household wealth rank) compared to other households in the community.

5.4 Results

5.4.1 Identifying the most vulnerable households

Identifying and ranking Food Coping Strategies

The strategies identified during the focus groups were as follows (in order of increasing severity):

- 'pass the whole day without eating meat or fish': This happens all the time and isn't considered a problem. To go for a whole month without eating meat or fish is not uncommon. However, there was some confusion within the focus groups as to the definition of meat or fish, with some women not counting smoked fish as proper fish. We agreed on counting all meat and fish (including smoked) as meat and fish, and ensured that this was specified in each interview.

- 'the mother eats less food to ensure that the children have enough': One woman explained that during the evening meal, everyone eats equally. If there is enough food, everyone eats again the next morning. If there isn't enough food then only the children eat and the mother goes into the fields to look for food without having breakfast (or lunch). This is a common strategy (buffering the vulnerable members of the household), and is also one of the strategies identified in the USA and Bangladesh questionnaires (Wolfe & Frongillo 2001; Hall 2004). However, to avoid biasing results towards to the numerous households without children, this question was asked but not included in the analyses.

- 'ask for a loan or gift of food': Groups reported that this happens commonly, and is usually small things like a bar of cassava, which would then be returned the next time that that household made cassava themselves.

- 'when there is no soap, don't buy more due to a lack of money': The most common and cheapest soap was used to clean clothes and pots, as well as people.

- 'when there is no petrol (kerosene), don't buy more due to a lack of money': This was deemed only slightly less serious than having a lack of salt, with the reason given that you couldn't prepare food without salt for more than three days in a row, but you could sleep in the dark. However, the order changed when there were many ants around when a lack of petrol became more severe than a lack of salt. This was because petrol was used with varying success to ward off large swarms of ants heading towards the kitchen. This became a serious problem about once a year, when large parts of the village would be overrun with ants, which would then eat any food in their path.

- 'when there is no salt, don't buy any more due to a lack of money': See above.

- 'eat only once a day': Respondents noted that this is quite rare.

- 'ask for a loan or gift of money': This was deemed one of the most severe strategies, but group members said that this depended on whether you were working and what the likelihood was that you would have money to pay back the loan quickly, as well as on the amount you were borrowing. So, for someone with a salary, or whose relatives regularly sent cash, to borrow money was not a big issue. In contrast, someone with no regular cash income would only borrow money (and would probably only be lent money) under extreme circumstances, such as needing money to buy medication or go to hospital. More common was asking for credit at the local shop, and this was viewed as far less serious, probably because the amounts involved were very small (usually 100-500 cfa). Neither asking for a loan, or getting credit from the shop, was included in the calculations due to the large potential differences in the amounts, and because the severity was likely to be very different depending on the wealth of the person (i.e. a wealthy person could borrow money or claim credit at the shop every morning, and probably pay it back every evening, without any problems).

- 'go all day without eating': This is extremely rare.

Questions were also asked on borrowing fish or meat, and mothers eating less fish or meat to ensure that children have enough of these foods, but these questions (being very similar to questions on all food types) seemed to confuse people, so they were dropped from the 2006 questions. Other strategies that were mentioned were the harvesting and sale or consumption of more agricultural food or more wild food. While these seemed to be important mechanisms for consumption and income smoothing, it was less easy to see how these could be measured, particularly given that they were long-term food harvest strategies for a large number of households; without regular questionnaires over a number of seasons and years, it would be impossible to distinguish between a regular activity and a short-term response to a food shortage. Consequently, these questions were not included in the questionnaire. The purchasing of salt, soap and petrol was originally raised in focus group discussions on short term accumulation strategies, and these items were identified as among the first that would be bought with any money available (if the household didn't already own them). After further discussion, it was decided that a lack of these items was a better indicator. This was particularly true given that these items were bought in a wide range of quantities (i.e. people could buy a cup of salt or a 5kg sack of salt), so measuring the frequency of purchase would be meaningless.

In 2005, each household was asked to rank the severity of the strategies that they had used (Table 5.2). In 2006, the severity rank was instead decided in three focus groups in each village, with strategies ranked according to how serious, or drastic a strategy was (i.e. the strategies that people were most likely to avoid until all other options were exhausted were deemed the most severe). The results are shown in Table 5.1 and show generally a great deal of agreement between focus groups and villages. The biggest difference was that people in Beayop viewed borrowing money as far less serious than people in Teguete. After discussion, it was explained that if you had a regular income, or had family who had money, it didn't matter if you borrowed money, as you were likely to be able to pay it back quite quickly. Consequently, it was for the poorer households that borrowing money was the most serious, and in Teguete far fewer households had family members earning a regular monetary income. This, in addition to the large differences in quantity of money that could be borrowed (which again was not reflected in the questionnaire asking about the frequency of strategy use) meant that data from this question were not included in the analysis. For similar reasons, we did not use data on the frequency of gaining credit from the shop. Although this was viewed as less serious than borrowing money, partly because the amounts involved were often much lower, it was still reported to be more likely that wealthier households would get credit, partly because shop owners were more willing to give them credit, and partly because they were more likely to eat shop-

bought food. The average frequency of use and number of households using each strategy in 2005 and 2006 are shown in Table 5.2 and Table 5.3.

Table 5.1 Severity rankings for the different coping strategies from the 2006 focus groups and the final ranking.
1 = least severe, 10 = most severe (i.e. the strategy most avoided). In B1 and T1 (the first focus group in Beayop and Teguete, respectively), a lack of soap, petrol and salt was not included in the rankings. The final rank shows the rank used in calculations. Strategy 2 was not used in calculations, to avoid biasing results to those households without children (and hence who did not use this strategy). Strategies 4 and 8 were also not used in the calculations (see text for discussion).
*The median and mean scores use ranks only from the four discussions where all coping strategies were discussed.

Strategy	B1	B2	B3	T1	T2	T3	Median score* Beayop	Median score* Teg	Mean score*	Final Rank (2006)
1. The family doesn't eat fish or meat during the day	1	1	1	1	1	1	1	1	1	1
2. Mother eats less so that the children have enough	2	2	2	2	2	2	2	2	2	X
3. Ask for a loan or gift of other food	3	3	3	3	3	3	3	3	3	2
4. Ask for credit at the shop	4	4	4	4	4	5	4	4	4.25	X
5. When there's no soap, can't afford to buy any more		5	5		5	4	5	4/5	4.75	3
6. When there's no petrol, can't afford to buy any more		8	7		6	6	7/8	6	6.75	4
7. Family eats only once during the day	6	7	8	5	7	7	7/8	7	7.25	5
8. Ask for a loan or gift of money	5	6	6	6	10	9	6	9/10	7.75	X
9. When there's no salt, can't afford to buy any more		9	9		8	8	9	8	8.5	6
10. Nothing eaten all day	7	10	10	7	9	10	10	9/10	9.75	7

Table 5.2. Coping strategies for 2005 including respondents' severity rankings.
No. HH refers to the number of households that report using this strategy in the previous 2 months. Mean score refers to the mean severity ranking (higher scores denoting a more severe strategy). The rank of scores is simply the average severity scores, ranked. (both) indicates both villages combined.
[1] Not included in calculations

Strategy	No. HH both	Mean severity score (both)	Rank of av. score (both)	No. HH Beay.	Mean severity score Beay.	Rank Beay.	No. HH Teg.	Mean severity score Teg.	Rank Teg.
The family doesn't eat fish or meat during the day	119	1.6	2	48	1.54	2	71	1.66	2
Mother eats less so that the children have enough	56	4.5	7	3	1.33	1	53	4.72	6
Ask for a loan or gift of other food	71	4.6	8	22	1.86	3	49	5.78	7
When there's no soap, can't afford to buy any more	58	3.2	3	2	2.5	8	56	3.27	3
When there's no petrol, can't afford to buy any more	62	3.7	5	2	2.5	8	60	3.78	4
Family eats only once during the day	48	1.1	1	2	2	4	46	1.02	1
Ask for a loan or gift of money [1]	64	4.6	8	25	2.24	5	39	6.10	8
Nothing eaten all day	0			0			0		
Mother eats less meat or fish so that the children have enough [1]	57	4	6	4	2.25	6	53	4.09	5
Ask for a loan or gift of meat or fish [1]	16	3.25	4	12	2.25	6	4	6.25	9

Table 5.3 Frequency of use for different coping strategies in both villages, 2006.
Total no. HH refers to the total number of households replying to this question (note a reduced number for strategy 3, where households with no children have not answered the question). No. HH refers to the number of households reporting use of this strategy at least once. Average frequency refers to the average proportion of days this strategy was used across all households.

Strategy	Total no. HH Beayop	No. HH Beay.	Average freq. Beayop	Total no. HH Teg.	No. HH Teg	Average freq Teg
1. The family doesn't eat fish or meat during the day	99	82	0.328	91	88	0.649
2. Mother eats less so that the children have enough	80	54	0.236	57	41	0.176
3. Ask for a loan or gift of other food	99	59	0.119	91	41	0.090
5. When there's no soap, can't afford to buy any more	99	37	0.053	91	24	0.094
6. When there's no petrol, can't afford to buy any more	99	49	0.024	91	27	0.095
7. Family eats only once during the day	99	22	0.039	91	38	0.138
8. Ask for a loan or gift of money	99	25	0.006	91	8	0.001
9. When there's no salt, can't afford to buy any more	99	28	0.019	91	24	0.068
10. Nothing eaten all day	99	6	0.003	91	6	0.015
Worry about where food for next day coming from	99	44	0.054	91	40	0.088

Aside from the final list of coping strategies, there was some interesting discussion around the subject of what respondents would do if there were food shortages in the household. They were asked to describe the sequence of events, from what they would do if there were no food in the house, going through all the first options, and if each of these in turn were not successful, what the following action would be. A typical sequence of events in Teguete was described:

- If they don't have any food in the house, then they look for some in their fields or buy some.
- If they have no money and the 'staple' foods in the field are finished (i.e. their stock of cassava is used up), then they would ask family members or other people in the village for food from their fields (e.g. cassava, yams, maize, sugar cane, greens)
- If there is still no food, or they have run out of 'sauce' foods (e.g. peanuts, calabaza, bush mango that are eaten with or without meat, and accompanied by a staple such as cassava), because they are between harvests, then they might ask to borrow food from other people's kitchen stores, or they would go and look for greens (typically found on the edges of fields and forests), but they would only do this if they have palm oil (also collected from the forest or fields)

- If this fails, they would then go to the forest; men would set snares or would fish with rods or fish-traps, and women would go fishing using 'esia' a natural fish poison (only possible in the dry season), fish traps or hand–held fish nets, 'tariyas' (again mainly done in the dry season), and would continue to eat peanuts and calabaza as the 'main food' (i.e. an undesirable substitute to meat and fish – peanut and calabaza soups are generally eaten with meat or fish in them).

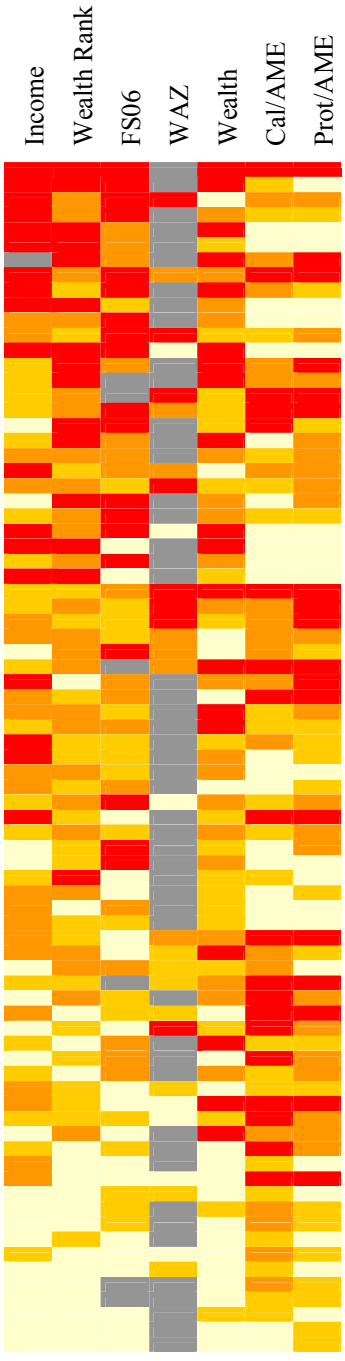
The women in Teguete raised other points. The main issue was that the lack of money is due to a lack of food sales (i.e. lack of market opportunities). Some women in the village have six fields of cassava, but can't sell it as there aren't enough people in the village to buy it, and nobody comes from Bata (the main town) on a regular basis. The women in Beayop did not have this complaint, but said that most women who wanted to sell cassava could sell it on the side of the road to passing cars. They also pointed out that the people in Cogo (a town on the south-west coast, bordering Gabon) had it easy because traders visit from Libreville and buy not only cassava, but even the leaves used to wrap up the cassava, and consequently, the women in Cogo are rich like the men. They also said that if someone is ill, they still work, but they just do less (i.e. have a smaller field). People in Beayop expressed an appreciation of the forest slightly differently, saying that the people of Ebibeyin and surrounding areas (where population density is much higher), are very unlucky as they have no forest, and consequently eat much less meat and fish. One older man also stated that in the Ebibeyin region, if a man has no job, he cannot try and make something from the forest, so people are poorer.

5.4.2 Characteristics of the least food secure households

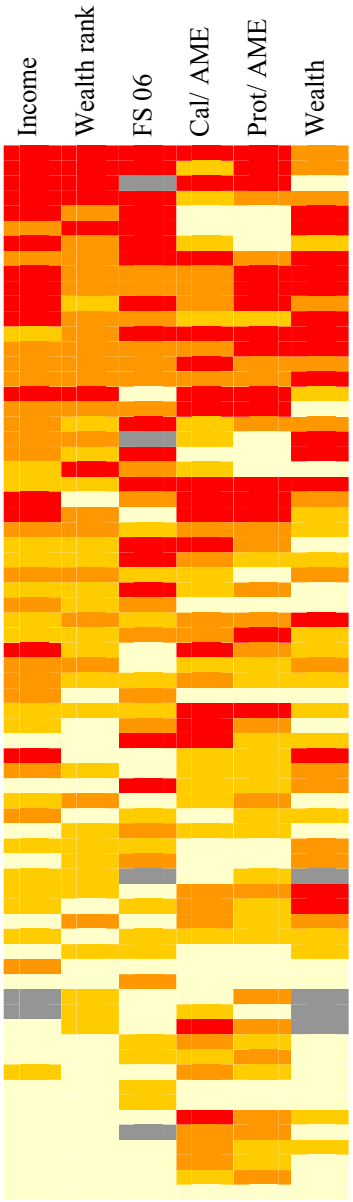
On all three measurements of wealth, poorer households in both villages are significantly less food secure; household income (deviance change = 64, $p < 0.0001$), household fixed wealth (deviance change = 14, $p < 0.01$) and wealth rank (deviance change = 10, $p < 0.05$, Table A 8.1). In addition, less food secure households have a significantly lower proportion of productive adults in the household compared to the total number in the household (deviance change = 22, $p < 0.0001$) and Teguete was significantly less food secure than Beayop (deviance change = 6, $p < 0.05$). The correlation between food security score and food consumption was not tested due to the large variations in activity levels and consequent energy needs. Associations across households between food security score in 2006 and indicators of wealth, calorie consumption, protein consumption and WAZ (for Teguete only) are summarised visually in Figure 5.1, illustrating the correlations between these measurements.

Figure 5.1 Showing household variables for all households in Teguete and Beayop.
Each row represents one household. Income, wealth rank, food security score, WAZ, calories/AME/ day, and protein/AME/day shown. Quartile 1 (red) indicates the least desirable quartile (i.e. poorest, least food secure, etc), followed by quartile 2 (orange), quartile 3 (yellow) and quartile 4 (while) which indicates the richest, most food secure). Cells in grey indicate that no data available. Cells ordered by income, wealth rank, Food security score 2006 (FS06) and WAZ.

Teguete



Beayop



Are the least food secure households also livelihood insecure?

The least food secure quartile of households and the poorest wealth ranking households have significantly fewer sources of production and income than the other three (Figure 5.2, Figure 5.3, Figure 5.4, and Figure 5.5), implying that poorest and least food secure households are also the least livelihoods secure.

Figure 5.2 Graph showing average number of livelihoods (producing goods) per household with food security quartile.
The least food secure quartile (4) have significantly fewer sources of production (deviance change = 15.4, $p < 0.001$, Table A 8.2**).**

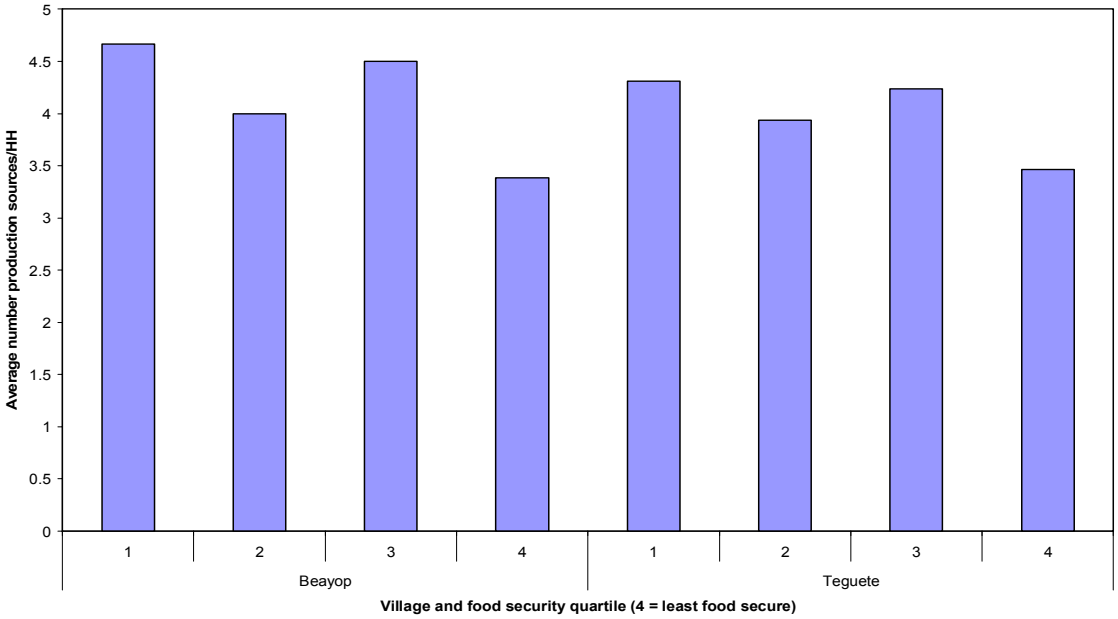


Figure 5.3 Graph showing average number of income sources per household for each food security quartile. The least food secure quartile (4) have significantly fewer sources of income (deviance change = 22.2, $p < 0.001$, Table A 8.3).

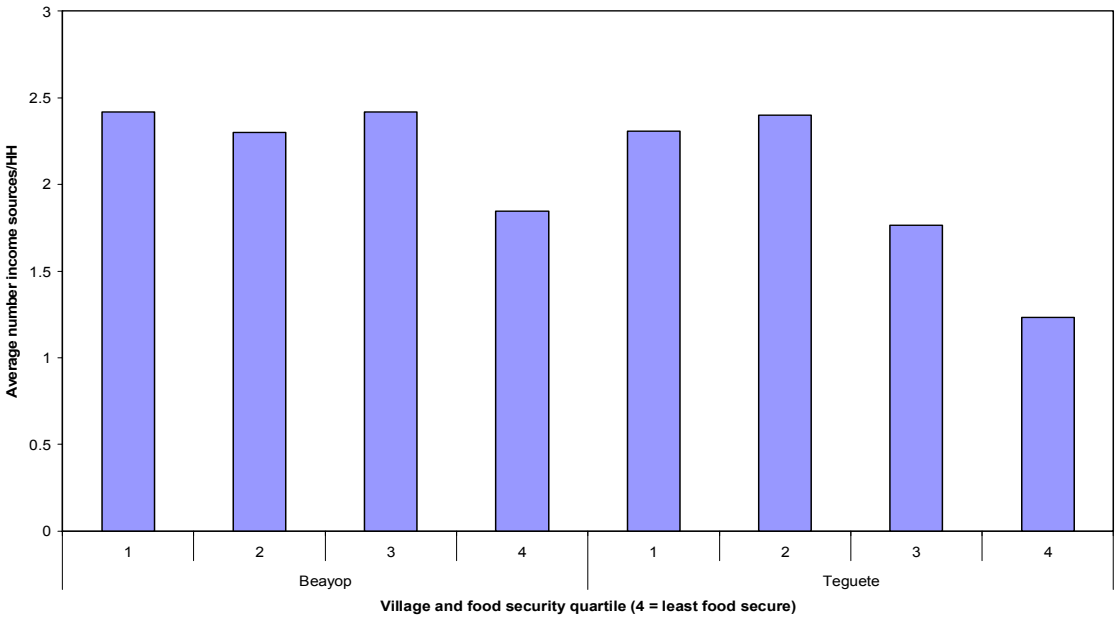


Figure 5.4 Graph showing average number of production sources with wealth rank.
The lowest wealth rank (1) have significantly fewer sources of production (deviance change = 10.2, $p < 0.01$), although there is some evidence of an interaction between village and wealth rank (deviance change.= 2.8, $p = 0.096$, Table A 8.4**).**

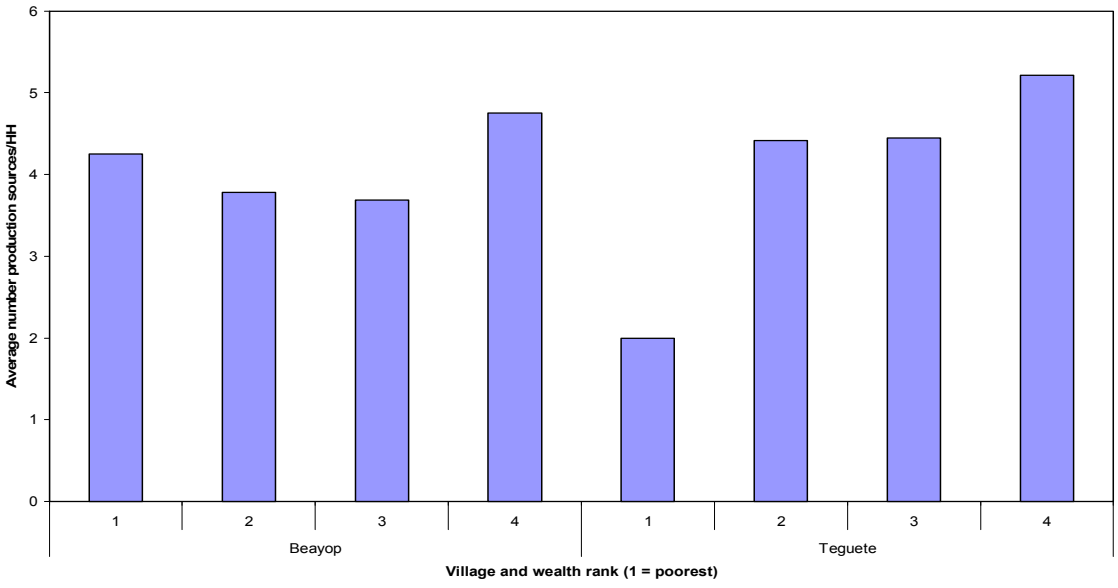
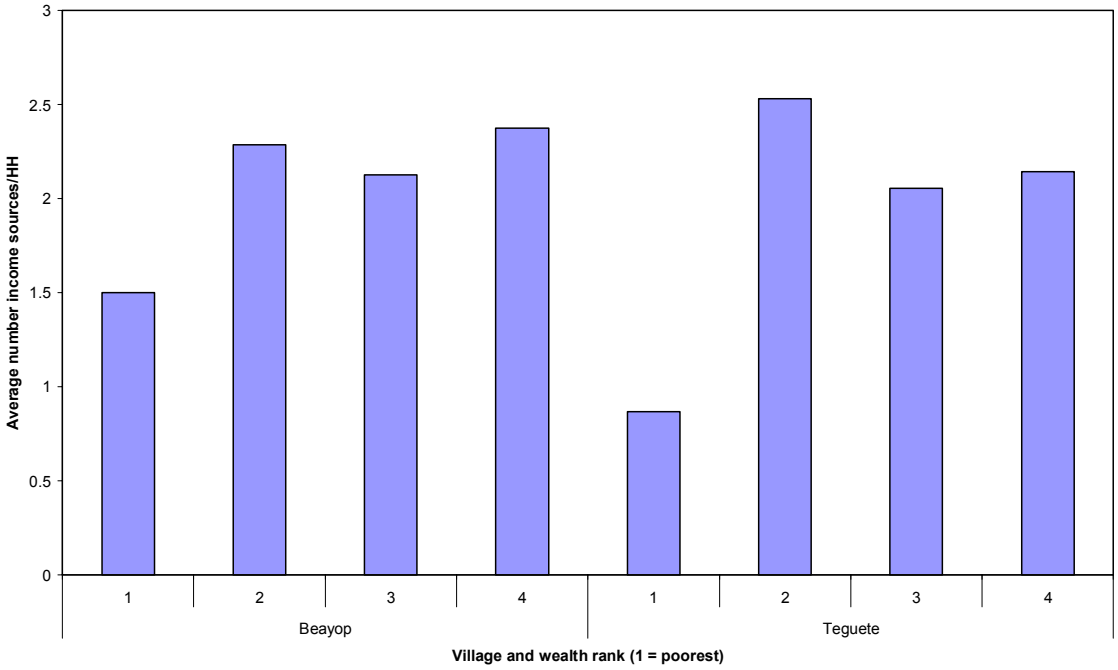


Figure 5.5 Graph showing average number of income sources per household for each wealth rank.
The lowest wealth rank (1) have significantly fewer sources of income (deviance change = 10.6, $p < 0.01$, Table A 8.5**).**



5.4.3 Identifying the most vulnerable seasons

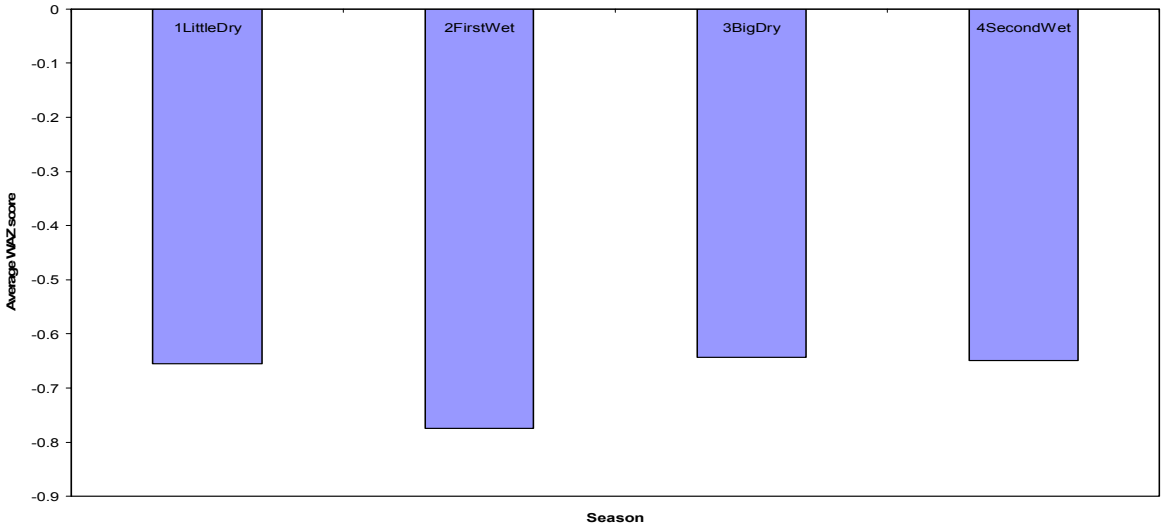
In which seasons are children more likely to be underweight?

For the anthropometric data where the individual is known and still in the village (a sample size of 52 individuals), older children and male children weighed significantly relatively less for their age (deviance change = 5, $p < 0.05$ and deviance change = 8.7, $p < 0.01$ respectively,

Table A 8.6). The second season (the first wet, and reported 'hungry season') showed significantly relatively lower WAZ scores and the first season, (the shorter, hotter dry season) showed the second lowest WAZ scores (deviance change, = 8, $p < 0.01$).

When all data were used, year, season and age were all significantly correlated with weight-for-age z-score (Table A 8.7). Older children again were significantly underweight relative to younger children (deviance change = 64, $p < 0.001$). They also weighed significantly different in different years (deviance change = 26, $p < 0.05$), but without historical records, it is difficult to say why that might be. Across seasons, children weighed significantly less in the second season of the year, as with the first set of data (deviance change = 8, $p < 0.05$, Figure 5.6). In all seasons they weighed less than the global average.

Figure 5.6 Graph showing average WAZ score per season.



5.4.4 Are particular food sources more important for vulnerable households or in vulnerable seasons?

The composition of the diet and income sources of the least food secure household was analysed in comparison with the rest of the population within the same village. There was a significant difference in the composition of diets between villages ($p<0.01$), but not between households with different food security scores. As shown in Chapter 3, Beayop had a greater proportion of food that was bought ($F = 65.2$, $p < 0.001$) while Teguete has a greater proportion of food that was from agriculture ($F = 10.4$, $p < 0.01$) and the forest ($F = 104.9$, $p < 0.0001$), and there was no significant difference in the proportion received as a gift. This does not appear to change between households that are more or less food secure.

The same analyses were done using the food and income compositions of the same least food secure households, but adding season as an additional explanatory variable. The first and second seasons

referred to as the 'hungry' season (those identified as the potentially most difficult to find food, according to focus groups and the child weight scores) were compared to the other two seasons ('not-hungry'). There were no significant differences between seasons.

There is a significant difference between villages in proportion of calories consumed from agriculture, bought and forest foods ($F = 9.4$ and $p < 0.01$; $F = 75.9$ and $p < 0.0001$; and $F = 146.6$ and $p < 0.0001$ respectively, Table A 8.16). In addition, there is a significant interaction between village and food security status, for the proportion of food consumed from gifts ($F = 4.5$, $p < 0.05$). Across all food security categories, consumers in Beayop consume a greater amount from gifts, but among the least food secure, it is households in Teguete that have a far greater proportion from gifts. This may be a reflection of the differences in both the wealth and the proximity to urban areas between Beayop and Teguete. In Beayop, a far greater proportion and total amount of gifts and income is received as gifts from relatives, normally from those living outside the village, and it is often the wealthiest households that receive the greatest quantity and value of gifts (indeed, it gifts from relatives that may push them into higher wealth rankings). In addition, the food received is more likely to be sacks of rice, and luxury foods such as frozen fish and meat that are commonly sent by relatives, particularly to the wealthier households. In contrast, in Teguete far fewer people have relatives outside the village, and they receive fewer presents from them. Instead, it is often the poorest people who rely on gifts of food from family members within the village for basic consumption needs, commonly bars of cassava and portions of the family meal, given by relatives in the village.

5.4.5 Are particular livelihood sources more important for vulnerable households or in vulnerable seasons?

Households in Teguete gain a significantly higher proportion of the value of production and income from the forest (Figure 5.7, Figure 5.8, Figure 5.9 and Figure 5.10), while households in Beayop gain a significantly higher proportion of income from agriculture (Figure 5.8 and Figure 5.10). There are no significant differences between the least food secure quartile and other households, but the poorest households (those in the lowest wealth rank) do gain a significantly higher proportion of production from the forest, particularly in Beayop. There is also some evidence that households in the lowest wealth rank gain greater income from forest products (particularly for Teguete) and less from trade (Figure 5.10).

When season is also taken into account, there are significant differences in the proportion of production and income from different sources between the two villages, with households in Teguete showing a higher proportion of production and income from forest sources and lower from paid sources (Tables 5.4, 5.5, 5.6 and 5.7). There is also a significantly higher proportion of production value from trade in Beayop (Tables 5.4 and 5.6). The relationship between food security and the proportion of income from forests is significantly different between villages, with the least food secure group in Teguete gaining significantly more income from forests. There is also some evidence that the least food secure group gains a higher proportion of production from forests in both villages ($p = 0.062$). These differences are echoed by households in the poorest wealth rank, and they gain a significantly higher proportion of production from forests (particularly in Beayop) and a significantly higher proportion of income from forests (particularly in Teguete). There is a significant interaction between food security group and village for the proportion of income from agriculture, and between wealth rank and proportion of value from agriculture. Households in the poorest wealth rank also gain less production value and income from trade.

During the second season (identified as the most vulnerable), households in both villages gained significantly less income from agriculture than they did in other seasons. There were no other detectable differences in the proportion of income gained from different livelihoods between seasons (Tables 5.5 and 5.7).

Figure 5.7 Graph showing the proportion of household value gained from different livelihood sources for food security quartiles.
Compositional analysis shows that the proportion of value from forest is higher in Teguete ($F = 15.05$, d.f. = 1, $p < 0.01$), and proportion of value from the agriculture is slightly higher in Beayop ($F = 3.91$, d.f. = 1, $p = 0.051$). N (no. households) = 101.

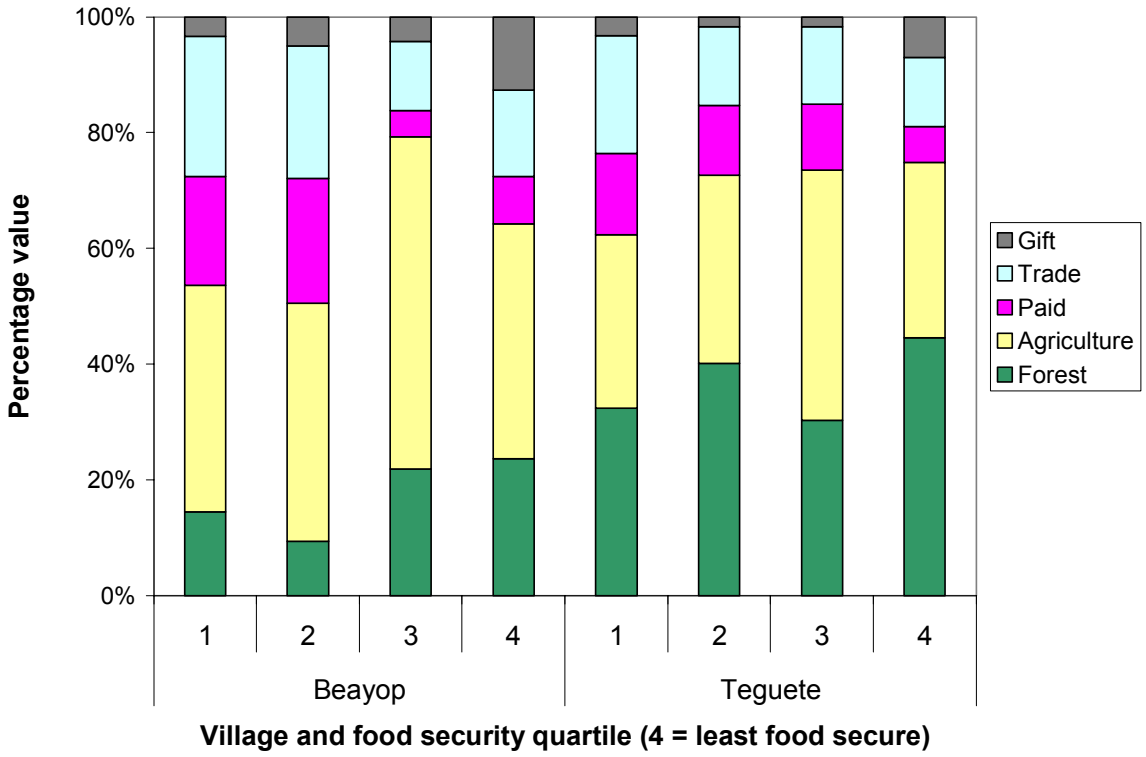


Figure 5.8 Graph showing the proportion of household income from livelihood sources for food security quartiles.
The proportion of income from forest is higher in Teguete ($F = 10.49$, d.f. = 1, $p < 0.01$), and proportion of income from the agriculture is higher in Beayop ($F = 7.54$, d.f. = 1, $p < 0.01$). N (no. households) = 91 (because some households showed no income from any sources except gifts).

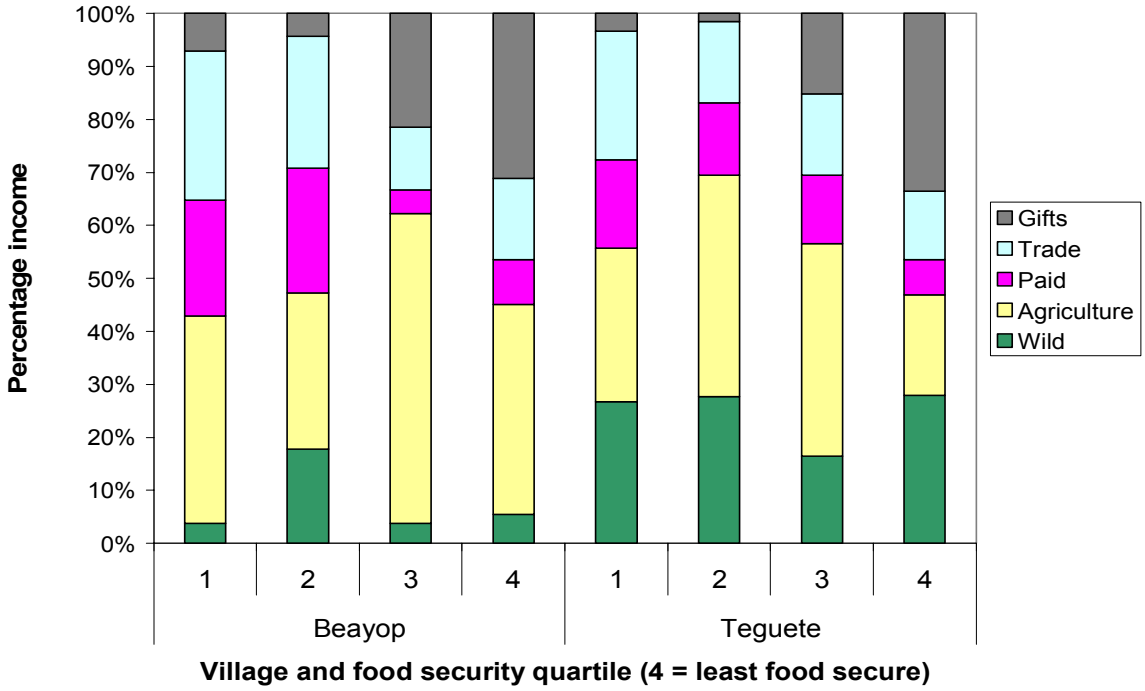


Figure 5.9 Graph showing the proportion of household value from livelihood sources for wealth ranks.
The proportion of value is significantly different between villages for forests ($F = 12.62$, $p<0.001$) and significantly different between wealth ranks for forests ($F = 4.02$, d.f. = 1, $p<0.05$) and trade ($F = 4.39$, d.f. = 1, $p<0.05$). There is also a significant interaction between village and wealth rank for forest ($F = 9.77$, $p<0.01$) and agriculture ($F = 4.22$, $p<0.05$).

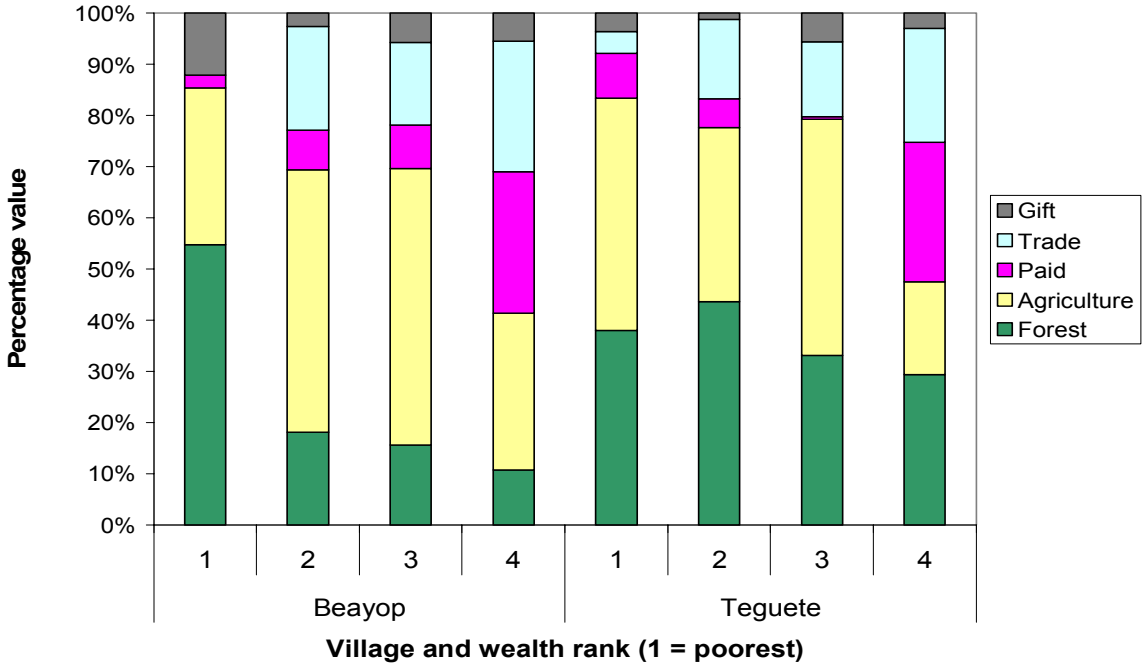


Figure 5.10 Graph showing the proportion of HH income from different livelihood sources for wealth ranks. The proportion of income is significantly different between villages for forest ($F = 10.64$, $p < 0.01$) and agriculture ($F = 7.68$, $p < 0.01$) and slightly different between wealth ranks for forests ($F = 3.89$, $p = 0.052$) and trade ($F = 3.09$, $p = 0.082$).

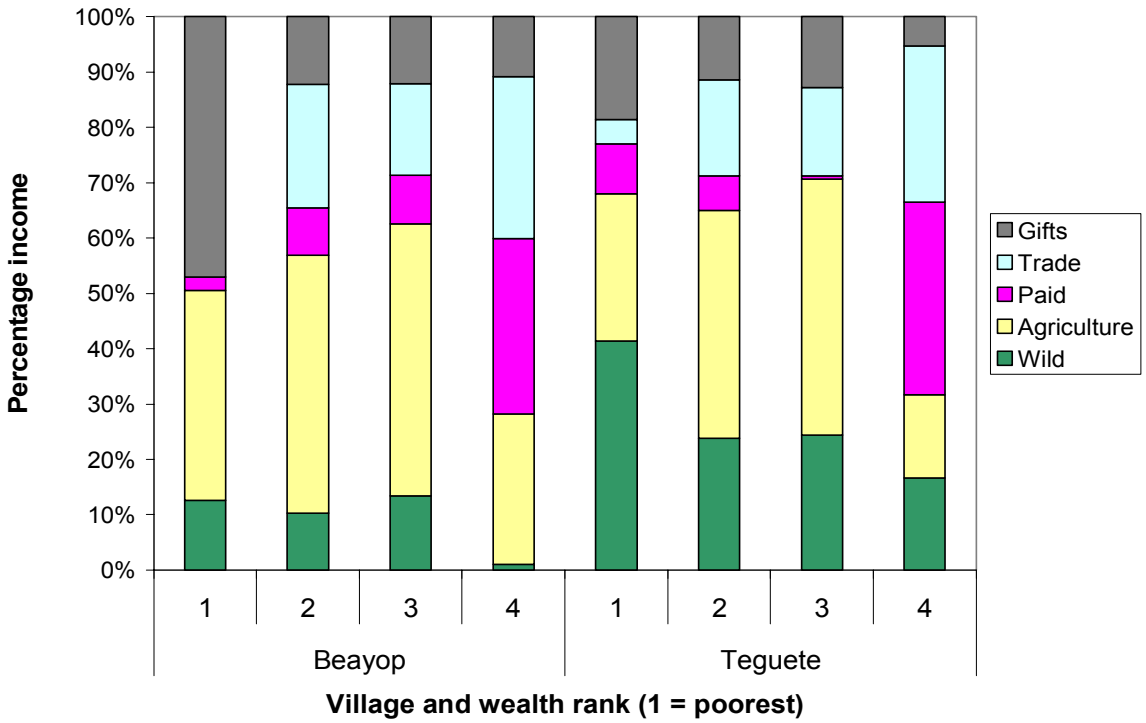


Table 5.4 The percentage production from livelihoods in households of different food security and in different seasons.
Production is significantly different between villages for forest ($F = 22.94$, $p < 0.0001$), paid ($F = 6.08$, $p < 0.05$) and trade sources ($F = 7.45$, $p < 0.01$). Production is slightly different between different food security groups, with the least secure getting a higher proportion of production from forests ($F = 3.50$, $p = 0.062$).

	Beayop				Teguete			
	Lean season		Other seasons		Lean season		Other seasons	
	Other HHs	Least food secure HH	Other HHs	Least food secure HH	Other HHs	Least food secure HH	Other HHs	Least food secure HH
Forest	15.0	22.6	14.8	20.9	24.4	33.0	32.2	38.6
Paid	14.9	13.8	14.3	9.1	8.6	0	8.6	4.0
Agriculture	52.0	44.4	59.5	61.3	58.5	64.9	52.5	52.1
Trade	18.1	19.1	11.4	8.8	8.5	21.9	6.7	5.3

Table 5.5 The percentage income from livelihoods in households of different food security and in different seasons.
The proportion of income from forests is significantly different between villages ($F = 23.07$, $p < 0.0001$) and food security groups ($F = 9.21$, $p < 0.01$). There is a significant difference in agricultural income between seasons ($F = 4.31$, $p < 0.05$) and significant interaction between village and food security groups for forest income ($F = 12.64$, $p < 0.001$) and agricultural income ($F = 7.35$, $p < 0.01$).

	Beayop				Teguete			
	Lean season		Other seasons		Lean season		Other seasons	
	Other HHs	Least food secure HH	Other HHs	Least food secure HH	Other HHs	Least food secure HH	Other HHs	Least food secure HH
Forest	5.0	0	6.8	7.1	28.5	66.7	16.2	48.7
Paid	28.6	34.8	24.5	20.7	18.1	0	17.7	13.6
Agriculture	23.2	22.3	41.8	54.7	34.4	0	40.5	17.1
Trade	43.2	42.9	26.8	17.5	19.0	33.3	25.6	20.6

Table 5.6 The percentage production from livelihoods in households of different wealth ranks and in different seasons.
The proportion of production is significantly different between villages for forest goods ($F = 21.84$, $p < 0.0001$), paid work ($F = 9.33$, $p < 0.01$) and trade ($F = 5.93$, $p < 0.05$). There is a significant difference in the proportion of production between wealth rank groups for forest ($F = 8.90$, $p < 0.01$) and trade ($F = 9.72$, $p < 0.01$) and significant interaction between village and wealth rank groups for forest production ($F = 16.15$, $p < 0.001$) and agricultural production ($F = 4.18$, $p < 0.05$).

	Beayop				Teguete			
	Lean season		Other seasons		Lean season		Other seasons	
	Poorest WR	Other HHs	Poorest WR	Other HHs	Poorest WR	Other HHs	Poorest WR	Other HHs
Forest	61.0	14.5	46.1	12.6	31.3	24.2	30.0	33.4
Paid	7.3	15.0	4.4	14.8	0	8.0	6.3	6.9
Agriculture	31.7	51.8	49.5	60.5	68.7	57.7	62.7	52.1
Trade	0	18.7	0	12.0	0	10.1	1.0	7.6

Table 5.7 The percentage **of** income from livelihoods in households of different wealth ranks and in different seasons.
The proportion of income is significantly different between villages for forest goods ($F = 21.85$, $p < 0.0001$) and paid work ($F = 4.86$, $p < 0.05$). There is significant difference in the proportion of income between wealth rank groups from forests ($F = 9.14$, $p < 0.01$) and trade ($F = 8.02$, $p < 0.01$) and significant a difference in the proportion of income from agricultural between seasons ($F = 3.91$, $p < 0.05$).

	Beayop				Teguete			
	Lean season		Other seasons		Lean season		Other seasons	
	Poorest WR	Other HHs	Poorest WR	Other HHs	Poorest WR	Other HHs	Poorest WR	Other HHs
Forest	26.7	4.3	17.3	6.6	78.6	29.1	46.7	19.5
Paid	33.3	28.0	13.6	25.7	0	18.9	13.3	15.9
Agriculture	40.0	24.9	69.1	40.2	21.4	29.3	33.3	37.7
Trade	0	42.7	0	27.6	0	22.8	6.7	26.8

5.5 Discussion

It is illustrative of the lack of famine-like food shortages in this tropical area, that the common first response to being asked what people would do if they had no food was that they would go to the fields to get some, and if there was none to be had, they would go to the forest. This statement, coupled with many similar observations by the people of both Beayop and Teguete also provides clear qualitative evidence that there is some reliance on the forest for food or income, particularly in times of need. Indeed, a repeated theme in all the food security focus groups was the discussion of going to look for food in the forest once agricultural resources were exhausted and if it was not possible to borrow food from other people in the village. This indicates the use of both social networks and natural resources as safety nets to buffer against food shortages. Previous studies have suggested that communities are a central buffer system to the poor, whereby households can rely on extended family and neighbours through a reciprocal, often unspoken agreement to provide each other with food in particularly bad times. Indeed, it is the breakdown of these relationships due to conflict, HIV and natural disasters that is often held responsible for contributing to the negative impact of these situations. However, at times when all households are experiencing a reduction in resources (such as during a lean season), social networks may be less able to act as a buffer, and so it may be in these times that natural resources, such as forest products, become most important (e.g. Daniggelis 1997).

In this chapter, I have given quantitative evidence for some aspects of this dependence on forest products. To do this, I have first assessed which households might be most at risk by measuring the use of household coping mechanisms. These methods have been developed as a quick measure of food security in developed countries such as USA or developing countries with more extreme food shortages (such as Bangladesh), so it is interesting to find that they can also be reliable in a tropical forest environment. Similarly, although the food coping strategies developed for use in this study were identified up by respondents in the focus groups, strategies from three of the four groups used in previous studies were identified, namely strategies of dietary change, food seeking and rationing. The exception was that no strategies were identified involved changes to household structure, but as the long-term coping strategies of migration, for many people living in the village was the fall-back strategy, so children, wives or whole families may move from the city to stay with relatives in the village in times of hardship. Consequently, these strategies would not be seen in the village, but may be present in urban areas.

The least food secure households were shown to be poorer, with a lower ratio of productive adults to dependents and with fewer livelihood and income sources. However, during the process of

establishing a list of measurable food coping strategies, a number of issues occurred. The most frustrating is that some strategies commonly mentioned are very difficult to quantify and their frequency of use may vary greatly between households in ways that do not reflect food security. Crucially, this included foraging for food from the forest, which was done in times of need by some households, but was part of the regular array of livelihood activities for others, including some of the wealthier households. The difficulties of quantifying an activity that is for some a coping strategy but for others a regular (and sometimes very profitable) livelihood activity has been observed in other studies, but in this case we could not find a solution. Similarly, the borrowing of money was for some of the poorest households a drastic action, reflecting critical food insecurity, whereas for some wealthier households, it was an everyday occurrence, reflecting nothing more than the equivalent of having forgotten their wallet.

Other issues occurring were in the interpretation of some of the questions. Even seemingly simple questions such as how often a family had passed the whole day without eating meat or fish were at first misinterpreted, as some people did not include smoked fish in this category (questions were quickly changed and re-asked to be more explicit in this case). Similarly, two people claimed to have eaten nothing all day, but when further questioned, this actually meant that they had eaten nothing 'of importance', but had in fact eaten greens or peanuts and cassava or other staples.

There was no evidence of the least food secure households relying on different food sources, but there were clear indications that the most vulnerable households (either the least food secure or the poorest) gained greater income or production from the forest than the rest of the population. Interestingly, there was some evidence that poorer or least food secure households rely on the forest more for production in Beayop, and more for income in Teguete. Given the significantly lower amounts earned from paid work, trade and agriculture in Teguete, particularly for the poorest households, this may simply be a reflection of similar absolute incomes from the forest in both villages, but this being more important in Teguete (and making up a greater proportion of the total) because there are fewer alternatives. In contrast, Chapter 4 shows that the value of production from forest products is lower in Beayop than Teguete for all wealth ranks except the poorest, where it is approximately equal. That less of this produce is sold may be because it is less profitable, compared to the greater access to and income from other sources that Beayop offers.

The second season (and to some extent the third season) is shown to be the most vulnerable time of year. Indistinct evidence from previous chapters showing that consumption, production and income are lower in the second season is strengthened by results showing that children are most likely to

weigh relatively less in the second season. The second season is the first, and shorter, wet season, but is also the time when most agricultural work has to be done, as fields are cleared and planted for both peanut and Calabaza crops. In addition, there are no major crop harvests in this season (the two peanut harvests and the one Calabaza harvest occur in the other three seasons) and even staples may be more difficult to harvest (see agricultural calendar in Chapter 2).

In addition to seasonal effects, older children also weighed relatively less for their age. This has been shown in other developing countries, and often corresponds to a switch in diet at around two years old, from breast milk (or milk combined with solids), to diet of solids only that is high in carbohydrate and low in protein.

The only evidence for a difference in food or livelihood sources in the lean season was a lower income from agriculture in both villages. Given that agriculture provided the greatest production and income for most households, a lower income from agriculture would have a great impact (and is probably one of the reasons it is named the lean season). Given that the more vulnerable households have fewer livelihood and income sources, and earn a lower proportion of income or production from trade and paid work, it is likely that the most vulnerable households will both feel the reduction in income from agriculture more keenly, and be less able to make up any loss of income from other sources. In these cases, income from forest products is most likely to be one of the few options available.

In conclusion, there is strong evidence that wildlife products are particularly important to the most vulnerable households for income and livelihoods, but it is less clear that they are important as a food source. While there is no evidence that forest products are more important in the lean season, during this time there is lower agricultural income, and this is most likely to impact poorer households to whom forest livelihoods may be one of significantly lower income sources.

Chapter 6.

The implications of urban bushmeat markets for rural villages

6.1 Abstract

The hunting of wild meat for food is a major threat to biodiversity in many tropical forest areas, but finding an adequate measure of hunting sustainability has proved difficult. Recently, studies have turned to urban bushmeat market surveys as an indicator of hunting, but until now there have been few or no data on the reliability of these markets in reflecting village offtake. I compare data on bushmeat offtake from the two primary study villages, Beayop and Teguete, with data from two 'hunter' villages, Sendje and Midyobo, and use these and data from urban bushmeat markets to illustrate how the two primary study villages fit into the context of the bushmeat offtake across Río Muni. I then combine data from village offtake in Sendje and Midyobo with data from the urban markets they supply to examine filters in bushmeat trade from village to market. I show that trade filters may vary depending on the remoteness of the resource and the effective monopoly power of the trader. In Midyobo, a village with very limited market access, species most likely to be traded are those that maximise trader profits. In Sendje, a village with far greater market access, species more likely to be traded are those where hunters gain the greatest income. Bushmeat was supplied to urban markets from 16 catchment areas varying in market access, forest cover and human population density. Larger and more vulnerable species were more likely to be supplied by catchment areas that were less accessible to the city, while there was no effect of forest cover or human population density. This suggests that there is a gradient of offtake occurring which is driven more by urban demand rather than local consumption. Analyses of changes in prey profiles within single catchment areas, and of changes in travel distances within single species between 2003 and 2005 suggest that, in one market at least, traders may have reached the limit of their possible exploitation range, and that the pressure within that range is now increasing.

6.2 Introduction

The hunting of wild meat, or bushmeat, is increasingly viewed as unsustainable in many tropical regions, and is recognised as a major threat to biodiversity (Robinson & Bennett 2000; Bakarr et al. 2001; Milner-Gulland et al. 2003). Although greater access to forests and markets has increased the supply of bushmeat, it is the increased demand for wild meat, particularly in urban areas, that is widely perceived to be responsible for much of the increased commercialisation of the trade and bushmeat harvest. Developing reliable indicators to assess the sustainability of bushmeat hunting is important in order to understand the problem and to identify priority areas for intervention.

Unfortunately, data on wildlife population densities are very time-consuming and costly to collect (Plumptre 2000; Rovero & Marshall 2004), particularly for hunted species (Caro 1999), and data on

village or hunter offtake rates usually focus on small geographical areas (often only one village, e.g. Kümpel 2006), therefore limiting the scope for assessment of sustainability at a landscape scale. Researchers have therefore more commonly turned to data from bushmeat markets as a cheaper, easier way to collect data that potentially reflects the wildlife communities within given catchment areas, particularly across wider geographical scales (e.g. Fa et al. 2006). However, these approaches are often treated incautiously, and recent criticism has suggested that market data are insufficient to infer sustainability in many cases.

Previous studies have suggested a range of potential indicators of wildlife depletion or unsustainable hunting, including:

1. A decrease in the proportion of slow-reproducing, larger, more vulnerable species within a fixed catchment area, reflected in a decrease in mean body mass (Fa et al. 2000; Jerozolimski & Peres 2003) or an increase in mean intrinsic rate of increase of individuals (Rowcliffe et al. 2003) as demonstrated abundantly in the fisheries literature (e.g. Roberts 1997). Proxy measures for this have also been used, including the proportions of animal groups seen in the offtake, with an increase in the proportion of robust groups such as rodents or a change in the rodent:primate or rodent:ungulate ratios taken as an indicator of a loss of more vulnerable species groups (Wilkie & Carpenter 1999). However, while market surveys have often recorded species occurrence, they have rarely collected data on the geographical origin of these animals, which may lead to misleading conclusions as changes in the origin of animals confound these signals;
2. A change in origin of bushmeat, often to areas of higher wildlife abundance and which may be more costly to reach (Milner-Gulland & Clayton 2002), reflecting a possible decrease in wildlife in more accessible areas and an expanding frontier of exploitation;
3. An increase in bushmeat prices and possibly a reduction in trade volume suggesting that demand is not being met. However this depends on bushmeat not having cheaper or equally priced equivalents (i.e. bushmeat not being considered equivalent to alternative protein sources, Crookes et al. 2005).

Total counts of animal carcasses have also been used to infer hunting sustainability, either by a change in carcass number or total biomass harvested over time (Hearn & Morra 2001) or by comparing estimated total biomass extracted against estimated maximum sustainable harvest rates (Wilkie & Carpenter 1999; Fa et al. 2006). However, both these inferences are problematic. The former requires knowledge of the numerous alternative social, economic, biological and policy-driven potential causes of a decrease, which is unfeasible in all but the best known systems. The

latter requires knowledge of the size of the source forest area and the proportion of total offtake represented by market offtake, and even then is subject to criticisms that offtake may not necessarily be unsustainable if at documented levels for only a short period of time, and that sustainability itself is not possible to detect.

Even when long-term data sets exist, it has still proven difficult to infer sustainability within a market, except in a few isolated incidences where additional data on prices of bushmeat and alternatives over a long time period, origin of animal carcasses and other data from catchment areas are also known (Cowlishaw et al. 2005). Crookes *et al* (2005) describe three main problems with inferring sustainability from market data: lack of knowledge on the origin of bushmeat in markets that often have a large catchment area, meaning that local wildlife depletion may be undetected as traders move to new areas; lack of understanding of how representative market data is of actual forest offtake, given that species may be traded or consumed in the village in varying proportions; and lack of knowledge about the economic drivers of hunter and consumer behaviour (critical determinants of levels of hunting and prey selection), making sustainability near impossible to ascertain in its absence.

In this chapter, I use a dataset collected over 24 months in 2003 and 2005 in two urban markets in the principal town of continental Equatorial Guinea, coupled with detailed offtake data from Beayop and Teguete, and from two 'hunter' villages, Sendje and Midyobo. Firstly, I compare village bushmeat offtake between the four villages to put the study villages in the national context. I then look at the difference between carcass profiles in Sendje and Midyobo and the carcasses arriving in the urban market from those villages during the same period to see how reliable market data are as a reflection of hunter offtake. Thirdly, I use data on human population density, market access and forest cover of 16 groups of villages ('catchment areas') supplying these urban markets to study the determinants of bushmeat offtake and differences in prey profiles from different regions. Lastly, I analyse changes in prey profiles within catchment areas and changes in travel distance within species to obtain some indication of the sustainability of bushmeat hunting and trading in continental Equatorial Guinea.

6.3 Methods

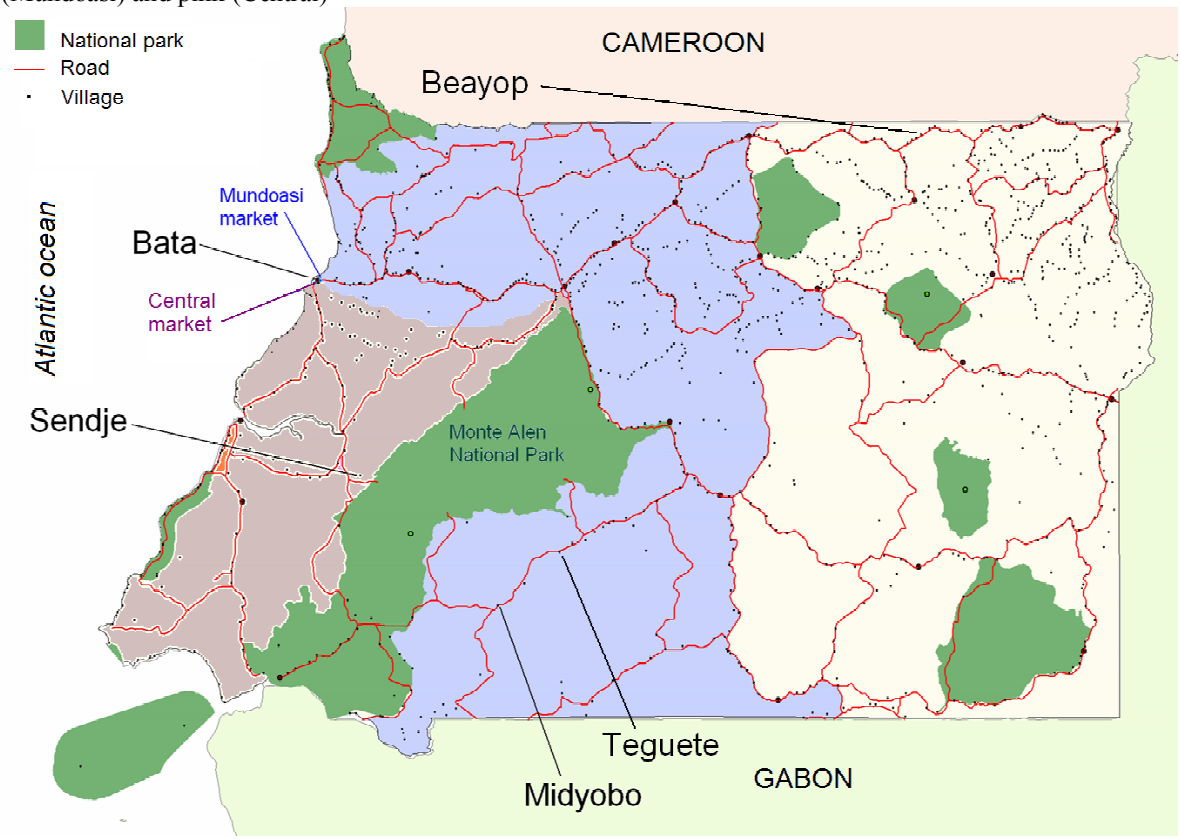
6.3.1 Study area

This study was conducted in Río Muni, the mainland province of Equatorial Guinea. The discovery of offshore oil in 1995 has led to a booming economy that was one of the world's fastest-growing in

2001 (UNSD 2008), averaging at 37% annual growth in the decade 1996-2006 (IMF 2006). Urban population and incomes have also increased. The proportion of urban population of the country rose from 35% in 1990 to 50% in 2000 (UNPD 2004). The official monthly minimum wage increased from 25,000 CFA (US$46) in 2000 to 90,000 CFA (US$164) in 2003, at which it remained until at least 2005 (Education International 2007). This has led to a 39% increase in cost of living and general consumer prices between December 2000 and December 2005 (IMF 2006).

Data were collected in Bata, the principal city of Río Muni, and the villages of Beayop, Teguete, Sendje and Midyobo Anvom (hereafter 'Midyobo'). Beayop was out of the catchment zone for Bata markets, and there was no evidence that it supplied any urban bushmeat markets, with any meat being sold locally. Levels of hunting were higher in Teguete than Beayop (see Chapter 4), but no traders visited the village specifically, buying meat in passing on the way to more remote villages. In contrast, both Midyobo and Sendje were major suppliers of bushmeat to the Bata markets during the study and both were the among the closest villages to the Monte Alén National Park, being 10km to the west and 40km to the east of the Park respectively (Figure 6.1). However, they differ greatly in access to markets: Sendje is about one hour by local transport to Bata and consequently has a number of regular bushmeat traders visiting (usually 2-4, visiting on Mondays, Wednesdays and Fridays), using share taxis. It is also on a main road, and is passed by numerous cars daily. Midyobo is approximately 10 hours from Bata by local transport and in 2005 was visited by one or two traders once or twice a week only. It is the only village a two-hour car journey along an abandoned logging road and the only cars that tend to visit the village are those of the traders. There are two bushmeat markets in Bata, Central market, towards the south of the city, and Mundoasi market, towards the north. The position of the markets in the city affects bushmeat supply. Bushmeat in Central market tends to come from the south, including Sendje, and bushmeat in Mundoasi market from the north and east, including Midyobo (Figure 6.1).

Figure 6.1 Map of Río Muni showing approximate market catchments for Mundoasi and Central markets in Bata.
Bata, the primary study villages Beayop and Teguete, and hunter villages Sendje and Midyobo are marked. Protected areas are shaded in green, including Monte Alén National Park, the largest protected area in Equatorial Guinea at 2000km^2. Approximate catchments for the two Bata markets are shown in blue (Mundoasi) and pink (Central)



6.3.2 Data Collection

Data for 2005 were collected in Central and Mundoasi markets according to standard methods (e.g. see Kümpel 2006). After a preliminary investigation and research assistant training, data were collected for 12 months (5/2/05–3/2/06), three days a week in each the two markets (i.e. on alternate days) Monday – Saturday for four hours a day. Once a month, the research assistant spent an entire day (06:00 – 17:00) at one of the markets to record any meat coming to the market outside the normal hours of data collection. At each market stall, data were collected for each carcass on the species, state, sex, age, method of capture, village and district of origin, price bought by traders (as reported by traders), price bought by consumers (as reported by traders, but verified by direct observation of sales on numerous occasions), and unit of sale (e.g. whole animal, quarter animal, leg, etc.). Data were also collected on the date the carcass had first appeared in the market (i.e. whether it was new to the market that day, or had arrived on a previous day). Data on carcasses that had not arrived on the day of recording were discarded to avoid duplication.

Data for 2003 were collected in the same way at Central market between January 2003 and December 2003 (Kümpel 2006) and at Mundoasi market for eight weeks in April and May 2003 using similar methods (Puit 2003; Puit et al. 2004). Information was collected on species, state, sex, method of capture, district of origin, price where possible, and for Central market, village of origin.

Village offtake data were collected in Beayop and Teguete from November 2005 – May 2006, according to the methods described in Section 4.3.1. Similar data were collected in the villages of Sendje and Midyobo in 2003 and 2005 respectively. In Sendje, hunter offtake was recorded throughout 2003, with data on carcasses collected directly from the hunters as they returned from hunting trips with their quarry (the vast majority of hunters used just one entry point to the forest, see Kümpel (2006)). All carcasses were weighed and measured *in situ*. In Midyobo, hunter offtake was recorded over eight months in 2005 through weekly recall interviews with hunters and daily records kept by hunters whilst in hunter camps (Rist 2007). In both villages, data were collected on species, age class, state, method of capture and sex for all carcasses. Both periods of village offtake recording overlapped with data collection in the Bata markets.

6.3.3 Data analysis

Market filters

Species profiles from all village offtake, village offtake reported as being sold, and urban markets were compared to look at differences in species size for carcasses sold compared to all carcasses in the four villages. Following this, detailed analysis was conducted to assess how representative market data are of village offtake and the factors affecting the likelihood of a particular species being sold to market or remaining in the village were investigated. The number of carcasses of each species recorded in the two hunter villages (Sendje and Midyobo) was compared to the number of carcasses of that species recorded in the market as coming from that village during the same time period. Data from the two villages were analysed separately, due to differences in village characteristics and year that they were collected. The probability of each species appearing in the market was compared to the following explanatory variables (see Table A 9.3 for further details):

- **Average species mass:** Weights used are those recorded in the Sendje offtake by Kümpel (2006) and represent the mean mass by species for all fresh adults (n = 5142). Where available were not available from the Sendje offtake, mean adult body mass was taken from Kingdon (1997).
- **Price/carcass:** Taken as average price per fresh adult carcass in Central market in 2003 (for the Sendje filters) and Mundoasi market in 2005 (for the Midyobo filters). Where carcasses were sold in pieces, the total price of all pieces was taken. Other valuations of price were

also considered (average price/adult carcass) but there was no significant difference between the two sets of figures.

- **Price/kg:** Price per dressed kg was calculated using the above data and based on average dressed weight as 0.65 of total body mass following the upper scale reported by Talbot *et al.* (1965).
- **Consumer preference:** Preference figures were taken from a study in Sendje, Equatorial Guinea asking respondents to rank each species (or group of species) from 1 (hate) to 5 (love). Scores were averaged to give a preference score for each species (Kümpel et al. 2007).
- **Trader profit 'mark-up':** For each carcass, the market price as a proportion of the village price was calculated (i.e. if a carcass bought in Sendje village was sold for double the price in Bata market, it was given the mark-up value of 2). The average mark-up for each species was calculated separately for Sendje and Midyobo. Transport costs were not included in the calculation as per kg costs from a single village were the same, so should not impact selection of species within a village.
- **Proportion of fresh carcasses:** For Sendje only, the proportion of carcasses in the village that were fresh or alive (as opposed to rotten or smoked) when brought into the village from the forest was calculated. Figures for the proportion of fresh carcasses in the market originating from Sendje were examined, but the lower sample size meant that there were too many species where all carcasses were recorded as being fresh, skewing the data. Using the proportion of carcasses that were fresh from all villages could have biased the results as it is likely that the proportion of fresh carcasses varies with origin village. For Midyobo, data on the proportion of fresh carcasses at the village level were not available, and other estimations had the same problems as with Sendje data, so this variable was not included in the Midyobo analyses.
- **Capture method:** Hunter methods were split into two groups. Unselective methods ('chance') were predominantly wire snares, but also species collected opportunistically by hand in passing (e.g. snails and tortoises). Selective methods ('target') were predominantly guns, but also lassos (used for crocodiles).
- **Season:** Seasons were defined as 'Small Dry' (Dec-Feb), 'First Wet' (Mar-May), 'Big Dry' (Jun-Aug), and 'Second Wet' (Sep-Nov).

All data were analysed in R, version 2.5.0 (R Development Core Team 2007). Data on market filters were analysed using a generalised mixed linear model with a quasi-binomial error structure and the maximum likelihood method, using the lme4 library in R (Bates & Sarkar 2007). The

dependent variable was the bound two vector response variable (number of carcasses sold to market, number of carcasses not sold to market). The number of carcasses sold to market was taken as the number of carcasses of that species for that time period from that village counted in the urban market, with adjustments made to account for differences in sampling. The number of carcasses not sold to market was taken as the total number of carcasses for that species in that time period recorded in the hunter offtake for that village, minus the successes. All explanatory variables (as listed above) were tested for normality and transformed where necessary. Similarly, correlations between explanatory variables were tested, and none found to be significant. Species was specified as a random effect. The model was simplified to obtain the minimum adequate model by fitting the saturated model and then comparing models with progressively simplified fixed effects using ANOVA. Significance was taken as $p<0.05$.

Catchment areas

Traders often bought bushmeat from more than one village in the same trip, and because they could not accurately recall which of the villages each individual carcass came from, many carcasses were recorded as coming from one of two or three villages. In addition, some hunter villages were very close together, so would have similar characteristics and potentially overlapping hunter zones. In order to look at the characteristics of origin village compared to the bushmeat they supplied to the market, these origin villages were grouped into 17 catchment areas of between 1 and 9 villages. A buffer area of 15km (the maximum distance travelled by hunters in Midyobo) was taken along the road between the first and last village in each group, and this was taken to be the catchment area from which bushmeat was sourced by hunters.

The species profile for each catchment area was characterised in two ways:

- **Average carcass mass** - calculated across all carcasses using average kg per fresh adult per species from Kümpel (2006); see Table A 9.3 for values used.
- **Average carcass Rmax -** calculated across all carcasses using species Rmax values as taken from Rowcliffe (2003), see Table A 9.3 for details and values used.

The amount of bushmeat harvested from each catchment area was characterised in four ways:

- **Kg meat/km^2** - total dressed weight of meat arriving at the market from the catchment area (as calculated from the average species mass) divided by the total km^2 of the catchment area.
- **Kg meat/village -** kg meat as calculated above, but divided by the number of villages recorded hunting within the catchment area.

- **No. carcasses/km^2** - number of carcasses arriving at the market from the catchment area divided by the total km^2 of the catchment area.
- **No. carcasses/village** – number of carcasses as above, but divided by the number of villages recorded hunting within the catchment area.

Each of these six dependent variables was analysed in turn to evaluate what effect, if any, was had by the following four catchment area parameters:

- **Population density** - taken from LandScan 2005 Global Population Database (ORNL LandScan^{TM} 2005) at 30 arc seconds (1km or finer).
- **Village density -** calculated in ArcMap from the map of Equatorial Guinea produced by the EU-funded Project for the Conservation and Management of Forest Ecosystems in Equatorial Guinea (CUREF) and the Ministry of Forests and Environment, Equatorial Guinea (CUREF 2002) as number of villages per 100km^2.
- **Access to markets** - calculated as time taken to travel to the mid-point in each catchment area. Road distances and type were taken from CUREF map of Equatorial Guinea (CUREF 2002), as used for village density, and km/hr speeds taken from the African Population Database estimates (UNEP/CIESIN), namely 50km/hr primary roads (motorway/major road), 35km/hr secondary roads (all weather/improved) and 25km/hr tertiary roads (partially improved/earth roads). An additional fourth category was included to cover unmaintained roads in very poor condition (15km/hr; author's estimation).
- **Access to forests** - taken as percentage tree cover in the catchment using 500m resolution MODIS data from the period November 2000 to November 2001 (Hansen et al. 2002; Hansen et al. 2002). This calculates percentage tree, herbaceous and bare land cover, but as there was no bare land cover except for one large river and the sea, percent tree cover only was used (and can be thought of as a ratio of tree:herbaceous cover). Although this data is potentially dated, there has not been significant deforestation since then: logging that does take place is predominantly selective for high value trees.

Each of the six dependent variables (representing aspects of the prey species profile or the quantity of bushmeat harvested from each catchment) were analysed in linear models to evaluate the effect of the four independent variables of catchment area characteristics. Data from each catchment area were weighted by the number of carcasses recorded by that catchment area. Due to unequal sampling in 2003 (because origin data exist only for Central market in this year), only data from 2005 were used.

Indicators of changing markets

I evaluated differences in the bushmeat harvest recorded in urban markets between 2003 and 2005 in two ways. Firstly, I analysed changes in average carcass Rmax and body mass within catchment areas using paired t-tests. As data on the village of origin of bushmeat carcasses existed only for Central market data in 2003, I could only compare offtake from a limited number of catchments, excluding those that predominantly supplied Mundoasi market, leaving a relatively low sample size of nine catchment areas. Secondly, for each species I compared the change in average distance travelled by carcasses in 2003 and 2005, and analysed this change in average distance per species against species Rmax. This change was also analysed with respect to species average body mass.

6.4 Results

A total of 11707 carcasses were recorded in Central market in 2003 (sampled as far as possible every day of the week) and 5268 in 2005 (sampled 3 days/week, and excluding Sundays) giving an estimated 11553 carcasses in 2005, taking into account missed sampling days. In Mundoasi, 4328 carcasses were recorded over 8 weeks in 2003 and 9348 in 2005 (sampled 3 days/week excluding Sundays), giving an estimated 31390 and 24883 carcasses/year in 2003 and 2005 respectively. This resulted in an average 197kg bushmeat per market day in Central market and 415kg/day in Mundoasi market. With an estimated population of 230,000 in Bata (Equatorial Guinea Census 2001), this gives 0.83kg bushmeat/person/year, just from meat recorded in the markets.

6.4.1 Price

There is a significant difference in price between product types and within bushmeat species. On average, fresh domestic meat is most expensive per kilo, followed by bushmeat then fresh fish, but there are large variations in price for the latter two (Figure A 9.3). Within bushmeat species, preferred species are significantly more expensive ($t=2.151$, adjusted, $R^2 = 0.28$, $df = 33$ $p < 0.05$). There is also a slight effect of average species size on price for bushmeat ($t = -1.92$, $p = 0.064$), with smaller animals being more expensive, as noted previously by Kumpel (2006).

6.4.2 Differences in species profiles

Hunter offtake recorded in villages varied between Beayop, Teguete, Sendje and Midyobo. As expected, Beayop had a higher proportion of smaller, more robust species (Figure 6.2), particularly showing a higher proportion of rodents, and lower proportion of ungulates and primates (Figure 6.3). Midyobo, the most remote village, showed the highest average carcass mass, lowest average R

max, lowest proportion of rodents and highest proportion of primates, while Sendje and Teguete showed fairly equal average mass and R max levels.

Figure 6.2 Average carcass mass and carcass R max recorded in village offtake for four villages.

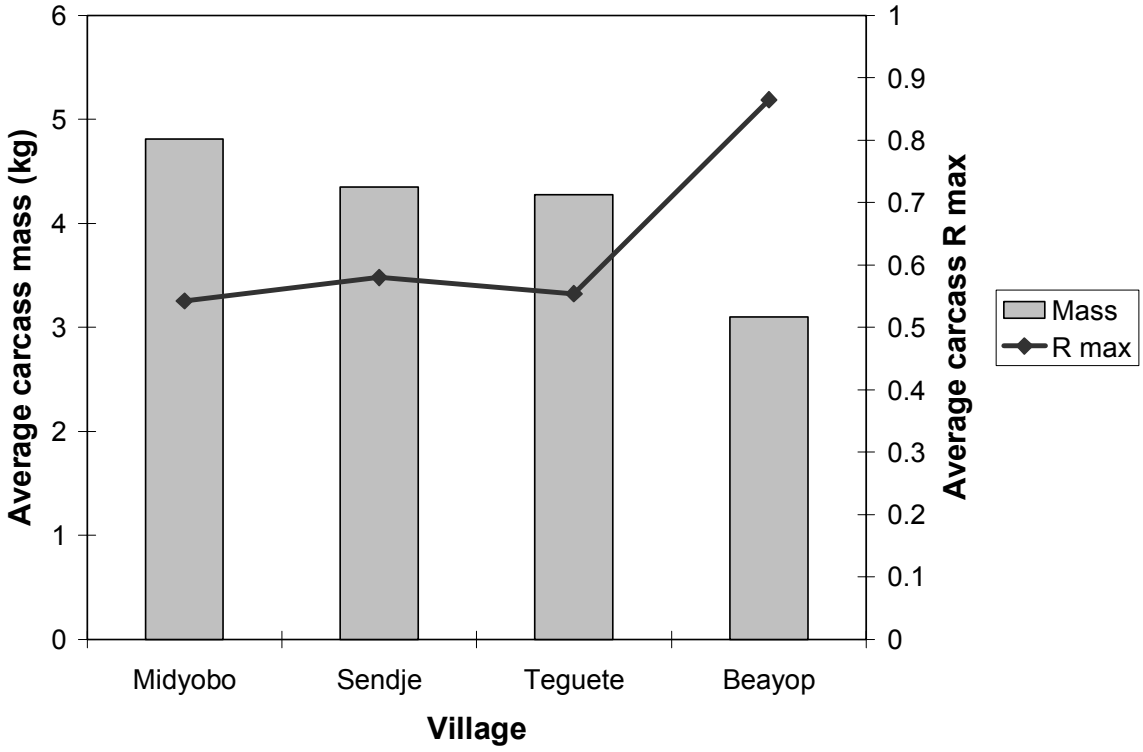
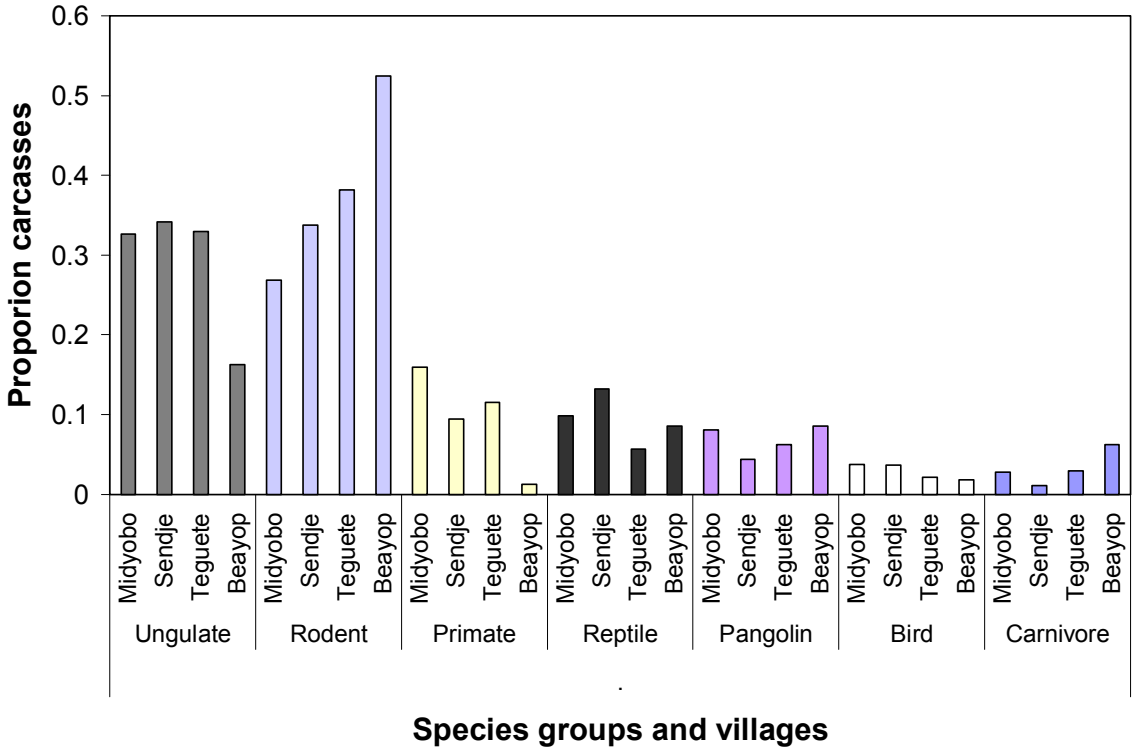


Figure 6.3 Proportion of carcasses recorded in village offtake for different species groups in four villages.



Amongst urban market bushmeat, larger species and species with a lower intrinsic rate of increase (i.e. more vulnerable species) were more likely to come from villages that were more difficult to access from the market, as measured by travel time to market (Table 6.1). In contrast, human population density and village density had no significant effect on average Rmax or body mass of offtake in different catchment areas. Percentage tree cover was correlated to market access, so these were analysed separately. Market access was found to be a better fit for the data, and was therefore used in subsequent analyses. In addition, the low variation and at times counter-intuitive distribution of tree cover values suggests that it may be difficult to distinguish between fallow agricultural land, secondary forest and primary forest.

I found no significant effect of catchment area characteristics on the quantity of bushmeat that each catchment contributed to the urban market. Quantity of bushmeat was calculated as amount of meat harvested/km^2 using original catchment areas, and also recalculated to exclude any land more than 15km from a village (i.e. in catchments further from Bata with more sparsely spread villages). I also calculated the number of carcasses and total kg of meat harvested per village, but these did not correlate to any catchment characteristics (Table 6.1).

Table 6.1. Linear model results for the effect of catchment area characteristics on prey species profile and bushmeat total offtake.
Data from 2005 only are used, to avoid effects of differential sampling of villages.

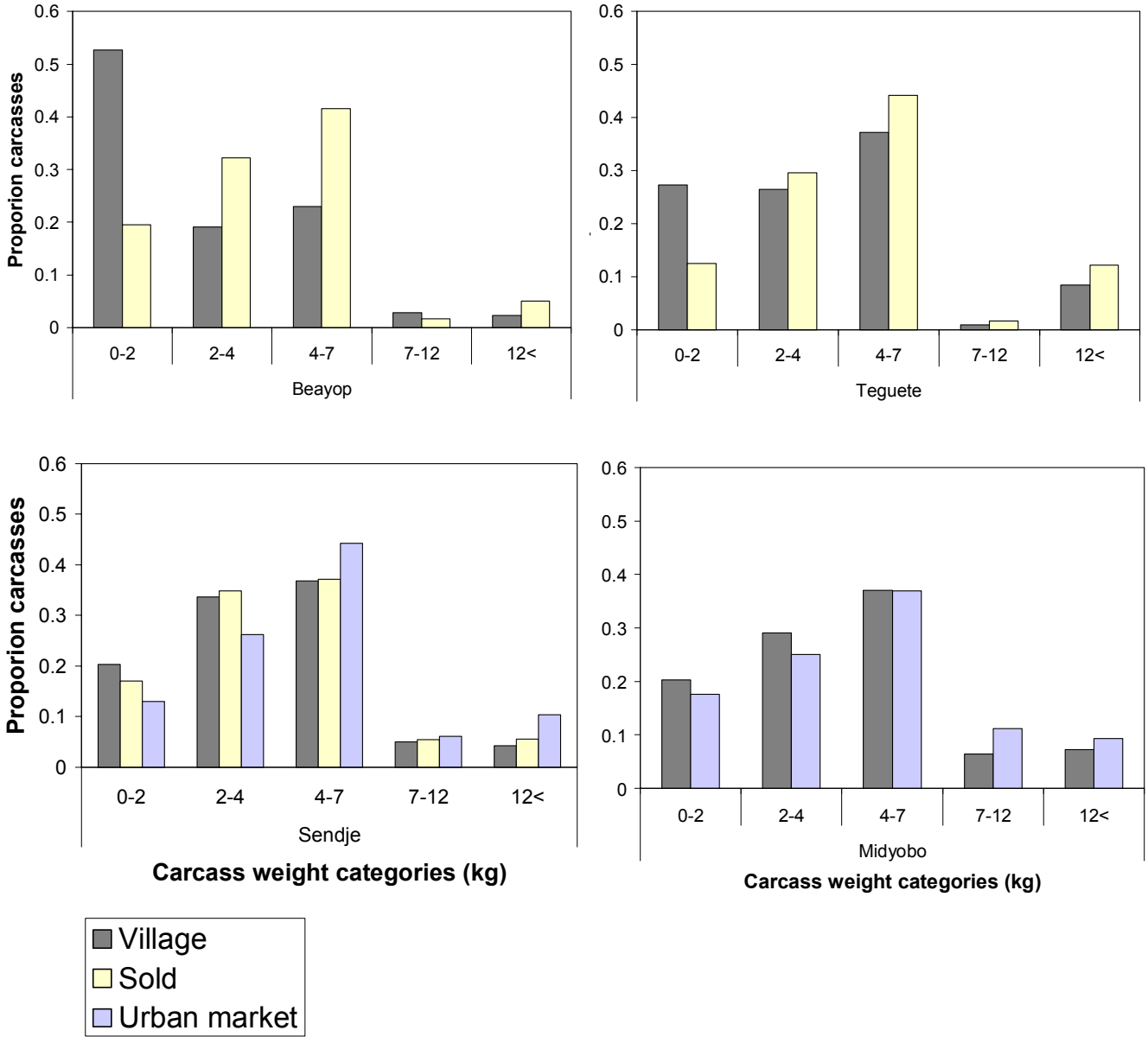
Catchment explanatory variables (data range in brackets)	Prey profile of catchment					
	Average carcass mass	Average carcass Rmax	Kg meat/ km^2	No. carcasses / km^2	Average kg meat /village	Average no. carcasses/ village
Village/Km^2 (0.008 - 0.09)	ns	ns	ns	ns	ns	ns
Population density (2.13 – 76.64)	ns	ns	ns	ns	ns	ns
Hrs travel (0.55 – 7.03)	(p = 0.061)	SE = 0.02 estimate = -0.058 p < 0.01	ns	ns	(p = 0.07)	ns
Tree Cover (63.5 – 76.8)	ns	ns	ns	ns	ns	(p = 0.07)
Overall model	Null model	Adj R^2 = 0.33 d.f. = 15, Residual SE = 0.70	Null model	Null model	Null model	Null model
N (catchments) = 17, N (carcasses) = 12999						

6.4.3 The reliability of bushmeat market data as an indicator of village bushmeat offtake

The species profile of village bushmeat harvests was significantly different to the species profile of carcasses reported as being sold (in village surveys), and different to the species profiles of carcasses going from that village to the urban market, showing that some filtering processes are taking place (Figure 6.4). For Beayop, Teguete and Sendje, hunter surveys recorded what the hunter did with each carcass captured, showing whether it was sold (both to urban traders and local consumers and traders) or consumed, with species over 2kg being generally more likely to be sold than smaller species. This was lower than the average carcass mass sold to urban markets in these villages, suggesting that the trade filters are either different or more relaxed for village sales.

Figure 6.4 Graphs showing the proportion of carcasses for different weight categories in four villages.

Data are shown for all carcasses recorded in village offtake ('Village'), those carcasses reported as being sold during village surveys to all destinations, including local sales ('Sold'), and as recorded in urban market offtake during the same period. There are no urban market data for Beayop and Teguete, as these did not appear in urban markets. There are no 'sold' data in Midyobo, as the destination of carcasses was not recorded.



The types of species more likely to be sold to urban markets varied between the two villages where data were available. In both villages, there was a higher proportion of larger species in the urban market sales than in the village offtake, but there were some significant differences between the two villages. In Sendje, species with a higher price per carcass were more likely to be sold to market. In Midyobo, by contrast, species with the highest price mark-up were more likely to be sold (Table

6.2). Consumer preference, and proportion of carcasses brought back to the village fresh had no effect on likelihood of sale to urban areas in either village.

In both villages, species normally caught by selective methods (guns or lassos) were more likely to be sold to market than those species normally caught by unselective methods such as traps (Table 6.1). Similarly there was a significant effect of season in both villages, with carcasses more likely to be sold in the first (Small Dry, and relatively hot) season. Carcasses were less likely to be sold to market in the second (First Wet, also relatively hot) season, although there was some difference between Midyobo and Sendje. Differences between seasons were tested, and all seasons were significantly different from each other. There was also a significant interaction between species capture method and the season caught. Particularly in the second season, but also in the third (Big Dry, relatively cooler) season, animals caught by selective methods were more likely to be sold to market than those caught in traps (see Figure A 9.1).

The ability of market surveys to detect trade levels of vulnerable species was assessed by looking at the relationship between price/carcass (Sendje) or the mark-up value (Midyobo) and species intrinsic rate of increase (Rmax), used here as an indicator of vulnerability. For the Sendje data, the more vulnerable species generally had a higher price (often because they are bigger). However, as some vulnerable species (particularly primates) may have a lower price/carcass than other species of similar vulnerability (Figure A 9.2), they may be under-represented in market surveys. A comparison of price mark-up with Rmax in the Midyobo data shows that species with a higher mark-up (which the data show are more likely to be sold to market) are actually the more robust species and again vulnerable groups such as primates may be under-represented in the market.

There was some level of correlation between the explanatory variables. In particular, price/carcass was highly correlated with species mass and price/kg, which is unsurprising given that price/carcass is a direct function of the other two variables. Consequently mass and price/kg were analysed separately from price/carcass. Mass and price/kg were significantly correlated to the likelihood of sale to market in Sendje, but this model was not as good a fit to the data as the price/carcass model. Other variables were correlated, albeit not significantly (Table A 9.1 and Table A 9.2).

Eight taxa (*Panthera pardus*, *Loxodonta africana, Synceros caffer, Aonyx congica*, *Conrana goliath, Achatina spp.*, squirrels and potto; see Table A 9.4 for species list) were recorded in one or both of the two villages, but not in the urban markets (or at least not as coming from the study villages). The lack of data on price, price mark-up and consumer preference meant that these

species were excluded from the analyses. Whilst they made up only a small proportion of carcasses and kilos of bushmeat in the village, these taxa tended to be either very large and rare (e.g. leopards and elephants), or small and with a very low value (e.g. squirrels, frogs and snails).

Table 6.2. Factors affecting likelihood of carcasses in Sendje and Midyobo villages being sold at urban markets.
Data analysed in a generalised linear mixed model with a quasi-binomial error structure.

Explanatory Variables		**Sendje**				**Midyobo**			
	Levels	Parameter estimate	d.f	χ^2	p	Parameter estimate	d.f	χ^2	p
	Intercept	*-13.52*				*-1.29*			
Preference Score					ns				ns
Mark-up					ns	0.53	1	40.8	<0.0001
Proportion of fresh carcasses					ns			NA	ns
Price/carcass (log)		3.32	1	37.5	<0.0001				ns
Capture Method	Chance Target	 1.01	1	5.17	<0.03	-1.79	1	8.61	<0.005
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0.58 -0.39 0 -1.23	3	556	<0.0001	0 -1.17 -3.81 0.68	3	766	<0.0001
Season:Method	1 SD/Target 2 FW/Target 3 BD/Target 4 SW/Target	0.69 0.89 0 -0.05	3	35.5	<0.0001	0 2.77 4.82 -0.58	3	138	<0.0001
Overall Model	Deviance =281.5 SD (species) = 1.7022, SD (residual) = 1.6667 n (species) = 23, n (observations) = 83 n (village carcasses) = 7745, n (market carcasses) = 2119 Data collection: 4/1/03 – 20/12/03					Deviance = 579.5 SD (species) = 3.3556, SD (residual) = 2.4857 n (species) = 21, n (observations) = 78 n (village carcasses) = 7473, n (market carcasses) = 2167 Data collection: 25/4/05 - 1/2/06			

This is demonstrated by the fact that average carcass mass recorded in village offtake in all four villages is lower than that recorded in urban markets from any catchment (Figure 6.5). Similarly, average R max is higher for village offtake than that recorded in urban market data for almost all catchments (Figure 6.6).

Figure 6.5 Average carcass mass from different catchments in 2003 and 2005, compared to village offtake and village offtake reported sold in four villages.

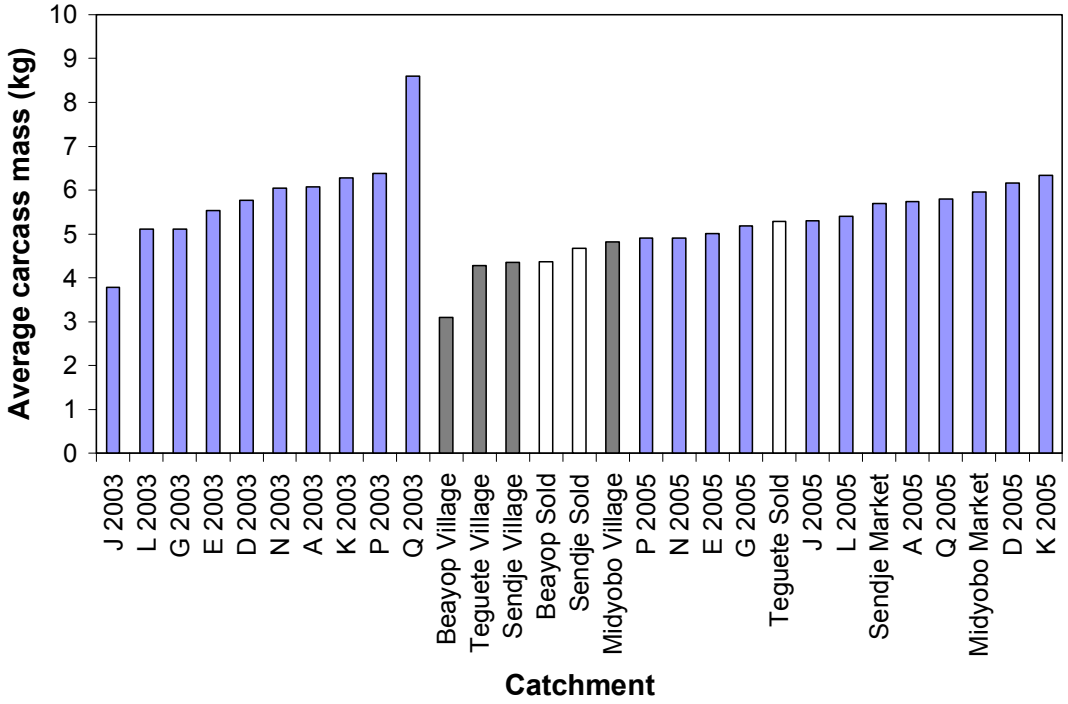
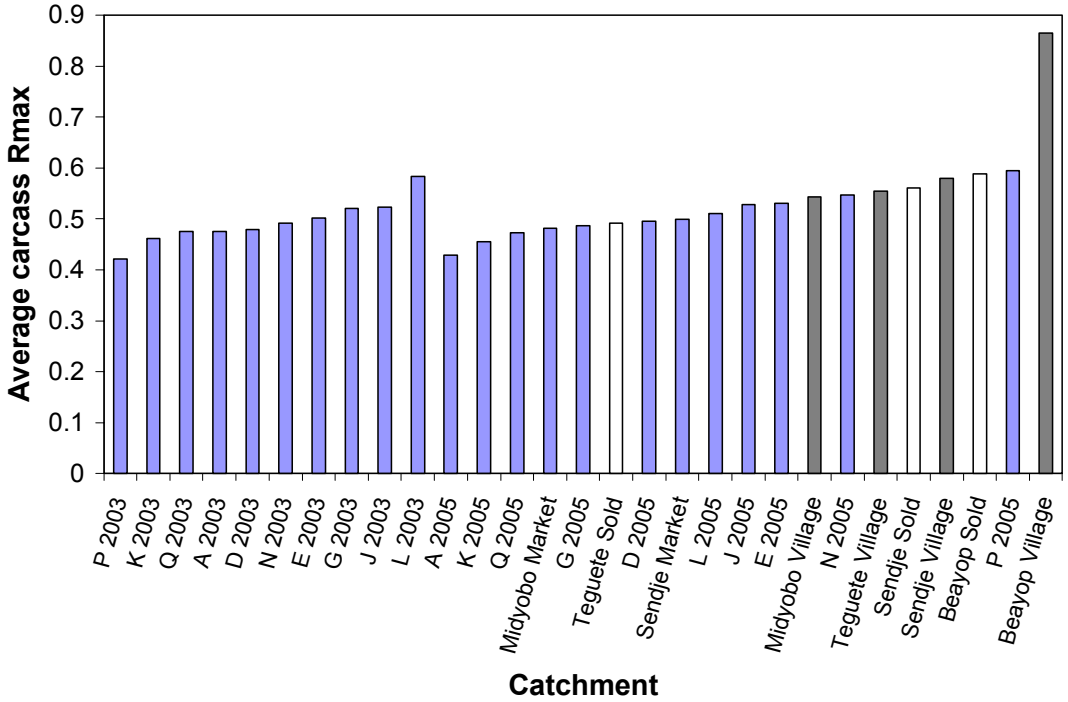


Figure 6.6 Average carcass R max from different catchments in 2003 and 2005, compared to village offtake and village offtake reported sold in four villages.



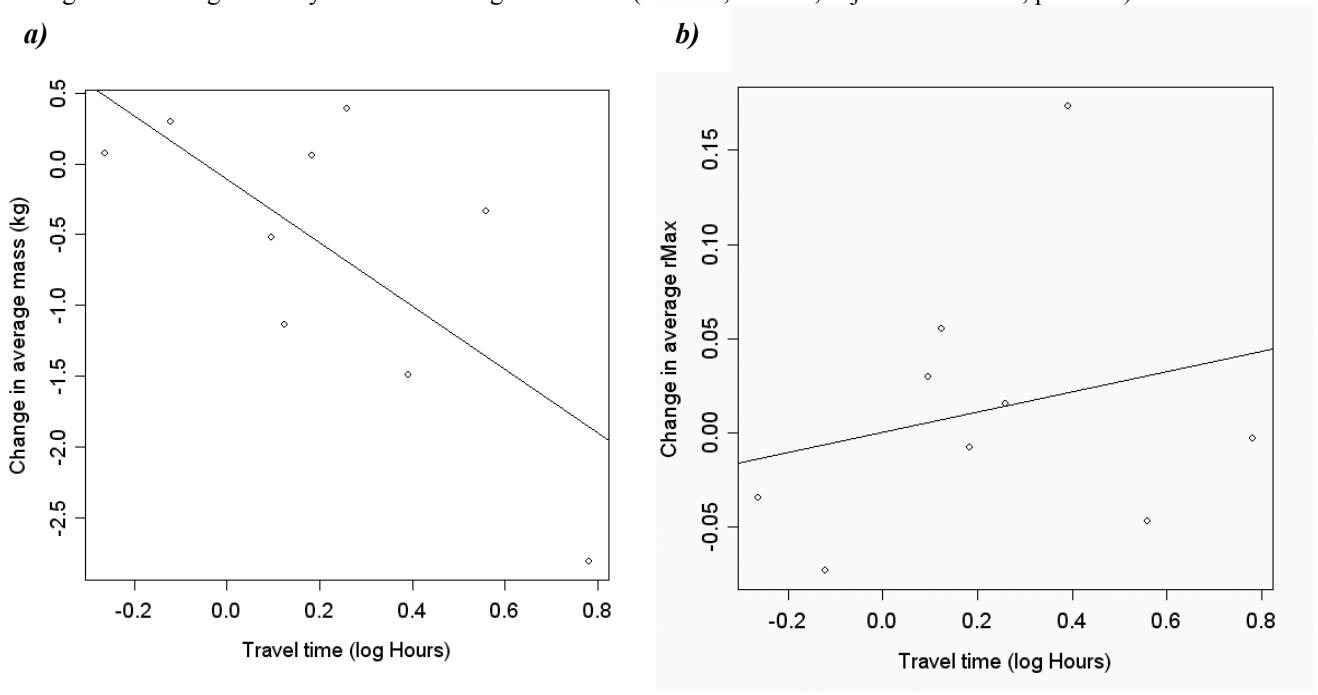
6.4.4 Indicators of changing exploitation

There was an overall increase in average Rmax (0.496 to 0.521) and decrease in average species mass (5.73kg to 5.13kg) between 2003 and 2005 in Central market, and a similar increase in Rmax (0.426 to 0.482) in Mundoasi for the same years but a small increase in average mass (5.60kg to 5.73kg). However, these figures alone say nothing about sustainability as such changes could be the result of changing areas of hunting, changes in access, change in demand, or other factors.

A comparison of average species mass and average Rmax between 2003 and 2005 for those catchment areas where there were >20 carcasses recorded in both years (only 9 catchments), showed no significant difference between 2003 and 2005 (paired t-tests: mass: d.f. = 8, t = 1.75, p = 0.12; Rmax: d.f. = 8, t = -0.50, p = 0.63). However, there is a correlation between the change in both average mass and average Rmax and travel time to catchment (Figure 6.7). Catchments showing an increase in average Rmax or a decrease in average mass are significantly further away from Bata. No other catchment characteristics are correlated. These results suggest that areas near to the urban centre have already experienced some loss of larger and more vulnerable species, and that consequently their average mass and Rmax figures may be more stable than those catchment areas further away that are currently experiencing a decline in larger or more vulnerable species. This may be particularly true of Central market where the traders are already going to the geographical limits of the area (Figure 6.1).

For carcasses arriving at Central market, the average distance travelled per carcass was 33.5 km in 2003, and 45.9km in 2005. However, this could be due to a change in species composition, so this was investigated by species. There was a significant increase in average distance travelled between 2003 and 2005 at the species level (paired t-test: t = -6.61, df = 19, p < 0.001; see Figure A 9.4). Only Rmax is significantly correlated with the change in distance travelled, with animals with a greater Rmax being more likely to increase the distance travelled between years (t = 2.38, p = 0.029, adjusted R^2 = 0.197, df = 18, Figure A 9.5). This echoes the previous result, suggesting that vulnerable species are already seen only in the furthest catchment areas, and it is the species of medium to low vulnerability that traders are now having to travel further to obtain.

Figure 6.7. Change in average a) mass and b) Rmax for each catchment between 2003 and 2005, against catchment travel time to market.
a) Change in average mass is significantly correlated to log travel time ($t = -5.29$, d.f. = 7, adjusted R-sq = 0.77, $p < 0.01$), analysed with a linear model, weighted by total number of carcasses in catchment. Change in average Rmax is significantly correlated to log travel time ($t = 2.85$, d.f. = 6, adjusted $R^2 = 0.44$, $p < 0.05$).



6.5 Discussion

The data presented show that the trade filters affecting the proportion of each species sold from hunters to urban markets are complex and may vary between villages, depending on remoteness and the effective monopoly power of the trader. In Midyobo, a village where traders visit only once or twice a week, species most likely to be traded were those with the highest mark-ups, or effectively those with the highest profit per kg, so maximising trader profits. In contrast, in Sendje, a village with much greater market access and several cars passing daily, the most significant factor in the probability of a species being sold to urban markets was the price/carcass, effectively profitability to hunter. A similar result has been shown by Brooks (2008), where mark-up varied with distance for water snake traders. In both study villages, although meat was only very rarely refused by a trader (with the exception of rotten meat), in situations where a hunter wants to sell only part of his catch and eat the rest, the decision over which species is sold may depend on the balance of power between the hunter and the trader.

There may also be some implications of this for selective hunting methods. Species normally captured by a targeting method such as a gun are far more likely to be sold to market. This is

probably due the fact that a gun hunter is more actively choosing the species hunted (and so is unlikely to target something undesirable) and can choose the time of day or week to go hunting, and so can coordinate hunting trips with trader visits, leaving less time for the meat to go rotten (or avoiding having to smoke it to preserve it). Rotten meat was rarely seen in the urban markets and smoked meat was a lower price/carcass than fresh meat, so rendering less profit per carcass. Seasonal differences are likely to be due to a range of factors. Increased humidity and temperature affects the ability to store bushmeat and the speed at which it rots in a trap, so meat in hot or wet seasons (particularly if trapped) may be less likely to be fresh when the traders arrive. Other factors also potentially affecting seasonal patterns of trade include local changes in job availability and seasonal changes in hunter effort (e.g. more people hunting before Christmas). In addition, the relatively small number of traders means that the decision of one individual trader to trade in a particular week had a large effect on the data in some circumstances, which may also have contributed to the differences between seasons.

The results suggest that market data can be a useful reflection of hunter offtake, but that to have confidence in the results and their limitations, it is also necessary to have an understanding of the factors affecting trade filters and consequently what may be over- or under-represented in the data. Particular caution should be taken in assertions concerning the following taxa:

- Taxa which are vulnerable but have a relatively low market price or profit may be under-represented in urban markets, but village offtake may still be high. In the study area, primates are not particularly preferred, and given their high vulnerability relative to other taxa, the overall price/carcass is therefore likely to be low compared to their vulnerability.
- Valuable or preferred species, which may be over-represented at the urban market level.
- Species which have specialist markets, are illegal to hunt or are particularly rare may not appear in urban markets at all. In this study, some of the largest and more vulnerable species (such as elephants, gorillas, leopards, buffalo) did not appear in the market, despite the fact that they were recorded as being hunted in the study villages. Elephants (the only species which require a licence to kill) were generally consumed and sold in the villages, mainly due to problems of transporting the meat and low price/kg. Buffalo, although not illegal to hunt, were also generally eaten and sold in the villages due to transportation problems. The two leopards caught were consumed and sold locally, with the skin prepared for later sale.

Unsurprisingly, species profile varies between catchment areas. However the only catchment characteristic that affects species profile is access to the village: human population density and

vegetation cover have no significant impact. This suggests that hunting is driven more by urban demand than local consumption and emphasises the impact of new roads and the opening of forest areas by logging and road companies, as noted by other authors (Wilkie et al. 2000). In addition, while I would expect a gradient of resource exploitation moving away from populated or urban areas, our results suggest that we should base our expectations on transport and access routes, rather than population density, forest cover, or absolute distance. The lack of attributable variation in quantity of bushmeat between catchment areas could mean that traders are acting economically rationally and balancing the increased costs of further transport with the ease of access albeit lower returns of nearby areas.

Whilst it is difficult to assess the sustainability of bushmeat hunting with certainty with data spanning only three years, our results do show changes in the species profile in Río Muni, which are consistent with unsustainable hunting. This includes lower numbers of some species within particular catchments, causing traders to travel further on average to buy even small, more robust species. Traders in Central market now travel to the country border and so may have reached the edge of the exploitation range, and therefore current changes seem to reflect an intensification of harvesting within the existing exploitation range. Particularly, small and medium-sized species are increasing their representation in catchment areas that are further away. The lack of village origin data from Mundoasi in 2003 mean that the second market could not be fully analysed, but it seems likely that traders in that market will continue to expand the frontiers towards the interior of the country.

Data suggest that the group of species experiencing the greatest change in origin could be an indicator of the stage of exploitation within a market. For example, in a 'new' market, we might expect large, vulnerable species to show the greatest change in average distance travelled over time (i.e. that traders travel to buy them), as they are rapidly hunted out of nearby catchment areas. As a market begins to mature, species of medium vulnerability may also show signs of over-exploitation in nearby catchment areas, and so may then show greatest changes in average distance travelled. If hunting continues to be unsustainable, we would finally expect even robust species to disappear from catchment areas near to the market, and so over time, they too would finally show a larger change in the average distance travelled. These results are perhaps unsurprising given the huge increase in urban wealth and reported commercialisation of the bushmeat trade in Equatoriual Guinea, but certainly give serious cause for concern.

These results provide a methodological defence for the use of market data as an indicator of hunter sustainability, but with important qualifiers. They also add to mounting evidence that access of hunters to markets is one of the most important factors affecting bushmeat harvest, and provide cautious indicators that bushmeat hunting in continental Equatorial Guinea is having a discernable effect on prey species profiles and wildlife populations.

Chapter 7.

Discussion

7.1 Dependence on wildlife in Equatorial Guinea and the future of wildlife use

In order to answer the central question of this thesis, namely whether or not people depend on wildlife in Equatorial Guinea, I address each of my initial research questions in turn. Then I review potential options for management strategies, and comment on their prospects for success in Equatorial Guinea, and finally discuss implications for future research.

7.1.1 How important are wild foods for regular use?

Households in both villages ate wild foods frequently, and gained a substantial proportion of their diet, livelihood production and income from wild foods on a regular basis. These contributions were particularly important given a lack of alternative food and livelihoods in either village, and particularly in Teguete, the more remote village. The almost total absence of reared domestic meat consumption and the low wild fish harvests meant that bushmeat provided the one animal protein source that households could produce themselves. Even those with the financial capacity to buy imported meat or fish were limited in choice – only smoked fish was commonly available in Teguete, and smoked fish and frozen products in Beayop, both of which research has shown are the least preferred meat and fish types (East et al. 2005; Kümpel 2006). The very large numbers of women cultivating fields (almost equal to the number of households in the village) and men with traps (almost equal to the number of households in Teguete, and approximately one third in Beayop), and the presence of only about five paid jobs in either village attest to the low number of livelihood options in either community. Trade provides an important income source in Beayop, but without passing traffic in Teguete, people's income sources are limited, and so wildlife is an important regular (and often the only) income source for many people.

7.1.2 How important are wild foods as a safety net?

Anecdotal evidence collected during group discussions showed that some households consciously think of the forest as a back-up plan – something to turn to when there is no food or money, and when family cannot provide any support (chapter 5). The use of family ties and a social network as a 'community buffer' has been observed in other studies (Beuchelt et al. 2005), and evidence here shows that this is certainly the case in Beayop and Teguete. Poorer households in Teguete consumed more food received as a gift than in Beayop and respondents reported that family members are the first port of call in times of need. Previous studies have pointed to wildlife being particularly important as a buffer when social ties are broken, such as during conflict (Jamiya et al.

2007) or disease epidemics (Barany et al. 2004). These studies imply that social resources may be a primary safety net, and that natural resources offer a secondary safety net, used once social resources are exhausted or as a longer term strategy (i.e. amongst the chronically poor).

Given this, we would expect to see more evidence of forest resource use as a safety net during times when the whole community is equally suffering resource shortages (such as during seasonal shortages) than we would when an individual household is experiencing short-term food or income shortages. In Río Muni, the second season was identified as the most vulnerable, probably due to lower agricultural production, leading to lower agricultural consumption and income, and lower total production and income, during this time. This is strong evidence that agriculture is still the primary livelihood activity for many households, which is particularly likely given the female-biased demographics of the villages and the gender divides in livelihood activities. Although poorer households gained similar proportions of production and income from agriculture as wealthier households (although lower total amounts), they were less able to make up any deficits in production and income during the agricultural lean season, because they were less likely to earn income from paid work or trade. During this season, households in Teguete consumed higher average amounts of wild foods harvested directly from the forest. Bushmeat harvest contribution is lowest in this season, and the difference is mainly made up by increased wild plant consumption, giving strong evidence that wild plants are particularly important as a dietary safety net in Teguete during the lean season. There was no such evidence in Beayop, the more market-integrated village.

7.1.3 Are wild foods more important for vulnerable people?

Previous studies have noted that food coping mechanisms, and 'famine' behaviours may be incorporated into the regular food and livelihood strategies of households that remain food insecure over long periods of time (Devereux et al. 2004). If wildlife products are important as a safety net during periods of temporarily reduced productivity such as the lean season, we would also expect chronically poor, vulnerable people to use wildlife products more often, even as part of their regular dietary and livelihood resources. Three such groups have been identified in this study: women, poorer and less food secure households, and less accessible communities.

Women

Within communities and households, women produced and earned less on average, as did female-headed households, and this is a common pattern across much of the developing world (UNDP 1995). Women are considered more vulnerable to income shocks (Khan 2001), and at the same time, often contribute more to the welfare of the household, particularly dependents (FAO 2001).

Overall, there was no difference in consumption (although we might not have detected it if there were), but men in general produced more and earned more from wildlife. However, women were significantly more likely to use wildlife resources, which suggests that low value products are harvested more often by women, and are therefore more likely to make up a regular contribution to the household. Of wildlife products, women did produce substantially more wild plants. The lack of significant sex difference in sales of wild plants implies that these small regular wildlife harvests may be mainly consumed in the household.

Poorer and less food secure households

The most vulnerable households in both villages (as indicated by wealth or food security estimates) produced and earned more from forest products both in absolute amounts, and as a proportion of production and income, compared to wealthier households in the same village. This pattern was mainly the result of bushmeat hunting. Although wealthier hunters earned higher average incomes from hunting, bushmeat contributed most to poorer people. In addition, the poorest households produced significantly more wild plants (but not income from wild plants) in Beayop, and the poor in both villages were most likely to sell wildlife.

These vulnerable households were also less livelihood secure, having fewer production and income sources, implying that the livelihoods that they did have (such as the forest) are more important when returns from other livelihoods in their relatively smaller arsenal of livelihood options decrease, as well as playing a proportionally more important role in regular production.

Households in the two lowest wealth ranks were also more likely to consume food produced directly by the household, and less likely to consume imported protein, implying that for the poorest households, alternative bought, protein-rich foods (such as domestic meat and fish) are less accessible, probably due to the higher cost. In addition, poorer households gained a greater proportion of protein from agricultural products, suggesting that plant proteins make up a larger proportion of the diet. These observations were usually strongest from the second lowest wealth rank, while the lowest wealth rank and the least food secure (especially in Teguete) relied heavily on gifts of food, reflecting the generally low labour availability (and correspondingly low production capacity) of these households.

Less accessible communities

Teguete has less access to urban centres and passing traffic than Beayop, and probably as a result its inhabitants consumed, produced and earned less, and were less food secure. People in Teguete relied more on wildlife for consumption, livelihood production and most particularly income. There was a pattern between villages, whereby among poorer households, wildlife played a greater role in income provisioning in Teguete, and a greater role in production in Beayop. This probably reflects the lower availability of income sources and the lower actual income from those sources in Teguete.

7.1.4 How useful are urban market data as a tool for monitoring wildlife offtake such as bushmeat?

Urban bushmeat market data were shown to be a useful tool for bushmeat monitoring, reflecting village offtake fairly well, although vulnerable taxa with relatively low prices for their body size such as primates may be under-represented at the market level. This should be taken into consideration when evaluating market data on the basis of the proportions of different taxa (i.e the proportion of primates to rodents, as reported by Wilkie & Carpenter 1999). My finding that the bushmeat species profile differs significantly between catchment area, particularly with access to markets, emphasises the importance of collecting data on the origin of carcasses, as notably demonstrated by Milner-Gulland & Clayton (2002). This ensures that changes in the source of bushmeat species, such as increased access due to new roads, traders travelling further distances, or reduced access along certain roads, are taken into account when considering changes in species profile over time.

There may be a large number of villages in any region, and specifically in Río Muni, whose offtake is not reported in urban markets and so are not reflected in any assessments based on urban markets. Considering the reduction in average animal size with market access, we would expect villages such as Beayop (which is accessible to markets and has no protected forest area nearby) to have a bushmeat species profile consisting of smaller, less profitable species. However, even in this village, bushmeat represents a large percentage of income and consumption, suggesting that offtake is still quite high. Furthermore, very few carcasses from Teguete, which does have reasonable forest access, were recorded at the urban markets. Yet over a third of all income in Teguete comes from bushmeat, so village offtake is likely to be substantial.

Urban market data may be a similarly useful tool to assess the harvest of other wildlife products such as forest plants or fish, should those products become widely traded in urban areas, and given similar assessments as to any trade filters in place. However, currently most wild plant and fish

products in the study villages were consumed or traded locally, so monitoring the sustainability of harvest would have to be done at local levels.

7.1.5 What are the implications of current wildlife harvests for continental Equatorial Guinea?

The bushmeat market data analysed here, together with previous studies (Fa et al. 1995), strongly suggest that bushmeat hunting is unsustainable in Río Muni, at least in one urban market. Hunting of vulnerable primates such as the black colobus may be particularly unsustainable (Kümpel 2006) and our findings suggest that village offtake of primates may be relatively higher in rural villages than expected from market data. The recent ban on gun-hunting in Equatorial Guinea (legislation in 2007), and the enforcement of this ban, is the first and vital step in reducing primate offtake. The vast majority of primates are killed by gun, and given that there are few gun-hunters in either study village, coming from wealthier households, they are less likely to depend on bushmeat as a safety-net resource and so there will be fewer repercussions for development.

Among the remaining hunters, it does seem that wildlife harvest is important for livelihoods. That most trade in bushmeat is done along roads is likely to be true for other products, including other forest products. If this is the case, it makes sense that:

- Households in villages that have the most access to markets but still have good access to forests (i.e. are near protected areas, such as Sendje), will make the most money out of wildlife.
- Households in villages that have the most access to markets, but no access to forests will generally gain the least from the forest. Such households will probably have access to more alternative livelihoods, including income from agriculture, but the poorest may find it especially hard to cope. This is representative of villages near to urban areas, or peri-urban households, and it is these households which often benefit from the nutritional and livelihood benefits from wild plants (e.g. Gockowski *et al* (2003); Stoian (2005)).
- Households in villages that have the least access to markets and most access to forests will make less money out of the trade, but there will be fewer wealth differences within the community, and the poorest will not be so badly off (e.g. households in Teguete and Midyobo).
- Households in villages that have the least access to markets and the least access to forests will be most vulnerable and most livelihood and food insecure (e.g. households in the North-East of Río Muni).

Consequently, we would expect villages in the north-eastern region in Río Muni, where forest is highly degraded, population density is high, and villages off the main roads do not have regular

passing traffic (and so have little access to urban areas) to be most vulnerable to food insecurity and poverty.

7.1.6 Other issues

Comparing bushmeat, wild fish and forest plants

Bushmeat played the biggest role for livelihoods and consumption overall, and contrary to previous studies (e.g. de Merode et al. 2004) this was still important for poorer households. However, wild plants may contribute more to food and livelihood security in Teguete, with greater consumption in the lean season, and greater importance to vulnerable groups such as women. Wild fish contributed only small amounts to food and livelihoods, although this is likely to be more important in villages near better water sources.

Demographic composition of rural areas

Teguete in particular showed a skewed demography, whereby the population was increasingly made up of children and elderly people, and with substantially more women than men. Many households consisted of grandparents and grandchildren (under the age of about 14) while medium-aged adults lived and worked in urban areas, sending remittances to their rural families. One consequence of this may be a lower number of hunters in the villages, but it is also these groups who are most likely to be food insecure. In addition, this demographic (older people and women) are more likely to harvest forest plants. Some have commented that this arrangement – a largely economically inactive rural population relying heavily on presents from urban family members and imported foods – is the best thing for conservation, given that it reduces hunter numbers. However, this is not conducive to long-term economic development. In addition, while this may work to some extent in Equatorial Guinea due to oil revenues and associated increases in urban wealth, it is not a model that can be readily applied as a solution to rural poverty to other countries.

7.2 Management options

The results presented here show that in Equatorial Guinea, the poorest households have few livelihood strategies and relatively high levels of food insecurity. In addition, commercial bushmeat hunting, which provides a substantial portion of livelihoods, particularly among the poor, is highly likely to be unsustainable in the longer term, which has important implications for rural communities. The low availability of alternative protein sources in rural villages means that bushmeat remains important for consumption, as well as income.

The most commonly cited solutions to reducing bushmeat hunting without negative impacts on local communities, are the development of alternative livelihood strategies, accompanied by disincentives to hunt, particularly commercially. There are no indications that the harvest of wild edible fruits is unsustainable in Equatorial Guinea, and indeed these may represent an opportunity for income generation. In contrast, the destructive harvest of products such as rattan is unlikely to be sustainable without active management of the resource. An additional consideration is that while it is women who are more vulnerable and contribute most to household well-being, for bushmeat hunting disincentives to work, men must be presented with an economically attractive alternative livelihood that is not easily combined with hunting on a regular basis. I discuss options for alternative livelihoods and hunting disincentives below.

7.2.1 The development of alternative income-earning opportunities

Domestic meat and fish production

The production of alternative domestic meat and fish may represent an opportunity for improved livelihoods in rural areas, proffering the combined advantages of providing income and animal protein production. In Equatorial Guinea and other Central African countries, bushmeat is not a preferred good, so demand may be elastic and consumers are likely to consume fresh fish and domestic livestock alternatives if they are cheaper (East et al. 2005; Schenck et al. 2006). Unfortunately, the domestic breeding of livestock in forested central Africa has been largely unsuccessful. The widespread tsetse flies and trypanosomiasis severely limit cattle breeding in the many parts of West and Central Africa, and intensive livestock rearing often involves high start-up costs which are prohibitive for rural small holders. In addition (and if the aim is to provide alternative livelihoods to hunting as well as alternative sources of meat), the production of livestock often involves a different social category of people, involving wealthier entrepreneurs, as opposed to the poor young men that commonly hunt. However, small-scale livestock rearing may be more easily introduced. Projects have successfully introduced chicken farming in sub-Saharan Africa, resulting in decreased bushmeat hunting or increased food security (Kitalyi 1998), and tilapia and aquaculture projects have also been successful in Africa (Hishamunda & Ridler 2006). The presence of one successful livestock and aquaculture farmer in Equatorial Guinea (and he is probably the only one, INDEFOR, *pers. comm.*) confirms that start-up costs and knowledge are greater barriers than external barriers such as climate and ecosystem type.

Increasing incomes from agriculture

In Equatorial Guinea, there may be particular potential for increased production and income from agriculture. Agricultural production in Equatorial Guinea has significantly fallen in the last 30 years. Total agricultural production has decreased by half since the late 1960s and per capita production has reduced by two thirds (FAO 2002), making it much lower than in neighbouring Cameroon (FAOSTAT 2002). This has led to Equatorial Guinea being a net importer of food, even for agricultural products and fruits such as pineapples and mangoes, which are commonly imported from Cameroon for sale in Bata, despite being grown throughout Río Muni (*pers. obs.*). Although agriculture is currently dominated by women, in the days of Spanish colonialism men cultivated plantations of cocoa, coffee and fruits such as pineapples, and older men who remember these days claim to prefer agricultural livelihoods than hunting as they can 'sleep in the village' and not suffer the uncomfortable realities of forest life.

Sustainable livelihoods from forest products

Wild plants

The production and marketing of forest plant food products may hold potential for improving income in rural areas. Although wild plants have been viewed as inferior foods in some areas, certain species may have the potential to be surprisingly profitable. Research at the International Centre for Research in Agroforestry (ICRAF) has suggested that a number of trees in both Africa and South America are not only important for local nutritional needs but can also play a role in food security and in alleviating poverty in some countries (Leakey & Tchoundjeu 2001). These so called 'Cinderella' trees have been over-looked by scientists and occasionally even by local farmers, but are now getting more attention, and several relevant species have been selected for domestication, in the hope of expanding local and international markets (Leakey et al. 2003). Two such species in West and Central Africa, both present in Equatorial Guinea, have been identified as important. These are the bush mango, *Irvingia gabonensis,* and the African plum, *Dacryodes edulis*. The former is widely eaten both for its fruit, and also for its kernel which is made into a popular sauce to accompany many dishes. The latter is cooked and women value it for providing a quick accompaniment to cassava. In Equatorial Guinea they are widely harvested, but not 'farmed' or traded to any great extent. However, farmers in Cameroon intercrop these species with cocoa and coffee, using them to generate income when market commodity prices are low. This isn't a new strategy and the current African plum and bush mango trees found in relative abundance around some villages in Rio Muni (compared to deep within the forest) may be a legacy of forgotten Spanish plantations. In Cameroon in 1999, the African Plum national market was worth more than

$7 million, and research has shown that encouragingly, over 75% of the profits go back to the farmers. The international market is being investigated, and there may be potential markets in European cities with many West African immigrants. However, some have criticised the fact that despite increasing recognition of the socio-economic importance of NTFPs, and their potential to be over-harvested, most regions still lack sustainable management strategies for these products (Bikoue & Essomba 2007).

Fish

In certain cases, the controlled management of fisheries and fish stocks, particularly through community-based management, has played a significant role in increasing income and food security (Béné et al. 2003; Dugan et al. 2006). However, the scope for increasing fish harvests and income in Equatorial Guinea is largely unknown, and based on the low fish harvests in this study, is unlikely to be high. As with all wildlife resources, there is an inherent limit to the number of fresh-water fish that can be sustainably harvested, and for much of Rio Muni there are probably insufficient rivers or access to those rivers to support many people.

Forest animals

Despite the low productivity of tropical forest mammals, and the strong evidence for unsustainable harvest rates, bushmeat has been proposed to be useful for economic development, and there is historical evidence that bushmeat can play a secondary role in supporting economic change. Bushmeat played a part in underwriting the development of the Ghana cocoa industry and opening up the forest frontier (Asibey (1974), but see Oates, 1998). However, this is unlikely to provide enough income or be acceptable to conservationists in Equatorial Guinea, and the consensus is that bushmeat hunting is unlikely to play a large part in rural transformation (Brown & Williams 2003). In contrast, forest invertebrates such as wild snails and insects are gathered or reared and traded in some parts of Africa, as 'mini-livestock' (Hardouin 1997), providing regular income. In Equatorial Guinea, forest snails are occasionally eaten and sold, particularly in villages near urban areas, and although incomes are currently unlikely to rival incomes from bushmeat in villages beyond peri-urban areas of high human population density, it has potential to generate income and food in the future, especially if bushmeat hunting is severely reduced.

7.2.2 Disincentives for commercial bushmeat hunting

Some alternative livelihood projects have failed to reduce unsustainable use of natural resource, as local communities have often, quite rationally, viewed alternative income-earning initiatives as

supplementary to hunting, and have continued to gain income from bushmeat as well as newly introduced livelihoods. Consequently, there is a need to introduce disincentives for commercial hunting at the same time as launching alternative livelihood options. In addition, new income-earning opportunities have often failed to enlist the support of communities towards more sustainable resource use practices, and may even have often shifted attention away from the search for models for direct resource management.

Increase the availability and decrease the price of bushmeat substitutes

If there are no animal protein substitutes to bushmeat, attempts to decrease availability and increase the price of bushmeat are likely to actually increase the incentives to hunt (given that forests are an open-access resource). Thus it is crucial to increase markets for non-wild sources of animal protein (Wilkie & Carpenter 1999). In addition to the increased production of domestic livestock and aquaculture discussed above, the domestic breeding of forest species has often been suggested as a potentially more successful alternative to livestock breeding. Some projects have shown that smaller bushmeat species such as marsh cane rats (*Thryonomys swinderianus*), giant pouched rats (*Cricetomys emini*), and brush-tailed porcupines (*Atherus* africanus) can be reared domestically (Asibey 1974; Tewe & Ajaji 1982; Jori et al. 1995; Jori & Noel 1996; Jori et al. 1998; Edderai et al. 2001), but rearing these species as an alternative to hunting bushmeat will only be an attractive option once the costs of rearing are lower than the costs of hunting. This is unlikely to be the case until wild populations are very low, and so is not something that should be considered in Equatorial Guinea.

Increasing the price of bushmeat relative to substitutes

If bushmeat demand is elastic (as we suspect it is in Río Muni) then an increased supply of bushmeat substitutes should be coupled with measures to increase bushmeat price (e.g. through fines) or reduce bushmeat supply (e.g. by limiting access to forests or enforcing offtake quotas), and so make domestic meat options relatively cheaper, thereby reducing demand for bushmeat. To emphasize the point, given the large reliance on bushmeat for consumption and the current lack of alternatives in Equatorial Guinea, these measures are not appropriate without an accompanying increase in the supply of bushmeat substitutes.

Controlling market supply

Controlling bushmeat supply to urban markets directly is a practical and relatively cheap approach to reducing bushmeat consumption. Efforts can be concentrated on a small number of market

traders and enforcement need only consist of road blocks or market raids, with bushmeat being confiscated and sellers fined, making it relatively cost effective. This also requires trustworthy law enforcers and runs the risk of sending the bushmeat trade underground. An alternative enforcement of market supply is to charge a market tax. This increases the effective price of bushmeat, without encouraging corruption (except for market guards) and removes the temptation to sell confiscated game. Even if guards do pocket taxes, the price of bushmeat will increase, and so the demand for bushmeat and the price that traders are willing to pay hunters will fall, which should decrease hunter incentives. However, it is unlikely that this would be enforceable outside of large urban areas and so sales would continue within rural areas, as illustrated by the relatively low level of sales to urban market from the study villages Teguete and Beayop.

Changing consumer preferences

Although there is no definitive preference for bushmeat in Equatorial Guinea, consumers do prefer bushmeat in other countries (Bakarr et al. 2001). However, consumers are sometimes willing to change their preferences for luxury goods such as ivory (O'Connell & Sutton 1990) or goods that have little contribution to diet or household income (e.g. great apes) in response to social marketing and education. Only when the good is necessary for a particular need, or there is no substitute available, is changing consumer preference unlikely to be successful (Freese 1997; Fa et al. 2002).

7.2.3 Enforce sustainable hunting measures

An additional solution to reducing bushmeat harvest, and potentially increasing the likelihood that the resource will be have the potential to act as a consumption buffer in times of real need, is to enforce sustainable hunting measures as the same time as introducing alternative livelihood options. Although it is likely that some species, such as most primates, have very low sustainable harvest levels, other species, such as most rodent species, seem to maintain stable populations at far higher levels of hunting. If trade, sales or capture of more vulnerable species (depending on the point of enforcement) could be made illegal, while allowing trade in more robust species to continue, hunting may be more sustainable (Kümpel et al. 2007) and the first step in this (the banning of gun-hunting) has already occurred in Equatorial Guinea. Unfortunately, the non-selective trapping methods used by the vast majority of hunters across Africa would make bans on particular non-primate species difficult. Other suggestions to enforce sustainable bushmeat hunting include working with forest industries, such as logging companies, to ensure that companies take responsibility for bushmeat harvest within logging concessions (Schulte-Herbruggen & Davies 2006). Controlling access to who can hunt, or to hunting zones, through community management has also been cited as a way to conserve hunted species in developing countries (Kiss 1990; Hannah

1992; Wells et al. 1992; Bissonette & Krausman 1995), but this requires effective community institutions and an ability to overcome poverty's 'have-to-eat today' principle (Bodmer 1994). Broader institutional contexts, such as informal social networks and decentralised government structures with poor resources, may also pose a challenge to sustainable bushmeat management (Hurst 2007).

7.3 Implications and directions for future research

This research suggests that it is important to differentiate between wealth groups and seasons when analysing the use of wildlife products if a link to dependence is to be proven. Patterns of resource use among vulnerable people and at vulnerable times are most reflective of a real contribution to food and livelihood security. In addition, the higher overall contribution of wildlife to the income of poorer wealth groups, despite higher average earnings from wildlife per person among wealthy resource users, illustrates that it is not enough to look only at the average income gained per person – an assessment of the total contribution to a particular group must also be considered.

During this study I measured three different indicators of wealth (income, value of fixed assets, and wealth rank). Income and wealth rank were far better predictors of livelihood and consumption variables, while the value of fixed assets was not widely representative of resource use or other household variable indicators. Thus, I suggest that income and wealth rank are more useful indicators than assets in this study system. In addition, information on income was only useful when remittances were also considered as some relatively wealthy households earned very little income themselves, but gained large or regular amounts of cash from family members.

Assessment of the frequency of use of food coping mechanisms was a useful tool to identify the most vulnerable members of the community, although the results did not differ significantly from other wealth indicators such as wealth rank. The similarity of coping strategies between two quite different villages means that once strategies are identified, the same set of questions could be used in other communities in the same region, negating the need for lengthy group discussions in every survey village, and so reducing the costs and increasing the usefulness of coping strategy surveys as a tool. However, the importance of initial extensive group discussions cannot be over-emphasised. The first round of food security indicator data collected in 2005 suffered from an inadequate exploration of the coping strategies proposed, resulting in some strategies that were not used in data analysis (i.e. those differentiating between borrowing meat and fish, and separately borrowing 'other food'). In addition, distinctions that later became clear were not initially apparent, and this resulted in lost opportunities for using strategies that may have been illuminating. In particular, in

grouping the consumption of all meat and fish types, I ignored the very different status attributed to smoked fish, compared to fresh or frozen meat and fish types. Similarly, measures to identify lean seasons need not be resource intensive. Analysis of child anthropometric data simply confirmed what participatory discussions had identified as the hungry season, so researchers should have confidence in the assertions of resource users.

These data illustrate that low-value products such as forest plant foods can be very important to food security, particularly in vulnerable seasons, and yet barely register on any analysis of economic transactions even at the village level. This suggests that studies assessing the importance of wildlife products to communities should not over-look consumption data and the importance of largely subsistence products.

This study involved intensive research on a range of indicators of dependence over 15 months in 2 villages. This enabled me to develop a detailed understanding of the contributions made by the little products to consumption and livelihoods. The results confirm the importance of wildlife products to vulnerable groups in lean seasons, as had been found by de Merode *et al* (2004) and others. The strengths of this study are this details and the multi-dimensional approach to assessing dependence. However, this is, in a way, also its weakness. The level of detailed data collected, and the multiple indicators of wealth, while illuminating were also highly data intensive. The next step for research on the relationships between people and wildlife products is therefore to assess changes in these relationships on a broader geographical scale, using data on coping strategies, consumption, and wildlife trade. Data such as these were also collected during my thesis in a further 11 communities in Río Muni, and analysis of these data will permit assessment of these relationships at the level of communities.

I also intend to analyse differences in hunting offtake between Beayop and Teguete using hunter offtake data collected over six months in both villages. Using catch per unit effort (CPUE) indices, this will allow me to compare relative wildlife abundances. In addition, it will allow me to assess what affects the relative profitability of hunting (i.e. the relative effects of wildlife levels, market access and price, and opportunity costs related to access to alternative livelihoods) and so to assess at what stage hunting becomes so unprofitable so that people give it up.

Of the potential management options suggested above, it is likely that a combination will have the greatest chance of reducing unsustainable wildlife harvest, while maintaining food and livelihood security for rural populations. An evaluation of the potential profitability, cultural acceptance and

feasibility of alternative livelihood options such as small livestock production or aquaculture, is vital to assess their practicability in Equatorial Guinea.

Enforcement of the gun-hunting ban in Equatorial Guinea will be key to the reduction in offtake of the most vulnerable bushmeat species, namely primates. However, careful monitoring of other bushmeat species is also necessary to ensure that species commonly trapped are also not hunted at unsustainable levels.

7.4 Conclusions

This thesis demonstrates that wildlife resources can be important for food and livelihood security and it is important to assess the proportion of food and income that wildlife products contribute to vulnerable people and at vulnerable seasons to illustrate this dependence. In this way, foods such as wild plants that contribute relatively little in total, but have considerable value to the poorest households, can be identified. Methods to identify vulnerable households and seasons need not be costly, but do rely on an understanding of the resource system, and a good relationship with resource users.

People in rural Equatorial Guinea depend on wildlife for both food and income. Bushmeat provides the greatest contribution, and is important to the poor, but it is wild forest plants that are particularly important to the extremely vulnerable. However, the situation is hopeful. Equatorial Guinea is unusual in that it has a relatively low human population density, high wildlife density and a high GDP compared to most other African countries, and bushmeat is not a particularly preferred good. Consequently, and with political will, it represents an ideal opportunity to put conservation and development ideas for the management of bushmeat hunting and the development of alternative livelihoods into practice: if they do not work here, they are unlikely to work elsewhere.

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Appendix 1. Questionnaires

Table A 1.1 Census questionnaire.
Lines have been removed to fit appendix format.

Date:	Interviewer(s):	Start time:
Household code:	Interviewee(s):	End time:

QUESTIONNAIRE 1: Structure of the household

Name	Relation to head of house (1)	Sex M = male F = female	Age	If less than 15: Date of birth	How many children in total?		Education level (2)	What types of work have you done this year? How many months for each type of work? (3)		
					Male	Female		Type…	Type 2…	Type 3…

Tribe/nationality of head of house **How many wives has the head of house?** **Do they live in a different house? If so write where:**

(1) Relation to HouseHead J = jefe/a residencial A = grandma/pa Hj = Child N = grandson/daughter T = uncle/aunt So = nephew/niece
Hm = sibling M = wife, husband, companian Pd = father/mother Y = son/daught-in-law Hp = Lodger/relative of lodger Op = other relative (specify)
Cu = brother/sister-in-law C = other comanion Sg = father/mother-in-law Pm =primo/a E = HH employee/relative of employee Ot=other not related (specify)
(5)Nivel de estudio: A = analfabeto; Ps = preescolar; Pm = primaria (escribe que ano: 1, 2, 3, 4 o 5);S = secundaria (bachillerato elementar) (escribe que ano: 1, 2, 3, 4 o diploma); S = secundaria (bachillerato superior) (escribe 5, 6 o 7); U = universidad (titulado, maestría, licenciado o doctorado)
(6)Type of work: S = no work, Fi = Works in fields, T = trapper, CE = hunts with gun, P = fisher, B = has a bar/shop, Cc = other trader, Fb = works in a factory,
Em = Works for a firm (specify the name of firm), Ej = executive (works in an office), Es = student, Ma = teacher, Ml = military, O = other (specify)

Table A 1.2 Regular questionnaire.

Rows have been deleted to fit appendix format. Questionnaire is three pages long.

Date:	Day of the week:	Interviewer(s):	Start time:
Household code:	Village:	Interviewee(s):	End time:

QUESTIONNAIRE 3: Regular Household Interviews

SECTION 1: Food eaten YESTERDAY

	Names of people that ate	Food type (ingredients)	Amount consumed	Unit (1)	¿How many kilos per unit?	State when eaten (2)	If meat or fish State when obtained (3)	How obtained? (4) (Bought, etc.)	If bought …		When obtained (date)?
									Where/who from? (5)(Source & village)	Price/Unit	
Meal 1											
Meal 2											
Meal 3 / snacks											

¿What other foods left the house yesterday? E.g. did you give or lend food to other people in the village? If so, what types of food, what amount and who was it for?

Type of food	Who was it for? (5)	How much?	Unit (1)	How many kgs/unit?	State when food left the house (5)	State obtained (5)	How obtained? (4) (Bought, etc.)	If bought…		When obtained (date)?
								Who/where from? (4) (source & village)	Price/ Unit	

(1) Unit: E=entire, L=tinned, kg =kilo, Cu =quarter, Tz= piece (what part), M = pile, Ol =saucepan, B=bar (of yucca), Va=glass, Ce =basket, Es = bowl, Gr = bunch (of bananas), Ot =other (specify)

(2) State when eaten: G =cooked, Cr = raw, So = soup, B =bar (of yucca), Ot =other(specify)

(3) State when obtained: V= alive, F= fresh, A = smoked, Spe = without hair, Spi= without skin, Sa= salted, So=soup, L=tinned, C=frozen, P = rotten, Ba = bar (of yucca), O = other (specify)

(4) How obtained?: C = bought, F = grown in my fields, RB = collected in forest, TF = traps around the fields, TB = traps in the forest, Es = gun, P = fished, Rg = present from someone, Pr = borrowed, O = other (specify)

(5) From where/who?: B = bar/shop, M = market, S = supermarket, Ca = hunter/fisher from the village, Fp = family from the village, Fo = family from elsewhere, Pp = other person from the village, Ch = regular trader, Ct = travelling traders, O = other (specify)

SECTION 2: Acquisitions and expenditures for each person in the household YESTERDAY

Now I'd like to ask about the things acquired by each person in the family YESTERDAY

ACQUISITION OF GOODS	Item	Code of person in the family that obtained or bought it	Who was it for? F = all the family M= only that person C = to trade O = other	If bought… Where from? (source and location) (1)	If it was a gift… Who from? Fp = fam. (village) Pp = other pers. From the village Fo = fam (elsewh) O = other	If food: what state was it obtained ? (2)	Amount	Unit (3)	How many kgs per unit? (if possible	Price/ Unit CFA	Total price No need to ask	Notes
What things were obtained by the family or people in the family YESTERDAY? *Include:* Food, drink, cigarettes, soap, petrol, cartridges, wire, nets, machete, medication, clothes, uniforms or other school material, etc. CAN INCLUDE items bought OR received as presents												

OTHER HOUSEHOLD OR INDIVIDUAL EXPENDITURES YESTERDAY	Code of person in HH	Type of expense	For what period of time	Amount	Unit (3)	Price/unit CFA	From where/ who (1)	Notes
What other costs did the family or individuals in the family have yesterday? E.g. costs of… matriculation, permits, transport, bar, associations, debts or credit, rent, tax, construction, employees, labour hire, etc.								

(1) Who/where from?: B = bar/shop, M = market, S = supermarket, Ca = hunter/fisher of the village, Pe = other person of the village, Ch = regular trader, Ct = travelling trader, O = other (specify)

(2) State when obtained: V = alive, F = fresh, A = smoked, Spe = without hair, Spi = without skin, Sa = salted, So = soup, L = tinned, C = frozen, P = rotten, Ba = bar (of yucca), O = other (specify)

(3) Unit: P = packet (write how much/packet), E = entire, L = tinned, kg = kilo, Cu = quarter, Tz = piece (write which), M = pile, O = saucepan, Ba = bar (of yucca), Va = glass, Ce = basket, O = other

Has anyone in the family arrived or left to/from a journey in the last two weeks? *If YES:*

Has anyone in the family arrived or left to/from a journey in the last two weeks? *If YES:* Who (4)	What was the motive for their journey?	From where?	Destination?	Date of departure	Date of return	How much was the journey	What goods or 'help' was carried? (write the items and quantities)	
							Left the house:	Brought to the house:

(4) Who: FC = family of this household (Write their code or name), Fp = family living in a different household in this village, Fo – family from another village, O = other person (specify)

SECTION 4 (continued) ASK THIS AT THE END

Please could you tell us if there was any income for the household yesterday – e.g. income from rent (shop, room, generator, gun, etc.) and other income.

E.g. Income from loans/credit, associations, rent (e.g. shop, room, generator, gun, chainsaw, gun), presents	Item/type of income	From who?	Who collected it?	Amount (CFA)	Notes

SECTION 3: Activities and income for each person in the house YESTERDAY

Include: work in the fields, traps, gun-hunting, fishing, work with a company, cooking or collecting products for sale (e.g. yucca, palm wine, etc.), selling goods (write time spent, but put the items in section 4), making artisan productions (e.g. baskets, fish-traps, etc.), construction (e.g. roof weaving, etc.).

Name or code of person in the house	Activity (Use the codes) (1)	Time spent in this activity (aprox.)	Products (E.g. firewood, species of animal, fish or plant, etc.) (2)	Amount obtained/ produced	Unit (3)	Kilos per unit (if possible)	Amount for the family	Amount for sale	Where were you? (Use the map or write field codes	If salaried work (e.g. for a company)	
										Basic salary (4)	Bonus

(1) Activity: COM = food preparation; LAV = washing dishes or clothes; NIN = looking after the children; VENTA = selling goods; COMERC=trading (going elsewhere to buy goods); ART = production of artisan goods; FINCA = work in the fields; CHAPEA = clearing fields; RF = collecting fruits, leaves, etc. from the forest; RA = collecting animals from the forest (e.g. tortoises); MAD = cutting/collecting wood; LENA = cutting/collecting firewood, TrF = trapping around the fields; TrB = trapping in the forest; ESC = hunting with gun; LAZO = hunting with lasso (e.g. crocodiles); CONS = construction/repairing the house, etc.; SUEL = salaried work; NASA = fishing with traps; REDES = fishing with nets; TARIYA = fishing with tariya; ANZ = fishing with hook and rod; ESIA = fishing with esia; OTRO = other activity (specify)

(2) Products: *For animals, fish and plants* – write the name of the species in fang or Spanish. *Wood and firewood* – write the name of the tree in Fang. *Construction products (e.g. chapas), artisan and art products* – write the name of the item made.

(3) Unit: E = entire, Kg = kilos, Va = glass, Ce = basket, Cn = cane, O = other (specify)

(4) Basic salary: Write how much the salary is, and for what period of time (for how many days, or per day, week or month, etc.). E.g. 15,000/week, 70,000/month

SECTION 4: Things sold YESTERDAY

Please could you say what things the household sold yesterday?

Include: animals, fish, products from the fields or forest, products for the house (e.g. woven roof sheets), artisan products (e.g. baskets, bowls, etc.).

Who (Person code)	Product	How obtained? (1)	Quantity sold	Unit	Kilos per unit	Price/ unit	Total CFA gained (no need to ask)	Who bought it (2)	Notes

(1) How obtained: F = collected from my fields, TrF = trapped around the fields, TB = trapped in the forest, P = fished, Cm = bought to trade, RB = collected in the forest, ESP = hunted with a gun, H = made/cooked myself (e.g. for food and artisan products)

(2) **Who bought it:** P = person from the village; Cm = regular trader; Cc = other person in a car (i..e. passing driving/passenger); O = other (specify)

Table A 1.3 Questionnaires on buildings, fixed assets, and family remittances over the year.

Village:	Interviewer(s):	Start time: End time:
Household code:	Interviewee(s):	Date:

1. Buildings

Always:
NLS = Don't know
NQC = Don't want to reply

Is the house where you live yours?
If no, who does it belong to?
Do you pay rent?
How much?

Do you rent any other buildings (e.g. bars, etc.)
Give details of those buildings
How much rent do you pay for these?

Type of building (1)	Which kitchen	Where (which village)	How old is it (yrs)	Who bought the materials (2)	Who does it belong to?		How many bedrooms?	Floor (5)	Roof (6)	Walls (7)	For bldgs in this village…		Condition (10)
					Owner (3)	Responsible (4)					How many doors (8)	How many windows (9)	

(1) Type of building: V= house, Co= kitchen, CP= talking hut, Br= bar, Bn = toilet/ bathroom
(2) Who bought the materials? Fo = relative who lives in elsewhere, Fp = relative who lives in this village (in a different house), EC = this house (write their personal code)
(3) Owner: The person who owns the building
(4) Responsible: The person who is responsible for the building. That is, if you were to rent the building, who would gain the money?

Does anyone rent a room/house/bar/other building from you/your family?
How do they pay?

(5) Floor: Ti = mud, Ce = cement, Ca = wooden panels, Ta = wood planks, B = tiles
(6) Roof: N = thatch, Ch = corrugated iron, S = Wood panels and corrugated iron
(7) Floor: Ta = Word planks, Ce = cement, N = thatch, Ca = wood panels, NE = munse-esí (barro), L = tiles, P = pre-fabricated sheets
(8) How many doors?: S= simple, EPS= entre-paño simple, EPM = entre-paño modelo
(9) How many windows?: S = simple, EP = entre-paño, P = persiana
(10) Condition: T = unfinished, B = good, NP = uninhabitable

2. Goods/possessions

Item	Type and amount	Which kitchen	How old is it?	Condition (1)	How was it obtained (2)	Price when bought (write ~ and guess if unknown)	Total price (no need to ask)
Cooking apparatus L = wood fire HG = gas fire H = over							
Bed and mattresses Ma-D = soft wood Ma-F = hard wood B = bamboo CE = Sponge mattress CM = mattress with springs CP = feather mattress							
Chairs and seats Ma = wood Me = rattan/wicker P = plastic B = bamboo S = sofa/trisillio/salón							
Water source R = river, M = spring P = well							
Fridges and freezers							
Radio, radio-CD, radio-cassette							
Saucepans (g=big, m=medium, p= small)							
Grinders and wheelbarrows							
Television, video							
Chainsaw, gun, rifle							
Bicycle, car, motorbike							
Generator							

(1)

(2) **Condition:** 1 **=** good, 2 = a bit bad, but still usable, 3 = broken (unusable)

(3) **How was it obtained?:** Co = bought by someone in this house, Co-Fp = bought by family member in this village (and is still theirs), Co-Fo = bought by family member from elsewhere, RgFo = gift from family from elsewhere, RgFp = gift frm faily from this village, Hd = inherited, Hc = made

Domestic animals (Include adults only)

Kitchen	Chicken	Goat	Sheep	Duck	Cat	Dog	Pig	Other

Household code:	Interviewer(s):	Date:
Village:	Interviewee(s):	Start time: End time:

3. Money/help that left the house in 2005

People that are supported by this household…

Person (number)	Relation (1)	Kitchen	Where do they live?	Working status (2)	Type of help	Value (CFA)	Frequency in 2005	Total CFA (no need to ask)

4. Money/help that entered the house in 2005

People that contribute to the household…

Person (number)	Relation (1)	Kitchen	Where do they live?	Profession/work (3)	Type of help	Value (CFA)	Frequency in 2005	Total CFA (no need to ask)

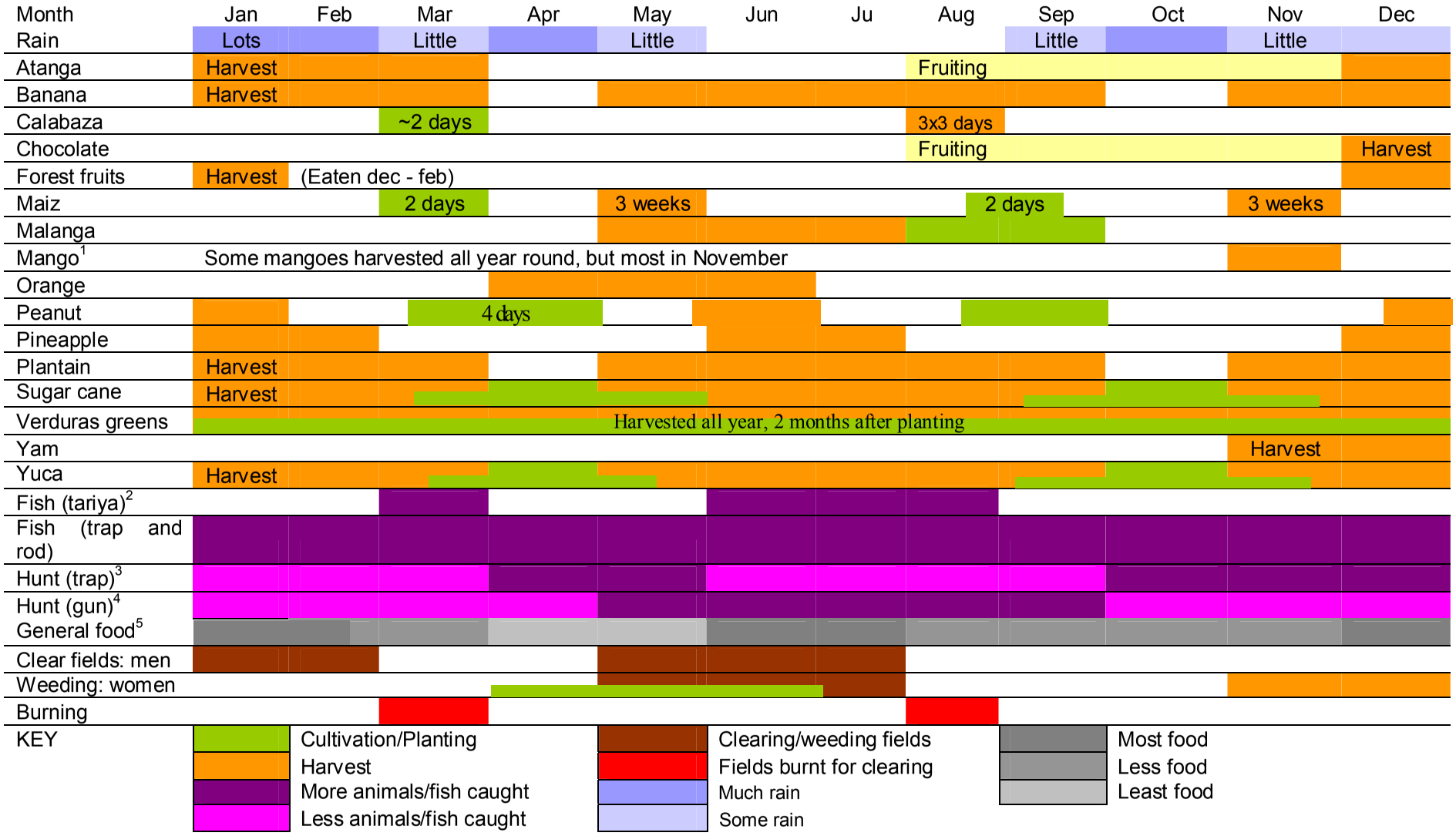
(1) Relation: J = jefe/a residencial; Hj = hijo/a; Y = yerno/nuera; T = tío/a
M = marido/mujer/compañero; Hm = hermano/a; Cu = cuñado/a; So = sobrino/a
N = nieto/a; Pd = padre/madre; Sg = suegro/a; Pm =primo/a
A = abuelo/a; C = otro compañero; Ot = otro no familia (declare que)

(2) Work status: Es = student, T = working, BT = looking for work, VM = lives with husband, VA = lives with boyfriend

(3) Profesión/work: Ma = manual work, T = technical work, Of = office work, M/P = teacher, Mi = military, G = work in the government, D = director, BT = looking for work, VM = lives with husband that works (write what type of work he has), VA = lives with boyfriend that works (write type)

Appendix 2. Agricultural calendar

Table A 2.1 Agricultural calendar



Appendix 3. Calculating building costs

Table A 3.1 An example of the cost of building a five bedroom house in Teguete (i.e. 6 rooms, no kitchen, no bathroom).
All prices are shown in CFA (1000cfa = £1.03, December 2006).

Item	Description	Cost Per Item	No. Needed	Total Cost/ House
Wooden planks	Made of soft wood harvested in the forest, and used overlapping for the walls	250	400	100000
Transport for wooden planks	Transport from the forest to the village (some people choose to carry it back themselves).	50	400	20000
Corrugated iron sheets	For roof	2700	109	294300
Vertical beams	House structure	300	80	24000
Roof support	House structure	350	100	35000
Horizontal beams	House structure	350	78	27300
Window shutters	All wooden			
- Slatted		15000	0	
- Decorated		10000	0	
- Simple		4000	12	48000
Doors				
- EP simple	Harder wood, simple design	17500		
- EP modelo	Harder wood, patterned	25000		
- Simple	Soft wood, simple design	2500	7	17500
Nails	Bought per Kg	1000/kg	30	30000
Hinges		500	14	7000
Locks and latches		500	7	3500
Carpenter	To cut and prepare the wood	100000	1	100000
	To construct the skeleton and roof	200000	1	200000
	To put the rest of the walls on (most people do it themselves)			
TOTAL				906600
OTHER materials sometimes used				
Ceiling (‘sierra’)	Ceiling made from thinner wooden strips (literally ‘cut with chainsaw’).			
Nipas	Palm roofing made by weaving palm fronds. People often make their own, but some people sell them.	300		

Nde-bevin	Tree bark used as wall	Us. collected, not sold		
Nde-esi	Mud bricks used as wall	Us. collected, not sold		
Calabo	Thin strips of wood used for wall or flooring			
Cement	For floors			
Breeze blocks	For walls			

Table A 3.2 Showing how the cost of a building was estimated.
Data collected included: number of rooms, building type, wall type, ceiling type and presence, roof type (and presence), floor type, no and type of doors, no. and type of windows, condition of house.

Data collected	How cost calculated
Doors	
No. EP simple	X 17500
No. EP modelo	X 25000
No. simple	X 2500
Windows	
No. slatted	X 15000
No. decorated	X 10000
No. simple	X 4000
Roof Cost	
Houses	If corrugated iron: 200,000 + No.Rooms X 20,000
Houses	If nipas: 30,000 + No.Rooms X 3000
Toilets	If corrugated iron: 4800
Toilets	If nipas: 600
Bars & Kitchens	If corrugated iron: 300,000
Bars & Kitchens	If nipas: 35,000
	* Bars and kitchens usually just have one big room, and are roughly the same size, so scaling by no. of rooms doesn't work. Similarly the toilet is usually barely more than one or two pieces of roofing over a hole, so using the same scale for different building types was impossible.
Other building costs	(beams, walls, nails, labour, etc.)
House	300,000 + No. Rooms X 40,000
Bars & Kitchens	300,000
Toilets	50,000
Wall	If brick add:
Floor	If cement add: (usually floor is bare earth)
Ceiling	If sierra laso ADD 100,000

Appendix 4. List of material assets recorded

Table A 4.1 A list and number of items recorded as material assets in each village.

Item	Beayop		Teguete	
	Total number in village	Average price per item (cfa)	Total number in village	Average price per item (cfa)
Kitchen items				
Grinder (for peanuts & calabaza)	80	13794.05	66	16370.02
GasCooker	4	18750	5	7000
Cooking pot - large	197	5000	196	5000
Cooking pot - medium	1609	3500	1315	3500
Cooking pot - small	156	2000	109	2000
Press (for clothes)	1	4000	0	
Livelihood equipment				
Press (for sugar cane)	24	3350	0	
Bread oven	1	40000	0	
Bar - wooden (in shop)	7	2500	1	150000
Wheelbarrow	27	28350	23	22777.78
Escopeta	5	156666.7	8	148000
Motosierra	5	255000	5	520000
SewingMachine	1	5000	4	6250
Bicycle	2	40000	14	69142.86
Bicycle - wooden	1	10000	0	
Freezer	2	245000	6	250000
Furniture				
Bed - wood	105	16530.61	14	5000
Bed - bamboo	568	2390.164	14	2390.164
Bed - metal	11	22000	0	
Bed - soft wood	145	10351.06	600	3850
Bed - hard wood	97	19928.57	66	23541.67
Chair - bamboo	3	3333.333	0	
Chair - metal	28	2264.706	4	2264.706
Chair - plastic	56	5407.407	144	5200
Chair - wicker	78	3444.444	46	5886.364
Chair - wood	152	4071.429	364	3370.879
Chair - soft wodd	18	31428.57	13	31428.57
Chair - hard wood	6	2000	9	5000
Mattress - feather	1	30000	0	
Mattress - sponge	424	20522.81	387	25608.11
Mattress - springs	8	30000	0	
Chair set - wicker	57	25185.19	3	15000
Sofa	6	8333.333	8	10000
Table - wood	2	15000	1	30000
Sofa set (1 sofa, 2 armchairs)	27	165224.2	15	74000
Wardrobe	2	110000	1	5000
Continued on next page				
Item (continued)	**Beayop**		**Teguete**	

	Total number in village	Average price per item (cfa)	Total number in village	Average price per item (cfa)
Domestic animals				
Goat	50	20000	129	20000
Pig	44	40000	0	
Hen	540	2000	431	2000
Cat	84	0	24	0
Sheep	21	18000	25	18000
Duck	52	2500	62	2500
Dog	10	0	21	0
Entertainment				
DVD	1	150000	0	
Music system	2	145000	0	
Radio	10	11900	30	14315.48
Radio Cassette	64	25420	45	24236.81
Radio CD	1	80000	2	60000
TV	10	139285.7	4	100000
TV Video	1	120000	0	
Video	3	20000	4	20000
Fields				
Peanuts and mixed crop	289		72	
Calabaza and mixed crop	188		214	
Peanut & Calabaza	3		2	
Pineapple	4		20	
Mixed tree crops (avocados, palm, etc)	1		3	
Other				
Lawn trimmer	2	625000	0	
Generator	20	140735.3	17	283294.1
Gas lamp	270	3500	105	3500
Torches	89	1000	23	1000

Appendix 5. Supplementary tables: Chapter 3

Total calories/day/individual (offset by individual AME)

Table A 5.1 Results of linear mixed model (LMM) showing correlation of daily calorie consumption per individual with season, and individual and household level variables.
Individual nested within household, within village specified as random effects. AME specified as offset. Parameter estimates shown for significant variables in the minimum adequate model (MAM). Explanatory variables were transformed to give normal distributions, and these transformations are shown in brackets. Explanatory variables were transformed in the same way for all other analyses. Results shown in brackets were not included in the MAM due to insignificance (where $p > 0.05$) or correlation with another explanatory variable (where more than one correlated explanatory variable significantly varied with the data, only the one explaining the greater part of the data was included in the MAM).

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	6.01			
Season	1 Little Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.074 -0.13 0.032	3	15	$p < 0.005$
Village	Beayop Teguete	0 -0.10	1	5	$p < 0.05$
HH Income (log)		0.034	1	4	$p < 0.05$
Fixed Wealth (sqrt)		0.000055	1	38	$p < 0.0001$
Wealth rank (factor)			3	1	ns
HH size (sqrt)		-0.17	1	31	$p < 0.0001$
No. productive adults (sqrt)			1	(5)	($p < 0.05$)
No. productive females (sqrt)			1	(10)	($p < 0.01$)
Productive males (yes/no)			1	2	ns
Proportion productive adults (sqrt(asin())			1	(5)	($p < 0.05$)
Proportion productive female (sqrt(asin())		0.17	1	6	$p < 0.02$
Sex			1	3	ns
Age (sqrt)		0.018	1	36	$p < 0.0001$
HH head sex			1	4	($p = 0.052$)
HH head education			3	2	ns
Variance: Individual = 0, HH = 0.03, Village = 0.0002, Season = 0.0003, Residual variance = 0.15 n (Village) = 2, n (HH) = 144 n (individual) = 966, n (season) = 4, n (observations) = 4797					

Total protein/day/individual (offset by individual AME)

Table A 5.2 Results of linear mixed model showing correlation of daily protein consumption (g) per individual with season, and individual and household level variables.
Individual nested within household, within village specified as random effects. AME specified as offset. Parameter estimates shown for significant variables in the MAM.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	2.39			
Season	1 Little Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.073 -0.070 0.031	3	8	$p < 0.05$
Village	Beayop Teguete	0 -0.17	1	5	$p < 0.05$
HH Income		0.058	1	5	$p < 0.05$
Fixed Wealth		0.00015	1	106	$p < 0.0001$
Wealth rank			3	2	ns
HH size		-0.016	1	11	$p < 0.005$
No. productive adults			1	0	ns
No. productive females			1	1	ns
Productive males (yes/no)			1	3	($p = 0.09$)
Proportion productive adults			1	1	ns
Proportion productive females		0.23	1	4	$p < 0.05$
Sex			1	1	ns
Age		0.014	1	9	$p < 0.005$
HH head sex			1	1	ns
HH head education			3	2	ns
Variance: Individual = 0, HH = 0.09, Village = 0.0005, Season = 0.0009, Residual variance = 0.39 n (Village) = 2, n (HH) = 144 n (individual) = 966, n (season) = 4, n (observations) = 4797					

Total calories/day/household

Table A 5.3 Results of linear mixed model showing the correlation of daily household calorie consumption/AME with season and household level variables.
Household nested within village specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Levels	Parameter values	d.f.	Deviance change	P
	Intercept	7.63			
Season	1 Little Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.13 -0.16 0.087	3	8	$p < 0.05$
Village			1	3	($p = 0.087$)
Wealth rank			3	2	ns
Fixed wealth		0.00014	1	48	$p < 0.0001$
HH Income			1	1	ns
HH size		-0.17	1	22	$p < 0.0001$
No. productive adults			1	1	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	3	ns
Proportion productive females			1	3	($p = 0.053$)
Household head sex			1	3	ns
Household head education			3	0	ns
Variance: HH = 0.034, Season = 0.0019, Village = 0.0045, Residual variance = 0.19 n (Village) = 2, n (Season) = 4, n (Household) = 146, n (Observations) = 1085					

Total protein/day/Household

Table A 5.4 Results of linear mixed model showing the correlation of daily household protein consumption (g)/AME with season and household level variables.
Household nested within village specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Levels	Parameter values	d.f.	Deviance change	P
	Intercept	4.22			
Season	1 Little Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.17 -0.15 0.09	3	10	$p < 0.05$
Village	Beayop Teguete	0 -0.19	1	5	p 0.05
Wealth rank			3	2	ns
Fixed wealth		0.00026	1	86	$p < 0.0001$
HH Income			1	2	ns
HH size		-0.16	1	10	$p < 0.005$
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	2	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	3	($p = 0.09$)
Household head sex			1	2	ns
Household head education			3	1	ns
Variance: HH = 0.06, Season = 0.0045, Village = 0.0022, Residual variance = 0.45 n (Village) = 2, n (Season) = 4, n (Household) = 146, n (Observations) = 1083					

Food Source: Agriculture, frequency eaten

Table A 5.5 Results of GLMM showing the frequency of agricultural consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-1.94			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.03 0.64 0.45	3	8	$p < 0.05$
Village			1	3	$p = 0.07$
HH Income			1	0	ns
Fixed Wealth		0.0008	1	46	$p < 0.0001$

Wealth rank	1 2 3 4 5	0 -0.35 -0.38 -1.92 -2.87	1	32	$p < 0.0001$
HH size		2.38	1	27	$p < 0.0001$
No. productive adults			1	(19)	($p < 0.01$)
No. productive females			1	(10)	($p < 0.01$)
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	1	ns
Proportion productive females		1.65	1	5	$p < 0.05$
Sex			1	1	ns
Age (sqrt)			1	2	ns
Education			3	0	ns
HH head sex			1	1	ns
HH head education			3	8	($p = 0.053$)
Variance: Individual = 0, Household = 5.52, Season = 0.0001, Village = 0 N: Season = 4, Village = 2, Household = 145, Individuals = 878, Observations = 5026					

Food Source: Agriculture, proportion calories

Table A 5.6 Results of LMM showing the correlation of proportion of calories consumed from agriculture with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.59			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.025 0.028 -0.021	3	20	$p < 0.001$
Village			1	4	($p = 0.054$)
HH Income			1	0	ns
Fixed Wealth		0.000018	1	41	$p < 0.0001$
Wealth rank	1 2 3 4 5	 0.097 0.088 -0.028 -0.19	1	18	$p < 0.005$
HH size			1	2	ns
No. productive adults			1	1	ns
No. productive females			1	1	ns

Productive males (yes/no)			1	0	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	2	ns
Sex			1	1	ns
Age			1	0	ns
Education			3	2	ns
HH head sex			1	2	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 0.026, Village = 0.0018, residual variance = 0.12 N: Season = 4, Village = 2, Household = 145, Individuals = 873, Observations = 4815					

Food Source: Agriculture, proportion protein

Table A 5.7 Results of LMM showing the correlation of proportion of protein consumed from agriculture with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.76			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet		3	8	(p = 0.050)
Village	Beayop Teguete	0.085	1	5	p < 0.05
HH Income		-0.032	1	47	p < 0.0001
Fixed Wealth			1	3	ns
Wealth rank	1 2 3 4 5		1	8	(p = 0.069)
HH size			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	2	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	4	(p = 0.063)
Sex			1		ns
Age			1		ns
Education			3		ns

HH head sex			1		ns
HH head education			3	2	ns
Variance: Individual = 0, Household = 0.026, Village = 0.00013, residual variance = 0.12 N: Season = 4, Village = 2, Household = 149, Individuals = 892, Observations = 4869					

Food Source: Bought, frequency eaten

Table A 5.8 Results of GLMM showing the frequency of bought food consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-5.59			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet		3	3	ns
Village	Beayop Teguete	0 -1.02	1	8	$p < 0.01$
HH Income		0.55	1	10	$p < 0.005$
Fixed Wealth			1	4	ns
Wealth rank		(+)	1	8	($p = 0.09$)
HH size			1	3	ns
No. productive adults		1.05	1	9	$p < 0.005$
No. productive females			1	4	($p = 0.09$)
Productive males (yes/no)			1	7	($p < 0.005$)
Proportion productive adults			1	1	ns
Proportion productive females			1	-1	ns
Sex			1	0	ns
Age		-0.06	1	9	$p < 0.005$
Education			3	2	ns
HH head sex			1	1	ns
HH head education			3	5	ns
Variance: Individual = 0, Household = 2.12, Village = 0.00013 N: Season = 4, Village = 2, Household = 144, Individuals = 931, Observations = 5120					

Food Source: Gifts, frequency eaten

Table A 5.9 Results of GLMM showing the frequency of gift food consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-4.34			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.77 -0.58 -0.86	3	38	$p < 0.0001$
Village	Beayop Teguete		1	1	ns
HH Income			1	1	ns
Fixed Wealth			1	-316	ns
Wealth rank	1 2 3 4 5	0 -0.86 -0.99 -0.60 0.052	1	36	$p < 0.0001$
HH size		-0.42	1	17	$p < 0.0001$
No. productive adults			1	2	ns
No. productive females			1	2	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	3	ns
Proportion productive females			1	1	ns
Sex			1	0	ns
Age			1	3	($p = 0.07$)
Education			3	1	ns
HH head sex			1	5	($p = 0.08$)
HH head education			3	5	ns
Variance: Individual = 0, Household = 1.47, Village = 0 N: Season = 4, Village = 2, Household = 151, Individuals = 955, Observations = 5196					

Food Source: Forest (all), frequency eaten

Table A 5.10 Results of GLMM showing the frequency of forest food source consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-3.13			

Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -1.93 -1.86 0.22	3	15	$p < 0.005$
Village	Beayop Teguete	 1.14	1	11	$p < 0.001$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 2.07 2.31 -0.29	3	172	$p < 0.0001$
HH Income		-0.014	1	129	$p < 0.0001$
Fixed Wealth			1	-327	ns
Wealth rank			1	7	($p = 0.069$)
HH size		1.19	1	36	$p < 0.0001$
No. productive adults			1	11	($p < 0.001$)
No. productive females			1	14	($p < 0.001$)
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	6	($p < 0.05$)
Proportion productive females			1	0	ns
Sex			1	0	ns
Age			1	0	ns
Education			3	3	ns
HH head sex			1	0	ns
HH head education			3	5	($p = 0.052$)
Variance: Individual = 0, Household = 1.57, Village = 0 N: Season = 4, Village = 2, Household = 150, Individuals = 879, Observations = 5057					

Food Source: Forest (all), proportion protein

Table A 5.11 Results of LMM showing the correlation of proportion of protein consumed from forest food sources with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.22			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.15 0.20 -0.06	3	39	$p < 0.0001$
Village	Beayop Teguete	 0.05	1	1	ns

Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.12 -0.17 0.12	3	15	$p < 0.005$
HH Income			1	-2	ns
Fixed Wealth			1	3	($p = 0.067$)
Wealth rank			1	3	ns
HH size			1	0	ns
No. productive adults			1	1	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	(6)	($p < 0.01$)
Proportion productive adults			1	0	ns
Proportion productive females			1	0	ns
Sex			1	1	ns
Age			1	1	ns
Education			3	1	ns
HH head sex	Female Male	 0.12	1	8	$p < 0.005$
HH head education			3	2	ns
Variance: Individual = 0, Household = 0.038, Village = 0.00023, residual variance = 0.10 N: Season = 4, Village = 2, Household = 123, Individuals = 718, Observations = 2348					

Food Source: Forest (all), proportion calories

Table A 5.12 Results of LMM showing the correlation of proportion of calories consumed from forest food sources with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model. The difference in sample size between models of proportion of protein and proportion of calories are due to the foods eaten containing no protein (i.e. some forest fruits contain no protein)

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.12			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.08 0.03 -0.06	3	131	$p < 0.0001$
Village	Beayop Teguete	0 0.06	1	5	$p < 0.05$
HH Income			1	-68	ns
Fixed Wealth			1	-37	ns
Wealth rank			1	4	ns
HH size			1	3	($p = 0.097$)

No. productive adults			1	1	ns
No. productive females			1	3	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	0	ns
Sex			1	0	ns
Age			1	1	ns
HH head sex	Female Male		1	3	(p = 0.062)
HH head education			3	2	ns
Variance: Individual = 0, Household = 0.006, Village = 0.00005, residual variance = 0.022 N: Season = 4, Village = 2, Household = 125, Individuals = 732, Observations = 2387					

Food Source: Forest animal, frequency eaten

Table A 5.13 Results of GLMM showing the frequency of forest animal consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-16.29			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.95 -0.13 -0.34	3	13	p < 0.005
Village	Beayop Teguete	0 2.08	1	10	p < 0.005
HH Income		0.59	1	40	p < 0.0001
Fixed Wealth			1	-349	ns
Wealth rank	1 2 3 4	0 1.59 0.38 -0.59	1	13	p < 0.01
HH size		1.20	1	11	p < 0.005
No. productive adults			1	(12)	(p < 0.01)
No. productive females			1	(4)	ns
Productive males (yes/no)			1	2	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	1	ns
Sex			1	0	ns
Age			1	0	ns
Education			3	2	ns

HH head sex	Female Male	0 1.83	1	27	$p < 0.0001$
HH head education			3	1	ns
Variance: Individual = 0, Household = 4.29, Village = 0 N: Season = 4, Village = 2, Household = 149, Individuals = 896, Observations = 5044					

Food Source: Forest animal, proportion protein

Table A 5.14 Results of LMM showing the correlation of proportion of protein consumed from forest animal sources with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.65			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.43 0.02 0.11	3	49	$p < 0.0001$
Village	Beayop Teguete	 -0.02	1	1	ns
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.36 0.21 -0.26	3	86	$p < 0.0001$
HH Income			1	1	ns
Fixed Wealth			1	0	ns
Wealth rank			1	2	ns
HH size			1	1	ns
No. productive adults			1	1	ns
No. productive females			1	6	$p = 0.051$ (-)
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	3	ns
Sex			1	0	ns
Age			1	1	ns
Education			3	0	ns
HH head sex			1	1	ns
HH head education			3	6	$p = 0.096$
Variance: Individual = 0, Household = 0.04, Village = 0.00034, residual variance = 0.046 N: Season = 4, Village = 2, Household = 63, Individuals = 371, Observations = 714					

Food Source: Forest fish, frequency eaten

Table A 5.15 Results of GLMM showing the frequency of forest fish consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model. Although wealth rank was not significant, it was still quite revealing – the highest frequency of consumption was for wealth rank 2.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	2.68			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.24 -0.13 0.16	3	12	$p < 0.05$
Village	Beayop Teguete	0 1.13	1	355	$p < 0.0001$
HH Income		-0.37	1	7	$p < 0.05$
Fixed Wealth			1	0	ns
Wealth rank			1	8	($p = 0.052$)
HH size		1.41	1	17	$p < 0.001$
No. productive adults			1	2	ns
No. productive females			1	3	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	2	ns
Proportion productive females			1	0	ns
Sex			1	0	ns
Age			1	1	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 4.69, Village = 0 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Source: Forest fish, proportion protein

Table A 5.16 Results of LMM showing the correlation of proportion of protein consumed from forest fish sources with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	0.11			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.21 0.20 0.38	3	79	$p < 0.0001$
HH Income			1	4	($p = 0.06$)
Fixed Wealth			1	3	($p = 0.08$)
Wealth rank			1	0	ns
HH size			1	3	ns
No. productive adults			1	2	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	3	ns
Proportion productive females			1	3	ns
Sex			1	2	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			1	0	ns
Money			3	0	ns
Variance: Individual = 0, Household = 0.036, Village = 0.0041, Residual = 0.02 N: Season = 4, Village = 2, Household = 61, Individuals = 342, Observations = 523					

Food Source: Forest plant, frequency eaten

Table A 5.17 Results of GLMM showing the frequency of forest plant consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	-3.66			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -2.80 -4.78 0.01	3	48	$p < 0.001$
Village	Beayop Teguete	 1.34	1	12	$p < 0.01$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 3.13 5.3 -0.52	3	421	$p < 0.001$
HH Income			1	0	ns
Fixed Wealth			1	-316	ns
Wealth rank	1 2 3 4	0 1.00 0.16 -0.25	3	15	$p < 0.005$
HH size		0.86	1	15	$p < 0.001$
No. productive adults			1	3	ns
No. productive females			1	5	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	3	ns
Proportion productive females			1	0	ns
Sex			1	1	ns
Age			1	0	ns
HH head sex			1	3	($p = 0.09$)
HH head education			3	6	($p = 0.08$)
Variance: Individual = 0, Household = 1.78, Village = 0 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Agriculture, proportion calories

Table A 5.18 Results of LMM showing the correlation of proportion of calories consumed from agricultural food types with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	1.21			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.091 -0.025 -0.055	3	19	$p < 0.0001$
Village	Beayop Teguete	 0.070	1	5	$p < 0.05$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.042 -0.014 0.14	3	19	$p < 0.001$
HH Income		-0.029	1	4	$p < 0.0001$
Fixed Wealth			1	1	ns
Wealth rank	1 2 3 4 5	0 -0.01 -0.02 -0.12 -0.16	1	11	$p < 0.05$
HH size			1	1	ns
No. productive adults			1	1	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	0	ns
Sex			1	0	ns
Age			1	2	ns
HH head sex			1	0	ns
HH head education			3	6	ns
Variance: Individual = 0, Household = 0.024, Village = 0.00012, residual variance = 0.12 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Agriculture, proportion protein

Table A 5.19 Results of LMM showing the correlation of proportion of calories consumed from agricultural food types with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	1.01			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.05 -0.02 -0.03	3	29	$p < 0.0001$
Village	Beayop Teguete	 0.15	1	5	$p < 0.05$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.02 -0.1 0.11	3	33	$p < 0.0001$
HH Income		-0.04	1	5	$p < 0.05$
Fixed Wealth			1	2	ns
Wealth rank	1 2 3 4 5	0 -0.05 -0.06 -0.16 -0.15	1	8	$p < 0.05$
HH size			1	1	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	3	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	1	ns
Sex			1	1	ns
Age			1	3	($p = 0.09$)
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 0.029, Village = 3.4 e^{-7}, residual variance = 0.14 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Coastal, frequency eaten

Table A 5.20 Results of GLMM showing the frequency of coastal food types consumed with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-1.96			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 0.16 1.04 0.25	3	50	$p < 0.0001$
Village	Beayop Teguete	 0.09	1	3	($p = 0.08$)
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.63 -0.92 -0.89	3	84	$p < 0.001$
HH Income			1	1	ns
Fixed Wealth			1	3	ns
Wealth rank			1	3	ns
HH size			1	0	ns
No. productive adults			1	1	ns
No. productive females			1	1	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	2	($p = 0.09$)
Proportion productive females		0.84	1	4	$p < 0.05$
Sex			1	0	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education		 -0.005 -0.78 0.22	3	(11)	($p < 0.05$)*
Variance: Individual = 0, Household = 1.16, Village = 0 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980 * correlated with wealth rank					

Food Type: Coastal, proportion protein

Table A 5.21 Results of LMM showing the correlation of proportion of protein consumed from coastal food types with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.35			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.02 -0.04 -0.16	3	59	$p < 0.001$
Village	Beayop Teguete	 -0.23	1	6	$p < 0.05$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.06 0.12 0.12	3	40	$p < 0.001$
HH Income			1	2	ns
Fixed Wealth			1	1	ns
Wealth rank	1 2 3 4 5	 0.06 0.12 0.12 0.15	1	13	$p < 0.01$
HH size			1	1	ns
No. productive adults			1	0	ns
No. productive females		-0.18	1	19	$p < 0.001$
Productive males (yes/no)			1	3	ns
Proportion productive adults			1	1	ns
Proportion productive females		0.28	1	14	$p < 0.01$
Sex			1	0	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 1.18, Village = 4 e^{-8} , 0.022 N: Season = 4, Village = 2, Household = 128, Individuals = 686, Observations = 1532					

Food Type: Import, frequency eaten

Table A 5.22 Results of GLMM showing the frequency of imported food consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-2.11			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.737 -0.86 0.15	3	15	$p < 0.005$
Village	Beayop Teguete	 -1.37	1	8	$p < 0.005$
HH Income		0.26	1	7	$p < 0.01$
Fixed Wealth			1	-395	ns
Wealth rank			1	4	ns
HH size			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	1	ns
Productive males (yes/no)			1	2	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	1	ns
Sex			1	0	ns
Age			1	0	ns
Education				1	ns
HH head sex			1	1	ns
HH head education	None Primary Secondary Higher	 0.11 1.00 1.06	3	12	$p < 0.01$
Variance: Individual = 0, Household = 1.11, Village = 0 N: Season = 4, Village = 2, Household = 145, Individuals = 932, Observations = 5129					

Food Type: Wild (all), frequency eaten

Table A 5.23 Results of GLMM showing the frequency of wild food consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-1.71			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.35 -0.25 -0.45	3	40	$p < 0.001$
Village	Beayop Teguete	 1.19	1	10	$p < 0.001$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 1.16 0.88 -0.28	3	43	$p < 0.001$
HH Income			1	0	ns
Fixed Wealth			1	-280	ns
Wealth rank	1 2 3 4	0 -0.3 -0.70 -0.01	1	10	$p < 0.05$
HH size		0.65	1	18	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	0	ns
Sex			1	1	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 0.85, Village = 0 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Wild (all), proportion protein

Table A 5.24 Results of LMM showing the correlation of proportion of protein consumed from wild food types with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.45			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.002 0.076 0.028	3	32	$p < 0.0001$
Village	Beayop Teguete	0 0.07	1	4	$p < 0.05$
HH Income			1	1	ns
Fixed Wealth			1	0	ns
Wealth rank			1	3	ns
HH size			1	1	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	2	ns
Sex			1	1	ns
Age			1	0	ns
HH head sex			1	2	ns
HH head education			3	1	ns
Variance: Individual = 6 e^{-17}, Household = 0.03, Village = 0 , residual variance = 0.11 N: Season = 4, Village = 2, Household = 138, Individuals = 776, Observations = 2794					

Food Type: Wild (all), proportion calories

Table A 5.25 Results of LMM showing the correlation of proportion of calories consumed from wild food types with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.28			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.03 -0.05 -0.08	3	49	$p < 0.0001$

Village	Beayop Teguete	 -0.008	1	7	$p < 0.01$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.11 0.11 0.04	3	36	$p < 0.001$
HH Income			1	1	ns
Fixed Wealth			1	2	ns
Wealth rank			1	0	ns
HH size			1	5	($p < 0.05$)
No. productive adults			1	4	($p = 0.06$)
No. productive females		-0.05	1	8	$p < 0.01$
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	2	ns
Sex			1	0	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	0	ns
Variance: Individual = 6 e^{-17}, Household = 0.007, Village = 0, residual variance = 0.022 N: Season = 4, Village = 2, Household = 138, Individuals = 776, Observations = 2794					

Food Type: Wild animal, frequency eaten

Table A 5.26 Results of GLMM showing the frequency of wild animal consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-4.0			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.53 -0.45 -1.0	3	50	$p < 0.001$
Village	Beayop Teguete	 1.46	1	10	$p < 0.01$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.06 0.75 1.20	3	27	$p < 0.001$
HH Income			1	2	ns
Fixed Wealth			1	-4	ns
Wealth rank			1	1	ns

HH size		0.79	1	17	$p < 0.001$
No. productive adults			1	4	ns
No. productive females			1	3	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	1	ns
Sex			1	1	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	6	ns
Variance: Individual = 6 e^{-17}, Household = 1.46, Village = 0 N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Wild animal, proportion protein

Table A 5.27 Results of LMM showing the correlation of proportion of protein consumed from wild animal with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.76			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.10 -0.05 -0.26	3	48	$p < 0.001$
Village	Beayop Teguete	 -0.13	1	1	ns
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.01 0.16 0.17	3	16	$p < 0.01$
HH Income		(+)	1	4	($p = 0.054$)
Fixed Wealth			1	0	ns
Wealth rank			1	1	ns
HH size			1	0	ns
No. productive adults			1	1	ns
No. productive females			1	2	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	1	ns

Sex			1	0	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 2.5 e^{-17}, Household = 0.04, Village = 3.8 e^{-8}, residual = 0.065 N: Season = 4, Village = 2, Household = 107, Individuals = 577, Observations = 1358					

Food Type: Wild Fish, frequency eaten

Table A 5.28 Results of GLMM showing the frequency of wild fish consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-3.22			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 0.81 1.20 1.32	3	0	
Village	Beayop Teguete	 1.28	1	1	
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -1.12 -1.19 -2.65	3	62	$p < 0.0001$
HH Income			1	1	ns
Fixed Wealth			1	1	ns
Wealth rank			1	4	ns
HH size			1	0	ns
No. productive adults			1	1	ns
No. productive females			1	-2	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	1	ns
Sex			1	0	ns
Age			1	1	ns
HH head sex			1	1	ns
HH head education			3	6	ns
Variance: Individual = 5 e^{-10}, Household = 1.87, Village = 5 e^{-10} N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Wild fish, proportion protein

Table A 5.29 Results of LMM showing the correlation of proportion of protein consumed from wild fish with season and individual and household level variables.
The arc-sin of the proportion of protein was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.75			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	0 -0.08 -0.01 0.08	3	49	$p < 0.001$
Village	Beayop Teguete	 -0.35	1	7	$p < 0.01$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.31 0.12 0.31	3	50	$p < 0.001$
HH Income		-0.025	1	4	p 0.05
Fixed Wealth			1	0	ns
Wealth rank			1	5	ns
HH size			1	2	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	2	ns
Sex			1	1	ns
Age			1	1	ns
HH head sex			1	0	ns
HH head education			3	7	ns
Variance: Individual = 0, Household = 0.25, Village = 0, residual = 0.024 N: Season = 4, Village = 2, Household = 92, Individuals = 495, Observations = 809					

Food Type: Wild plant, frequency eaten

Table A 5.30 Results of GLMM showing the frequency of wild plant consumption with season and individual and household level variables.
Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-2.0			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.91 -1.23 -1.84	3	148	$p < 0.001$
Village	Beayop Teguete	 1.98	1	11	$p < 0.001$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 1.77 1.74 -0.16	3	69	$p < 0.001$
HH Income			1	1	ns
Fixed Wealth			1	-30	ns
Wealth rank	1 2 3 4	 0.24 0.96 0.86		2	ns
Wealth rank : Village	T : 1 T : 2 T : 3 T : 4	 -0.18 -1.76 -0.91		10	$p < 0.05$
HH size			1	4	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	2	ns
Proportion productive females			1	2	ns
Sex			1	0	ns
Age			1	1	ns
HH head sex			1	1	ns
HH head education			3	7	($p = 0.08$)
Variance: Individual = $5 e^{-10}$, Household = 1.16, Village = $5 e^{-10}$, N: Season = 4, Village = 2, Household = 144, Individuals = 877, Observations = 4980					

Food Type: Wild plant, proportion calories

Table A 5.31 Results of LMM showing the correlation of proportion of calories consumed from wild plants with season and individual and household level variables.
The arc-sin of the proportion of calories was taken to give a normal distribution. Individuals nested within households nested within villages were specified as a random effect. Parameter estimates shown for significant variables in the minimum adequate model

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.32			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 0.007 -0.015 0.05	3	191	0.01
Village	Beayop Teguete	 0.009	1	25	$p < 0.05$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.10 0.05 -0.08	3	23	$p < 0.001$
Money		(-0.013)	1	7	$p = 0.058$
Fixed Wealth			1	1	ns
Wealth rank			4	1	ns
HH size		-0.06	1	28	$p < 0.001$
No. productive adults			1	8	($p < 0.01$)
No. productive females			1	14	($p < 0.001$)
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	3	ns
Proportion productive females			1	0	ns
Sex			1	0	ns
Age			1	0	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, Household = 0.005, Village = 0, residual = 0.009 N: Season = 4, Village = 2, Household = 122, Individuals = 603, Observations = 1720					

Appendix 6. Supplementary material: Chapter 4

Table A 6.1 Results from LMM – total household production value/household total AME. HH Income not analysed.

Variable	d.f.	Parameter estimate	d.f.	Deviance change	P
	intercept	-5.42			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.90 0.37 -0.25	3	44	$p < 0.0001$
Village	Beayop Teguete	 0.55	1	1	ns
Village:Season	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -1.25 -1.68 -0.61	1	15	$p < 0.01$
Fixed Wealth		0.71	1	11	$p < 0.0001$
Wealth rank			1	2	ns
HH size			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	3	ns
Proportion productive females		1.05	1	6	$p < 0.05$
HH head sex	Female Male	 0.61	1	8	$p < 0.01$
HH head education			3	3	ns
Variance: HH = 0.54, Village = 0.036, Residual = 3.49 n (HH) = 147, n (observations) = 521					

Table A 6.2 Results from GLMM - Likelihood of a household earning money in a particular season

Variable	d.f.	Parameter estimate	d.f.	Deviance change	P
	intercept	-12.77			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -1.10 -0.04 -0.53	3	19.3	$p < 0.001$
Village			1	0	ns
Fixed Wealth		0.77	1	11	$p < 0.05$
Wealth rank	1 2 3 4	 0.72 0.52 1.35	1	11	$p < 0.05$
HH size		0.65	1	9	$p < 0.01$
No. productive adults			1	8	ns

No. productive females			1	6	ns
Productive males (yes/no)			1	2.4	ns
Proportion productive adults			1	0.3	ns
Proportion productive females			1	0.1	ns
HH head sex	Female Male	 0.66	1	7	p < 0.01
HH head education			3	2.2	ns
Variance: HH = 0.0.46, Village = 0 n (HH) = 147, n (observations) = 521					

Table A 6.3 Results from LMM – Amount earned per HH per AME (earners only)

Variable	d.f.	Parameter estimate	d.f.	Deviance change	P
	intercept	7.53			
Season			3	0.6	ns
Village	Beayop Teguete	 -0.81	1	5.2	p < 0.05
Fixed Wealth			1	3.8	p = 0.052
Wealth rank	1 2 3 4	 0 -0.49 0.04	1	10	p < 0.05
HH size		-0.68	1	21	p < 0.001
No. productive adults			1	5.5	ns
No. productive females			1	7	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	6	ns
Proportion productive females			1	1	ns
HH head sex	Female Male	 -0.39	1	5.4	p < 0.05
HH head education	None Primary Secondary Higher	 0.43 0.97 0.27	3	13	p < 0.01

Table A 6.4. Results from LMM – likelihood of production, all forest products (>18)

Variable	d.f.	Parameter estimate	d.f.	Deviance change	P
	intercept	-1.06			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -1.49 -0.63 -0.84	3	48	p < 0.0001
Village	Beayop Teguete		1	1	ns
Gun (yes/no) (only 6 HHs)			1	1	ns
HH Income		-0.06	1	0	ns

Sex	Female Male	 -3.08	1	15	$p < 0.001$
HH Income: Sex	Income: Female Income: Male	 0.29	1	14	$p < 0.05$
Fixed Wealth			1		ns
Wealth rank			1	5	ns
HH size (sqrt)			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	2	ns
Dependence prop (adult)			1	0	ns
Dependence prop (female)			1	2	ns
Age	18 – 30 30 – 50 50 – 65 65+	 1.05 1.19 0.78	1	19	$p < 0.0001$
Education			3	7	ns
HH head sex			1	0	ns
HH head education			3	6	($p = 0.08$)
Variance: Individual = 0.46, HH = 0.031, Village = 0 n (Village) = 2, n (HH) = 152, n (individual) = 1348, n (observations) = 1348					

Table A 6.5. Results from LMM – (log) value of all forest products (>18, producers only)

Variable	d.f.	Parameter estimate	d.f.	Deviance change	P
	intercept	6.04			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.09 -0.90 -0.22	3	24	$p < 0.0001$
Village	Beayop Teguete	 1.93	1	6	$p < 0.05$
Gun (yes/no) (only 6 HHs)			1		ns
Chainsaw (yes/no) (only 10 HHs)			1		ns
HH Income			1	0	ns
Fixed Wealth			1		ns
Wealth rank	1 2 3 4	 -0.18 -0.57 -0.08	3	8	$p < 0.05$
HH size (sqrt)			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Dependence prop (adult)			1	0	ns
Dependence prop (female)			1	0	ns

Sex	Female Male	3.04	1	83	$p < 0.0001$
Village: Sex	T: Female T: Male	-2.19		47	$p < 0.001$
Age		-0.19	1	7	$p < 0.01$
Education			3	3	ns
HH head sex			1	0	ns
HH head education			3	3	ns
Variance: Individual = 0, HH = 0.043, Village = 0, Residual variance = 0.021 n: Village = 2, HH = 119, Individual = 206, Observations = 289					

Table A 6.6 Likelihood of income from all forest products (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	-5.31			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.40 0.36 -0.68	3	8.3	$p < 0.05$
Village	Beayop Teguete	 0.81	1	4.8	$p < 0.05$
HH Income			3	3.7	$p = 0.056$
HH Fixed Wealth			1		ns
HH Wealth rank			1	2.3	ns
HH size			1	0.1	ns
No. productive adults			1	0	ns
No. productive females			1	0.2	ns
Productive males (yes/no)			1	0.5	ns
Proportion productive adults			1	0.1	ns
Proportion productive females			1	0.5	ns
HH head education			3	3.3	ns
HH head sex			1	0.3	ns
Sex	Female Male	 1.77	1	16	$p < 0.0001$
Age			1	2.1	ns
Education			3	3.2	ns
Variance : Individual = 2.54, HH = 0, Village = 0 n: Village = 2, HH = 152, Individual = 473, observations = 1348					

Table A 6.7 Amount of income from all forest products (>18).
Age (categorical) also significant, but not significantly different from Age (continuous).

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	2.87			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet		3	3.5	ns
Village	Beayop Teguete		1	0.6	ns
HH Income		0.47	3	9.3	$p < 0.01$
HH Fixed Wealth			1		ns
HH Wealth rank			1	1.7	ns
HH size			1	0.1	ns
No. productive adults			1	0.1	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	0.8	ns
Proportion productive adults			1	0.1	ns
Proportion productive females			1	0.3	ns
HH head education			3	1.2	ns
HH head sex			1	1.6	ns
Sex	Female Male		1	5.1	$p = 0.079$
Age		-0.32	1	10.5	$p < 0.01$
Education			3	1	ns
Variance : Individual = 0.067, HH = 2.3 e^{-9}, Village = 0.033, Residual = 0.78 n: Village = 2, HH = 49, Individual = 59, observations = 68					

Table A 6.8. Results from GLMM – likelihood of production forest animals (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	-8.85			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.32 1.29 -1.44	3	14	$p < 0.001$
Village			1	1	ns
HH Income (log)			1	1	ns
HH Fixed Wealth (sqrt)			1		ns
HH Wealth rank			3	7	ns
HH size (sqrt)			1	1	ns

No. productive adults (sqrt)			1	0	ns
No. productive females (sqrt)			1	1	ns
Productive males (yes/no)			1	4	p = 0.07
Dependence prop (adult) (sqrt(asin())			1	2	ns
Dependence prop (female) (sqrt(asin())			1	0	ns
HH head sex			1	0	ns
HH head education			3	1	ns
HH Gun (yes/no) (only 8 HHs)			1	0	ns
Sex	Female Male	3.27	1	14	p < 0.001
Age (sqrt)			1	3	ns
Education	(higher education = lower hunting)		3	7	p = 0.06
Variance : Individual = 0.20, HH = 0, Village = 0 n: Village = 2, HH = 141, Individual = 382, observations = 1053					

Table A 6.9. Results from mixed model – value of production, forest animals (only producers > 18)

Variable (value logged)		Parameter estimate	d.f.	Deviance change	P
	intercept	2.96			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.05 -1.16 -0.45	3	20	p < 0.0001
Village			1	2	ns
HH Income (log)		0.30	1	6	p < 0.05
HH Fixed Wealth (sqrt)			1		ns
HH Wealth rank			1	4	ns
HH size (sqrt)			1	0	ns
No. productive adults (sqrt)			1	0	ns
No. productive females (sqrt)			1	3	ns
Productive males (yes/no)			1	1	ns
Dependence prop (adult) (sqrt(asin())			1	0	ns
Dependence prop (female) (sqrt(asin())			1	2	ns
HH head sex			1	1	ns
HH head education			3	0	ns
HH Gun (yes/no) (only 8 HH owned a gun)			1	2	ns
Sex	Female Male	 1.09	1	10	p < 0.01

Age (sqrt)			1	1	ns
Education			1*	2	ns
Variance : Individual = 0, HH = 0, Village = 0 n: Village = 2, HH = 51, Individual = 61, observations = 82 * only people with primary or secondary education gained value from forest animals (none with no education or higher education)					

Table A 6.10. Results from GLMM – likelihood of production forest fish (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	-8.78			
Season			3	7	p = 0.07
Village			1	0	ns
HH Income (log)			1	0	ns
HH Fixed Wealth (sqrt)			1	0	ns
HH Wealth rank			3	2	ns
HH size (sqrt)			1	0	ns
No. productive adults (sqrt)			1	0	ns
No. productive females (sqrt)			1	0	ns
Productive males (yes/no)			1	0	ns
Dependence prop (adult) (sqrt(asin())			1	0	ns
Dependence prop (female) (sqrt(asin())			1	0	ns
HH head sex			1	0	ns
HH head education			3	0	ns
Sex			1	0	ns
Age			1	1	ns
Education			3	1.5	ns
Variance : Individual = 5.69, HH = 0, Village = 0 n: Village = 2, HH = 141, Individual = 382, observations = 1053					

Table A 6.11. Results from GLMM – likelihood of production forest plants (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	0.91			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.89 0.75 0.50	3	33	p < 0.0001
Village	Beayop Teguete	 1.40	1	0	

Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -1.85 -3.01 -1.44	3	25	p < 0.0001
HH Income			3	0	ns
HH Fixed Wealth			1		ns
HH Wealth rank			1	4	ns
HH size (sqrt)			1	1	ns
No. productive adults			1	0	ns
No. productive females			1	1	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	0	ns
HH head education			3	8	(p = 0.051)
HH head sex			1	0	ns
Sex			1	2	ns
Age		0.62	1	28	p < 0.0001
Education			3	0	ns
Variance : Individual = 0.20, HH = 0, Village = 0 n: Village = 2, HH = 141, Individual = 382, observations = 1053					

Table A 6.12. Results from GLMM – value of production forest plants (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	4.25			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 1.16 -0.43 0.33	3	30	p < 0.0001
Village	Beayop Teguete	 2.93	1	6	p < 0.01
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -2.74 -2.50 -1.92	3	26	p < 0.0001
HH Income			3	0	ns
HH Fixed Wealth			1	0	ns
HH Wealth rank			1	7	p = 0.07
HH size (sqrt)			1	0.5	ns
No. productive adults			1	0	ns
No. productive females			1	0.5	ns

Productive males (yes/no)			1	2.5	p = 0.06
Proportion productive adults			1	0	ns
Proportion productive females			1	4	p = 0.055
HH head education			3	0	ns
HH head sex			1	5	ns
Sex	Female Male	 1.39	1	24	p < 0.0001
Age			1	0	ns
Education			3	5	ns
Variance : Individual = 0.20, HH = 0, Village = 0 n: Village = 2, HH = 141, Individual = 382, observations = 1053					

Table A 6.13. Results from GLMM – likelihood of income from forest animals (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	-11.87			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.38 0.55 -1.60	3	11	p < 0.01
Village	Beayop Teguete	 1.07	1	4	p > 0.05
HH Income		0.51	3	4	p > 0.05
HH Fixed Wealth			1		ns
HH Wealth rank	1 2 3 4	 -0.25 -1.07 -2.15	1	10	p > 0.05
HH size (sqrt)			1	0	ns
No. productive adults			1	1	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	4	ns
Proportion productive adults			1	1	ns
Proportion productive females			1	0	ns
HH head education			3	2	ns
HH head sex			1	2	ns
Sex	Female Male	 2.45	1	14	p < 0.001
Age			1	0	ns
Education			3	4	ns

Variance : Individual = 0.20, HH = 0, Village = 0 n: Village = 2, HH = 141, Individual = 382, observations = 1053

Table A 6.14. Results from GLMM – amount income from forest animals (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	1.39			
Season			3	4.5	ns
Village			1	-2	ns
HH Income		0.45	3	5.5	$p < 0.05$
HH Fixed Wealth			1	3	ns
HH Wealth rank			1	4	ns
HH size (sqrt)			1	1	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	2	ns
Proportion productive females			1	1	ns
HH head education			3	0	ns
HH head sex			1	3	($p = 0.09$)
Sex			1	0	ns
Age			1	0	ns
Education			3	1	ns
Variance : Individual = 0, HH = 0, Village = 0, Residual variance = 0.52 n: Village = 2, HH = 32, Individual = 35, observations = 39					

Table A 6.15. Results from GLMM – likelihood of income from forest plants (>18)

Variable		Parameter estimate	d.f.	Deviance change	P
	intercept	-9.53			
Season			3	1	ns
Village			1	0	ns
HH Income			3	0	ns
HH Fixed Wealth			1		ns
HH Wealth rank			1	0	ns
HH size (sqrt)			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0	ns

Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	0	ns
HH head education			3	2	ns
HH head sex			1	2	ns
Sex			1	1.5	ns
Age			1	0	ns
Education			3	1	ns
Variance : Individual = 5.9, HH = 0, Village = 0 n: Village = 2, HH = 152, Individual = 473, observations = 1348					

Figure A 6.1. Income from all people (18-65), average cfa per day (Beayop)

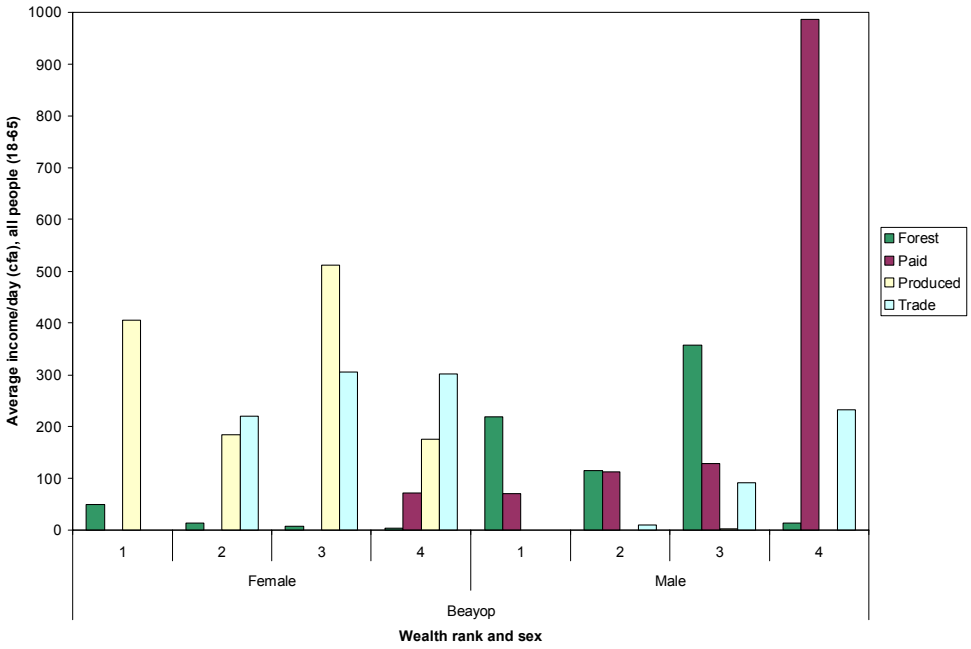


Figure A 6.2. Income from all people (18-65), average cfa per day (Teguete)

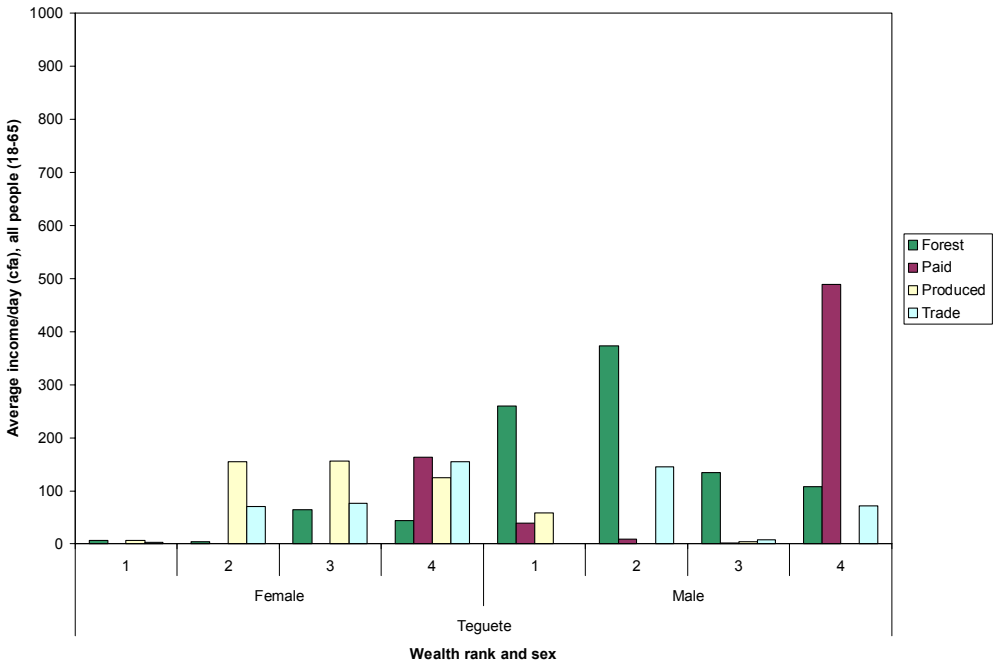


Figure A 6.3. Income from all sources, people earning from that income only (and in those seasons only), average cfa per day (Beayop), all ages

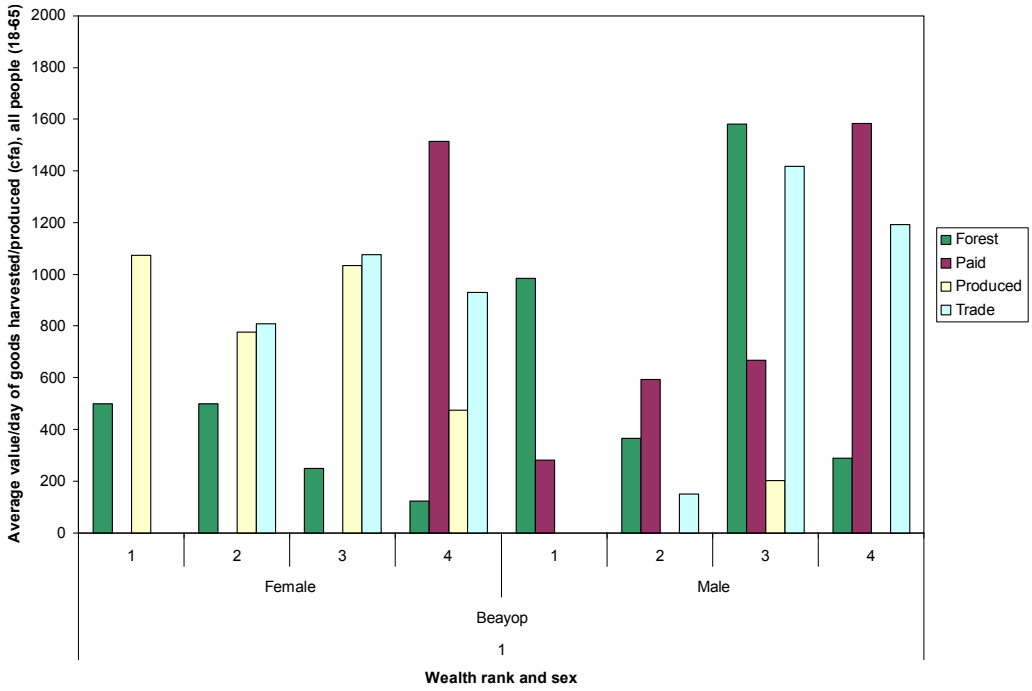


Figure A 6.4. Income from all sources, people earning from that income only (and in those seasons only), average cfa per day (Teguete), all ages

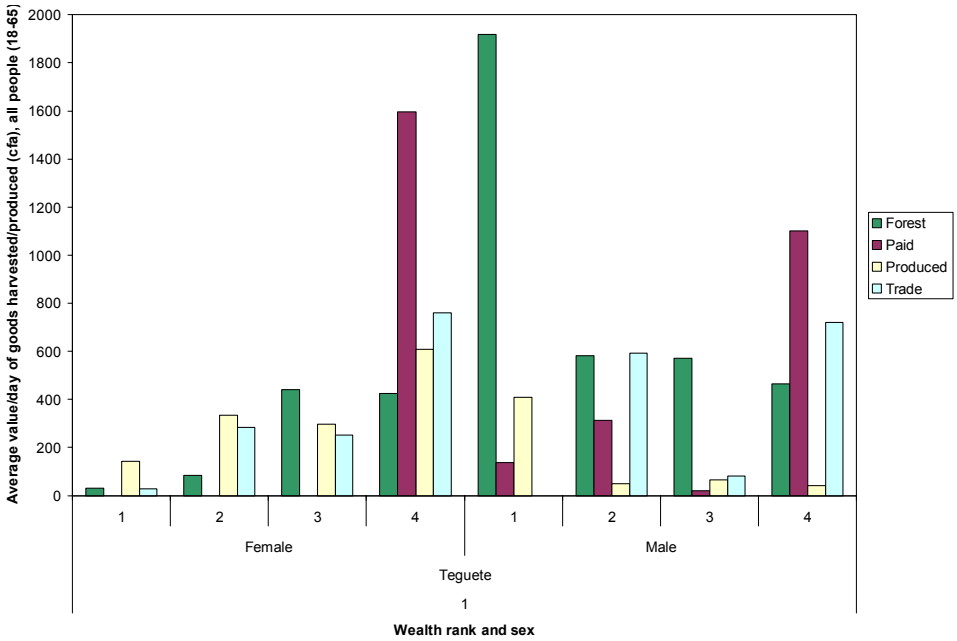


Table A 6.16. Results from GLMM – likelihood of value for agricultural products (all people >18).

Age (categorical) is a significantly better fit than age as a continuous variable.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-1.25			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.72 0.21 0.36	3	29	$p < 0.0001$
Village			1	0	ns
HH Income			3	0	ns
HH Fixed Wealth			1		ns
Wealth rank			3	7	$p = 0.07$
HH size			1	2	ns
No. productive adults			1	0	ns
No. productive females			1	1	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	2	ns
Proportion productive females			1	5	$p = 0.052$
HH head education			3	6	ns
HH head sex	Female Male	 0.57	1	10	$p < 0.05$

Sex	Female Male	 -0.359	1	220	p < 0.0001
Age	18-30 30-50 50-65 65+	 1.45 2.49 1.57	3	73	p < 0.0001
Education			3	4	ns
Variance: Individual = 1.25, Household = 0.093, Village = 0 N: Individual = 473, Household = 152, Village = 2, Observations = 1348					

Table A 6.17. Results from LMM - value of all agricultural products

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-0.71			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.73 0.37 -0.04	3	43	p < 0.0001
Village	Beayop Teguete	 0.05	1	2	ns
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.53 -1.09 0.32	3	17	p < 0.001
Age		0.69	1	79	p < 0.0001
Sex	Female Male	 -15.5	1	181	p < 0.0001
Wealth rank			3	7	(p = 0.08)
Income			1	3	(p = 0.09)
HH Head Education			3	7	(p = 0.07)
Variance: Individual = 1.58, Household = 0.07, Village = 0.02, Residual variance = 4.65 N: Individual = 411, Household = 147, Village = 2, Observations = 1149					

Table A 6.18. Results from GLMM – likelihood of income of all agricultural products

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-3.41			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -1.04 0.75 -0.62	3	16.7	p < 0.001
Village	Beayop Teguete	 -0.35	1	2.1	ns

Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 0.44 -1.24 1.35	3	23.5	$p < 0.0001$
HH Income			3	2.9	$p = 0.092$
HH Fixed Wealth			1		ns
Wealth rank	1 2 3 4	 0.49 0.75 -0.15	3	10.9	$p < 0.05$
HH size			1	1.8	ns
No. productive adults			1	3.3	$p = 0.070$
No. productive females			1	0.4	ns
Productive males (yes/no)			1	1.6	ns
Proportion productive adults			1	0	ns
Proportion productive females			1	0.1	ns
HH head education			3	1.8	ns
HH head sex			1	0.6	ns
Sex	Female Male	 -2.52	1	66.1	$p < 0.0001$
Age	18 – 30 30 – 50 50 – 65 65 +	 1.62 1.79 1.37	1	28	$p < 0.0001$
Education			3	4.7	ns
Variance: Individual = 0.74, Household = 0.21, Village = $5 e^{-10}$ N: Individual = 473, Household = 152, Village = 2, Observations = 1348					

Table A 6.19. Results from LMM – amount of income (log) of all agricultural products (earners only)

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	7.24			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.17 -0.37 -0.59	3	8.3	$p < 0.05$
Village	Beayop Teguete	 -1.03	1	5	$p < 0.05$
Season: Village	T: 1 Small Dry T: 2 First Wet T: 3 Big Dry T: 4 Second Wet	 -0.49 -0.55 1.10	3	11.2	$p < 0.05$
HH Income			3	0.1	ns

HH Fixed Wealth			1		ns
Wealth rank			3	0.6	ns
HH size			1	3.5	p = 0.062
No. productive adults			1	1	ns
No. productive females			1	1.7	ns
Productive males (yes/no)			1	1.8	ns
Proportion productive adults			1	3.3	ns
Proportion productive females			1	1.1	ns
HH head education			3	7	p = 0.07
HH head sex			1	0.4	ns
Sex	Female Male	-0.95	1	6.1	p < 0.05
Age			1	7.6	p = 0.053 (categorical)
Education			3	4.8	p = 0.09
Variance: Individual = 0, Household = 0, Village = 0.05, Residual = 1.33 N: Individual = 107, Household = 83, Village = 2, Observations = 147					

Table A 6.20. Results from GLMM – likelihood of trade (>18)

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	-12.95			
Season			3	5.5	ns
Village			1	0	ns
HH Income		0.51	3	4.1	p < 0.05
HH Fixed Wealth			1		ns
HH Wealth rank			1	5	ns
HH size			1	0	ns
No. productive adults			1	0	ns
No. productive females			1	0.5	ns
Productive males (yes/no)			1	0	ns
Proportion productive adults			1	0.6	ns
Proportion productive females			1	1	ns
HH head education			3	0.6	ns
HH head sex			1	0	ns
Sex			1	4	p = 0.055
Age			1	0.5	ns
Education			3	5	ns

Variance : Individual = 2.7, HH = 0, Village = 0 n: Village = 2, HH = 152, Individual = 473, observations = 1348

Table A 6.21. Results from GLMM – amount of trade (>18)

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	Intercept	0.92			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 0.12 -0.73 -0.03	3	16	$p < 0.01$
Village			1	1	ns
HH Income		0.51	3	14	$p < 0.001$
HH Fixed Wealth			1		ns
HH Wealth rank			1	0.8	ns
HH size (sqrt)			1	1.4	ns
No. productive adults			1	0.5	ns
No. productive females			1	0.5	ns
Productive males (yes/no)			1	1	ns
Proportion productive adults			1	0.1	ns
Proportion productive females			1	0.1	ns
HH head education	None Primary Secondary Higher	 0.81 1.63 1.93	3	18	$p < 0.001$
HH head sex	Female Male	 -0.64	1	5	$p < 0.05$
Sex			1	0.5	ns
Age		-0.24	1	5.3	$p < 0.05$
Education			3	3.7	ns
Variance : Individual = 0.55, HH = 0, Village = 0.038 n: Village = 2, HH = 58, Individual = 80, observations = 117					

Appendix 7. Accumulation strategies

Table A 7.1 Short term accumulation strategies.
For 2005, respondents only ranked the severity of strategies that they had used. Frequency (freq.) refers to the number of households that report using this strategy in the previous 2 months. Average score refers to the average severity ranking (lower scores denoting the things that would be done first, with higher scores being the things that would be done only once the lower scoring things were also being done). The rank of scores is simply the average severity scores, ranked.

	Freq. 2005 (both vill.s)	Av. Score 2005 (both vill.s)	Rank of av. Score (2005 both vill.)	Freq. Beayop 2005	Av. score Beayop 2005	Rank Beayop 2005	Freq. Teg 2005	Av. score Teg. 2005	Rank Teg. 2005
Save food for the next day	111	2	2	38	2	2	73	2	2
Eat 3 times or more each day	124	1	1	54	1.1	1	70	1	1
Sell food from agriculture or forest	113	2.8	3	44	2.55	3	69	2.96	3
Buy fish to eat	126	4.7	4	55	4.65	5	71	4.73	4
Buy meat to eat	122	5.05	5	51	4.61	4	71	5.37	6
Buy things for activities (cartridges, wire, hooks, machetes)	98	6.52	8	33	5.79	7	65	6.89	7
Buy preferred items (cigarettes, drinks, etc.)	81	7.07	9	27	6.48	8	54	7.37	8
Buy luxury items (clothes, jewerllery, shoes)	84	7.51	10	40	6.73	10	44	8.23	9
Help other members of the family	64	6.44	7	42	5.33	6	22	8.55	10
Pay off debts	70	5.29	6	19	6.53	9	51	4.82	5

Table A 7.2. Long term accumulation strategies.
For 2005, respondents only ranked the severity of strategies that they had used. Frequency (freq.) refers to the number of households that report using this strategy in the previous 2 months. Average score refers to the average severity ranking (lower scores denoting the things that would be done first, with higher scores being the things that would be done only once the lower scoring things were also being done). The rank of scores is simply the average severity scores, ranked.

Strategy	Freq. 2005 (both vill.s)	Av. Score 2005 (both vill.s)	Rank of av. Score (2005 both vill.)	Freq. Beayop 2005	Av. score Beay. 2005	Rank Beay. 2005	Freq. Teg 2005	Av. score Teg. 2005	Rank Teg. 2005

Buy domestic animals	44	2.91	4	26	3.27	6	18	2.39	4
Buy regular equipment for activities (machetes, cestas, etc)	122	1.12	1	53	1.28	1	69	1	1
Buy large equipment for activities (guns, nets, etc)	15	2.4	3	7	2.71	3	8	2.13	2
Buy things for entertainment (radios, mobiles, etc.)	60	3.03	6	33	3.64	8	27	2.3	3
Buy material to construct the house (cement, chapas, nipas, tablas)	43	2.16	2	32	1.81	2	11	3.18	5
Buy things for the house (furniture, carpet, tv)	18	3.44	8	16	3.31	7	2	4.5	6
Buy big things for the house (grupo, bar, fridge)	12	3.25	7	12	3.25	5	0	NA	NA
Buy a big thing (car, house)	1	3	5	1	3	4	0	NA	NA
Put money in the bank	0	0	NA	0	NA	NA	0	NA	NA

Appendix 8. Supplementary material: Chapter 5

Table A 8.1 Results from GLMM of household food security score from 2005 and 2006 against household level variables.
The higher the food security score, the less food secure. Parameter estimates are shown for the minimum adequate model. Year and household nested within village were specified as random effects. The number of productive adults and females and proportion of productive adults and females were all correlated, so each parameter was fitted to the model in turn, and the parameter explaining the greatest deviance taken in the minimum adequate model.

Variable	Level	Parameter estimate	d.f.	Deviance change	P
	intercept	4.91			
Village	Beayop Teguete	 2.38	1	6	$p < 0.02$
Income		-0.016	1	64	$p < 0.0001$
Fixed Wealth		-0.00063	1	14	$p < 0.005$
Wealth rank	1 2 3 4 5	 -1.44 -1.48 -1.42 -1.95	1	10	$p < 0.05$
Proportion productive adults		-2.11	1	22	$p < 0.0001$
Variance: HH = 0, Village = 0.125, Year = 0.17, Residual variance = 5.76 n (Village) = 2, n (HH) = 143, n (year) = 2, n (observations) = 245					

Table A 8.2. Results of LMM analysing the differences in the number of production sources/HH between villages and food security quartiles.
Food security quartiles are taken as those from 2006 data and the least food secure quartile in each village compared to the rest of the population. Village specified as a random effect. The number of production sources was logged to give a normal distribution.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	1.28			
Village			1	3.5	ns
Food security	Least secure (4) Rest (1-3)	-0.10 0	1	15.4	$p < 0.001$
Variance: Village = 1.83 e^{-10}, Residual variance = 0.37 n: HH = 102					

Table A 8.3. Results of LMM analysing the differences in the number of income sources/HH between villages and food security quartiles.
Food security quartiles are taken as those from 2006 data and the least food secure quartile in each village compared to the rest of the population. Village specified as a random effect. The number of income sources plus 1 was logged to give a normal distribution.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	1.07			
Village			1	-1.3	ns
Food security	Least secure (4) Rest (1-3)	-0.23 0	1	22.2	$p < 0.0001$
Variance: Village = 0.0007, Residual variance = 0.25 n: HH = 102					

Table A 8.4. Results of LMM analysing the differences in the number of production sources/HH between villages and wealth rank.
The poorest wealth rank in each village was compared to the rest of the population. Village specified as a random effect. The number of production sources was logged to give a normal distribution.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	0.84			
Village			1	-2.2	ns
Wealth Rank	Poorest (1) Rest (2-4)	 0.50	1	10.2	$p < 0.01$
Village: WR			1	2.8	$p = 0.096$
Variance: Village = 1.69^{e-10}, Residual variance = 0.34 n: HH = 111					

Table A 8.5. Results of LMM analysing the differences in the number of income sources/HH between villages and wealth rank.
The poorest wealth rank in each village was compared to the rest of the population. Village specified as a random effect. The number of income sources plus one was logged to give a normal distribution.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	0.64			
Village			1	-2.6	ns
Wealth Rank	Poorest (1) Rest (2-4)	 0.43	1	10.6	$p < 0.01$
Variance: Village = 1.22^{e-10}, Residual variance = 0.24 n: HH = 111					

Table A 8.6 Results of GLMM testing the significance of household and season variables for the weight-age score for the under-fives.
Weight to age was represented by the WAZ z-score, a score showing the standard deviation from the mean, normalised to account for difference deviations for each age and sex group. These data were taken from health centre records in Teguete from the years 1997-2000. Year and individual nested within household were all specified as random effects.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	-0.20			
Season	1SmallDry 2FirstWet 3BigDry 4SecondWet	 -0.07 0.16 0.08	1	8	$p < 0.01$
HH head education			3	6.6	($p = 0.08$)
Age		-0.08	1	5	$p < 0.05$
Sex	Female Male	 -0.66	1	8.7	$p < 0.01$
Variance: Person:HH = 0.98, HH = 0, Year = 0.0047, Residual variance = 0.27 n (HH) = 28, n(Person) = 52, n (year) = 6, n (observations) = 423, n (Season) = 4					

Table A 8.7 Results of LMM for all WAZ scores, as taken from health centre records in Teguete, 1997-2000, and the results of my own data collection, 2005 and 2006.
Individual, year and season were fitted as random effects. Year was fitted as a factor, not as a continuous variable.

Variable	Levels	Parameter estimate	d.f.	Deviance change	P
	intercept	-0.57			
Season	1 Small Dry 2 First Wet 3 Big Dry 4 Second Wet	 -0.035 0.18 0.21	3	8	$p < 0.05$
Age		-0.21	1	64	$p < 0.0001$
Year	1997 1998 1999 2000 2005 2006	0.17 0.30 0.26 0.37 0.93 0.27	6	26	$p < 0.02$
Variance: Individual = 0.92, Season = 0.0022, Year = 0.0039, Residual variance = 0.25 n (individual) = 243, n (season) = 4, n (observations) = 1185, n(Years) = 7					

Table A 8.8. Results of compositional analysis on proportion value from different livelihood sources for village and food security quartiles. (FS 1-3 and 4)
Food security quartiles are taken as those from 2006 data, and the difference in compositions assessed using a manova.

		Forest	Agriculture	Paid	Trade
Village	F	15.05	3.91	0.62	1.81
	d.f.	1	1	1	1

	p	p < 0.001	p = 0.051	ns	ns
FS quartile (06), gp	F	0.20	0.42	0.08	0.007
	d.f.	1	1	1	1
	p	ns	ns	ns	ns
residual sum of sq.s	(n (HH) = 101	8.18	10.68	5.54	4.28

Table A 8.9. Results of compositional analysis on proportion income from different livelihood sources for village and food security quartiles. (FS 1-3 and 4)
Food security quartiles are taken as those from 2006 data, and the difference in compositions assessed using a manova.

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	10.49	7.54	0.03	0.09
	p		p < 0.01	p < 0.01	ns	ns
FS quartile (06), gp	F	1	0.40	0.03	0.75	0.16
	p		ns	ns	ns	ns
residual sum of sq.s		89	7.82	14.47	4.47	10.23

Table A 8.10. Results of compositional analysis on proportion value from different livelihood sources for village and wealth ranks (1 and 2-4)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	12.62	2.70	1.52	0.54
	p		p < 0.001	ns	ns	ns
WR	F	1	4.02	0.22	0.03	4.39
	p		p < 0.05	ns	ns	p < 0.05
WR : Village	F	1	9.77	4.22	0.33	0.08
	p		p < 0.01	p < 0.05	ns	ns
residual sum of sq.s		107	8.17	11.39	5.93	4.81

Table A 8.11. Results of compositional analysis on proportion income from different livelihood sources for village and wealth ranks (1 and 2-4)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	10.64	7.68	0.07	0.48
	p		p < 0.01	p < 0.01	ns	ns
WR	F	1	3.89	0.06	0.13	3.09
	p		p = 0.052	ns	ns	p = 0.08
residual sum of sq.s		96	8.57	15.98	7.91	10.67

Table A 8.12. Results of compositional analysis on proportion value from different livelihood sources for village, food security (1-3 and 4) and seasons (1,3,4 and 2)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	122.95	0.79	6.08	7.45
	p		$p < 0.0001$	ns	$p < 0.05$	$p < 0.01$
FS (1-3 and 4)	F	1	3.50	0.01	2.81	0.49
	p		$p = 0.062$	ns	$p = 0.094$	ns
Season (2 and 1,3,4)	F	1	0.30	0.82	0.81	0.10
	p		ns	ns	ns	ns
residual sum of sq.s		444	50.94	73.3	28.94	23.82

Table A 8.13. Results of compositional analysis on proportion income from different livelihood sources for village, food security (1-3 and 4) and seasons (1,3,4 and 2)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	23.07	1.02	3.18	0.92
	p		$p < 0.0001$	ns	$p = 0.075$	ns
FS (1-3 and 4)	F	1	9.21	0.86	0.38	0.59
	p		$p < 0.01$	ns	ns	ns
Season (2 and 1,3,4)	F	1	0.47	4.31	0.31	1.41
	p		ns	$p < 0.05$	ns	ns
Village: FS	F	1	12.64	7.35	0.12	0.25
	p		$p < 0.001$	$p < 0.01$	ns	ns
residual sum of sq.s		283	28.39	55.29	41.50	47.46

Table A 8.14. Results of compositional analysis on proportion production from different livelihood sources for village, wealth rank (1 and 2-4) and seasons (1,3,4 and 2)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	21.84	0.30	9.33	5.93
	p		$p < 0.0001$	ns	$p < 0.01$	$p < 0.05$
WR (1 and 2-4)	F	1	8.90	0.07	2.27	9.72
	p		$p < 0.01$	ns	ns	$p < 0.01$
Season (2 and 1,3,4)	F	1	0.76	0.14	0.03	2.98
	p		ns	ns	ns	$p = 0.085$
Village: FS	F	1	16.15	4.18	1.21	0.96
	p		$p < 0.0001$	$p < 0.05$	ns	ns
residual sum of sq.s		484	53.91	80.74	31.15	25.79

Table A 8.15. Results of compositional analysis on proportion income from different livelihood sources for village, wealth rank (1 and 2-4) and seasons (1,3,4 and 2)

		d.f.	Forest	Agriculture	Paid	Trade
Village	F	1	21.85	0.45	4.86	1.01
	p		$p < 0.0001$	ns	$p < 0.05$	ns
WR (1 and 2-4)	F	1	9.14	0.60	0.29	8.02
	p		$p < 0.01$	ns	ns	$p < 0.01$
Season (2 and 1,3,4)	F	1	0.64	3.91	0.40	0.91
	p		ns	$p < 0.05$	ns	ns
residual sum of sq.s		308	33.54	61.98	44.25	50.15

Table A 8.16 Differences in food source composition between seasons and households.

	Agriculture		Bought		Forest		Gifts	
	p	F	p	F	p	F	p	F
Village	$p < 0.005$	9.4	$p < 0.0001$	75.9	$p < 0.0001$	146.6	ns	0.7
Season	ns	0.2	ns	1.5	ns	1.0	ns	0.9
Food Security	ns	1.0	ns	1.4	ns	0.4	ns	0.3
Village: Season	ns	0.6	ns	0.0006	ns	0.2	ns	0.9
Village: FS	ns	0.8	ns	2.4	ns	1.8	$p < 0.05$	4.5
FS: Season	ns	0.8	ns	0.001	ns	1.4	ns	0.5

Appendix 9. Supplementary material, chapter 6

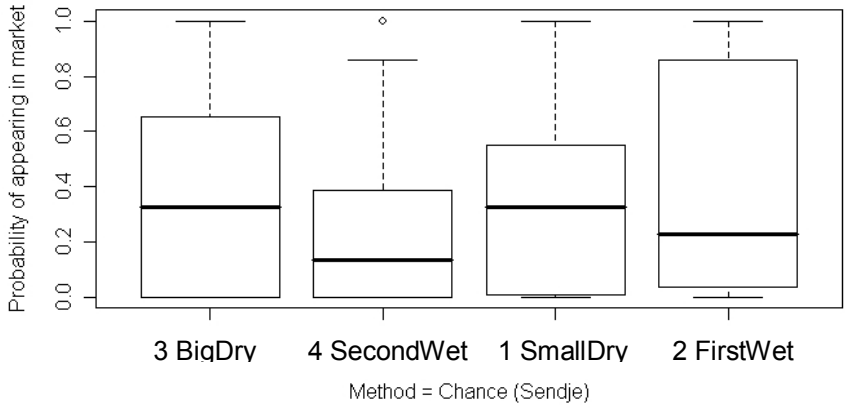
Table A 9.1. Correlations between explanatory variables for carcasses from Sendje.
Numbers in bold are significant ($p < 0.05$) and are shown only for those values over 0.1.

	Price/carcass	Price/kg	Mark-up	Preference	Method (target)
Mass	**0.939**	-0.229	0.365	0.255	
Price/carcass			0.355	0.313	
Price/kg				0.396	-0.21
Mark-up					0.168
Preference					0.139

Table A 9.2. Correlations between variables for carcasses from Midyobo.

	Price/ carcass	Price/kg	Mark-up	Preference	Proportion Fresh	Method (chance)
Mass (log)	**0.983**	-0.966	-0.246	-0.401	0.297	-0.413
Price/carcass (log)		0.950	0.206	0.492	-0.342	0.462
Price/kg			-0.180	0.328	-0.335	0.405
Mark-up				0.140	-0.119	0.175
Preference					-0.022	0.564

Figure A 9.1. Graphs showing the interaction between season and capture method with likelihood of sale to market in Sendje.



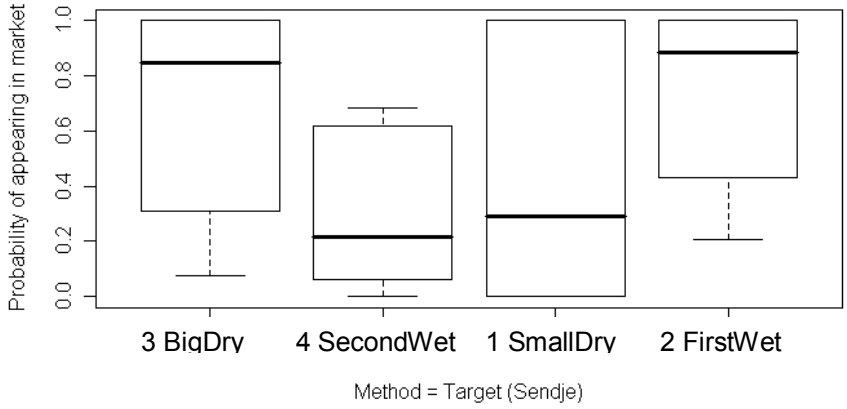


Figure A 9.2. Price per carcass against R max for bushmeat species sold in Bata market. Primates are shown in red.

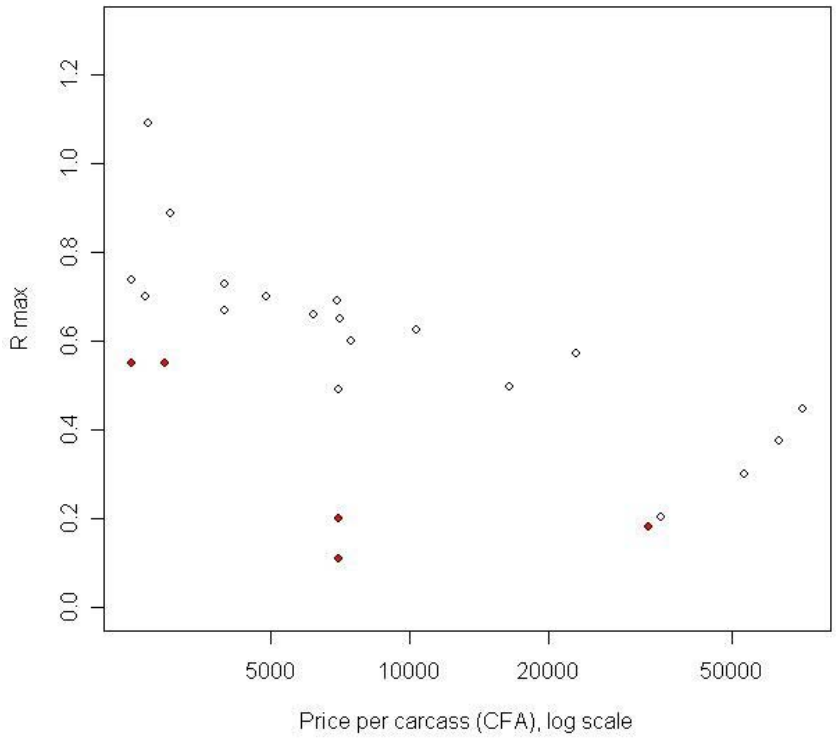


Figure A 9.3. Average carcass Rmax and travel time for each catchment. Travel time is shown on a log scale.

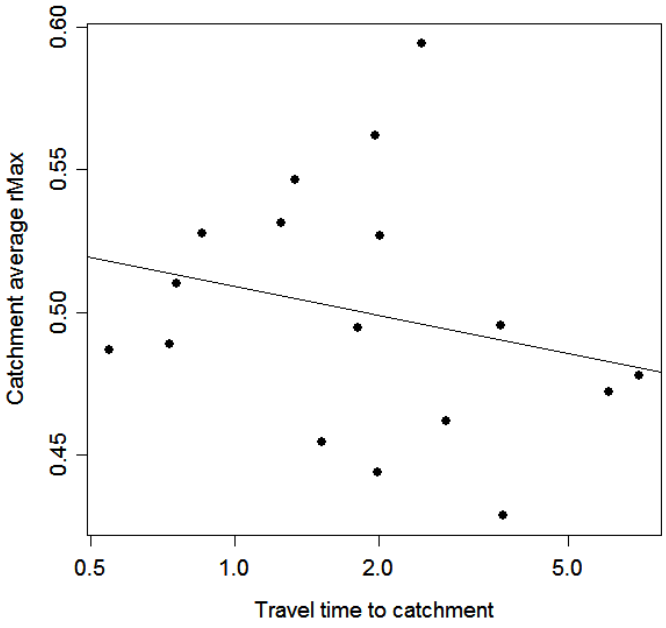


Figure A 9.4. Average km travelled for 2003 and 2005 for each species, Central market only. Species are listed in order of 2003 average km travelled.

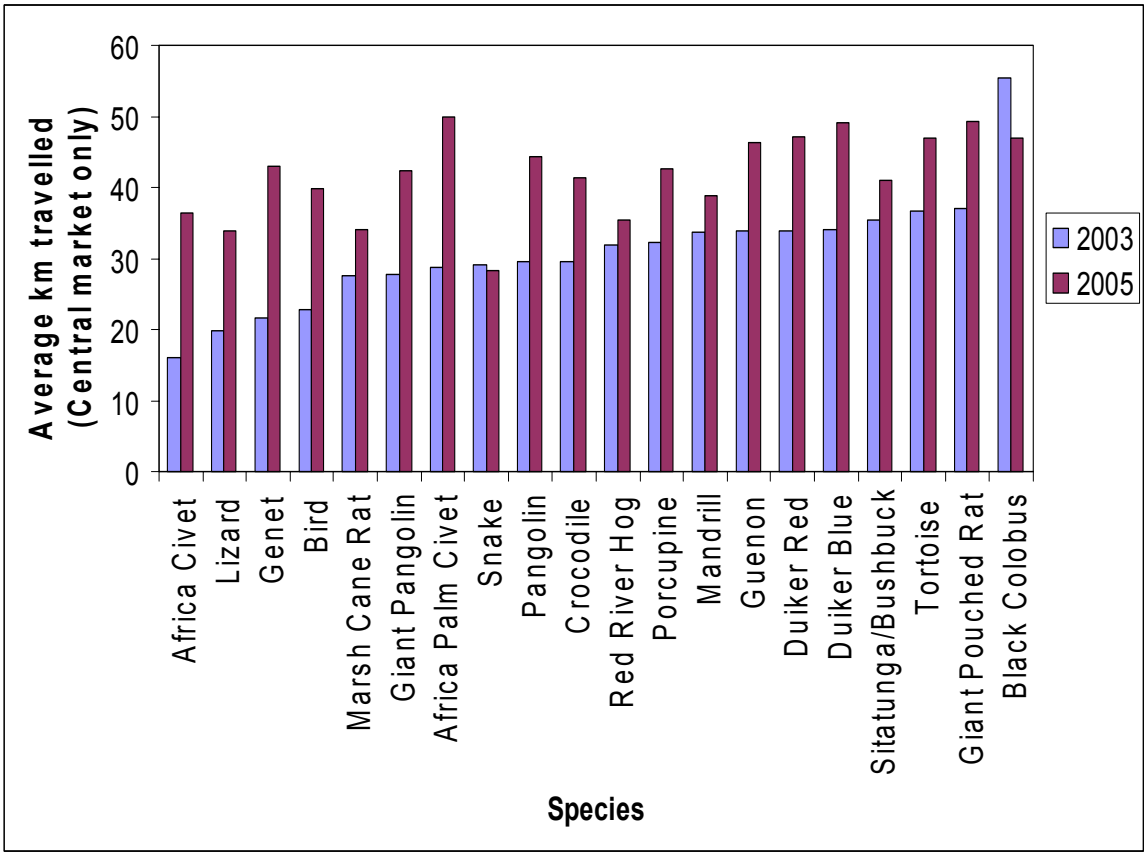


Figure A 9.5. Change in km travelled (2003 – 2005) for each species**.**

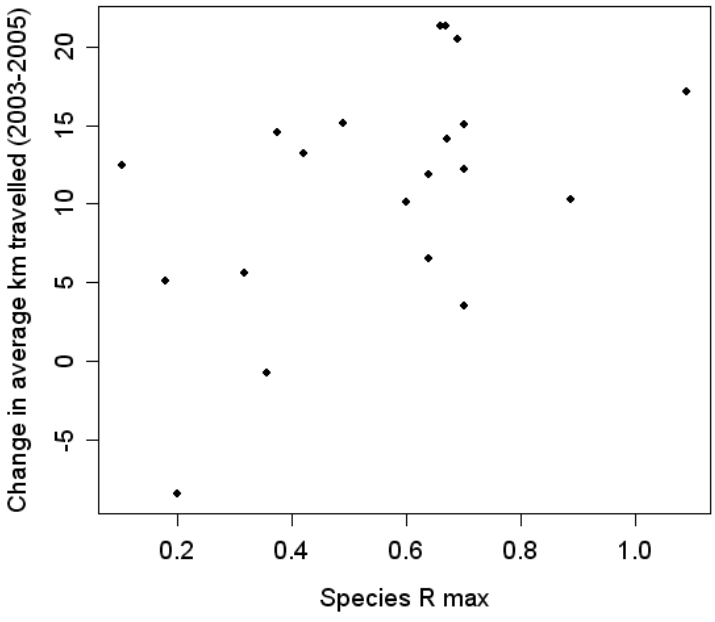


Figure A 9.6. Average price of meat per kilo for the range of products or species within a food category in Central market, 2005.
E.g. Each bushmeat species gives one data point within the category 'bushmeat'. FDomesticMeat = Fresh domestic meat (predominantly beef and goat), Ffactory = frozen meat/fish sold from three warehouses, generally sold wholesale (usually in boxes of 10 or 20kg) but sold in units of 1 kilo in at least one warehouse), FrozenMarkSale = frzen meat/fish sold in the market, SmkdFishSold = Smoked fish sold in the market.

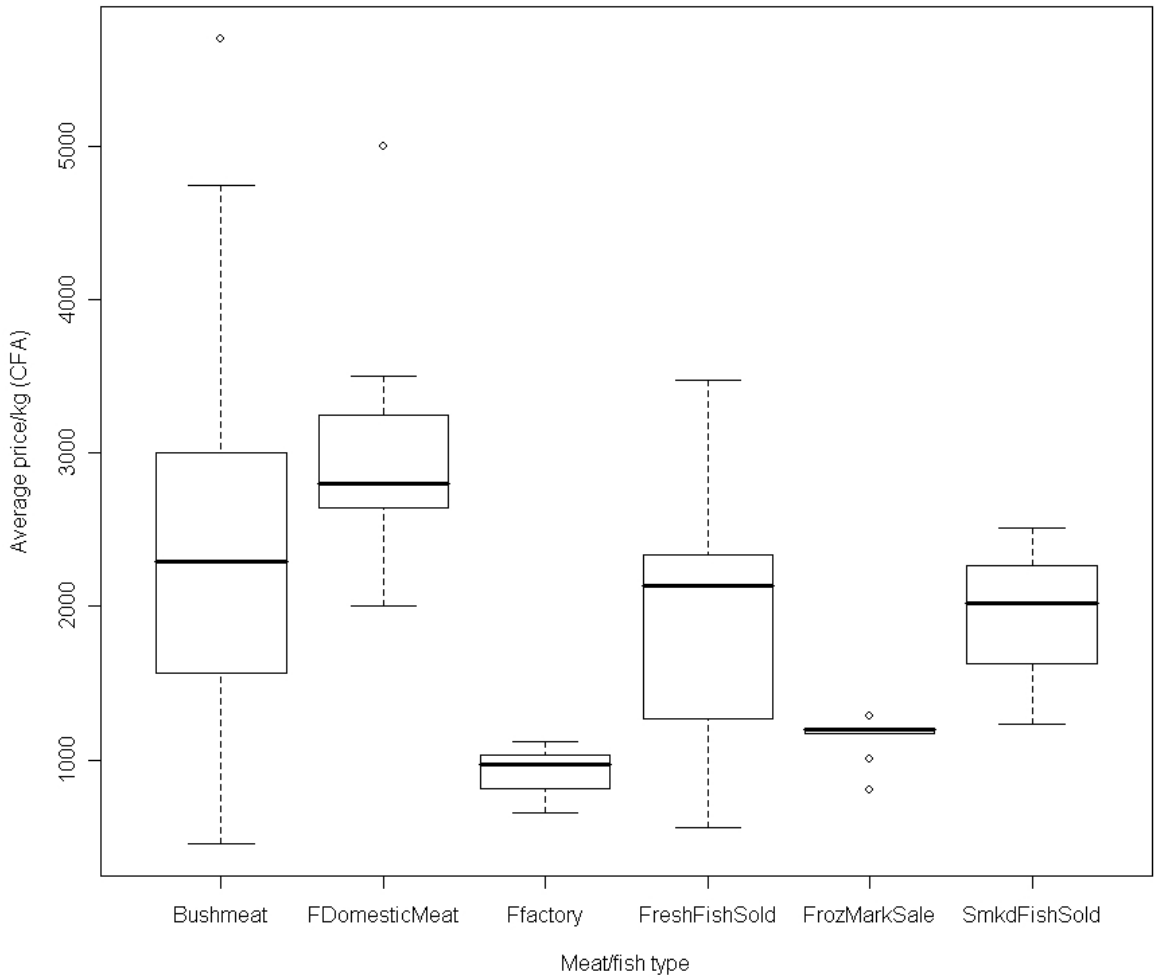


Table A 9.3. Showing data village and market carcass counts, and other species attributes.
Shaded cells show data that were not included in the analyses (shown here for reference). See following page for notes.

	Animal	Spp names	Sendje Village	Sendje Market	Midyobo Village	Midyobo Market [1]	Mass (kg) [2]	Rmax	Price/ carcass Central 2003 [3] (CFA)	Price/ carcass Mundoasi 2005 [4] (CFA)	Price/ kg dressed 2003 [5] (CFA)	Price/ kg dressed 2005 [5] (CFA)	Mark up Sendje 2003	Preference Score [6]	Mark up Midyobo 2005
Amphibia	Goliath frog	*Conraua goliath*	12	0	0	0	2.1	NA	NA	NA	NA	NA	NA	2.76	NA
Birds	Birds	(see table 2)	286	9	282	24	1.0	1.09	2717	2653	4370	4267	1.917	3.67	2.144
Carnivore	Spot-necked otter [8]	*Aonyx congica*	0	0	4	0	5.3	0.60	NA	NA	NA	NA	NA	NA	NA
	Africa civet	*Civettictis civetta*	1	1	5	0	6	0.69	7000	14000	1795	3590	1.917	4	NA
	Africa palm civet	*Nandinia binotata*	26	17	38	28	2.4	0.66	6209	8839	3980	5666	1.977	4	2.212
	Leopard [8]	*Panthera pardus*	2	0	1	0	23	0.36	NA	NA	NA	NA	NA	3.09	NA
	Genet & Linsang	(see table 2)	24	6	68	29	1.7	0.67	4000	3300	3652	3013	1.76	3.53	1.973
	Mongoose	(see table 2)	21	2	66	0	3.0	0.73	4000	6000	2051	3077	1.833	2.33	NA
Hyracoidea	Western tree hyrax	*Dendrohyrax dorsalis*	3	0	3	2	2.8	0.75	NA	3000	NA	1648	NA	NA	NA
Mollusc	African giant snail	*Achatina spp.*	1	0	0	0	0.5	NA	NA	NA	NA	NA	NA	3.31	NA
Pholiodota	Pangolin	*Phataginus tricuspis*	324	121	580	204	2.0	0.70	4915	9292	3781	7148	1.797	4.62	2.342
	Giant pangolin	*Smutsia gigantea*	12	10	20	10	21.0	0.375	63250	77050	4634	5645	1.923	4.62	2.449
Primate	Guenons & mangabeys [9]	(see table 2)	269	221	561	553	4.6	0.11	7056	8392	2244	2806	2.017	4.03	2.108
	Black colobus	*Colobus satanus*	378	134	449	449	9.5	0.20	7037	8763	1139	1419	1.912	4.03	1.914
	Demidoffs galago	*Galagoides demidoff*	0	0	1	0	0.3	NA	NA	NA	NA	NA	NA	4.03	NA
	Mandrill	*Mandrillus sphinx*	79	53	155	117	13.8	0.18	32986	16400	3677	1828	2.177	4.03	2.346
	Northern talapoin	*Miopithecus talapoin*	1	0	4	0	1.2	0.55	2955	1500	3788	1923	1.778	NA	NA
	Chimpanzee [n]	*Pan troglodytes*	1	0	18	16	34 [f]	0.07	NA	47000	NA	2127	2.438	1.46	2.185
	Potto	(see table 2)	3	1	4	0	1.0 [f]	0.55	2500	NA	3819	NA	1.667	NA	NA
Proboscidea	Forest elephant [8]	*Loxodonta africana*	0	0	1	1	900 [b]	0.10	NA	NA	NA	NA	NA	3.76	NA
Reptile	Africa forest turtle	*Kinyxis erosa*	865	261	665	620	1.7	0.89	3048	3829	2758	3466	2.002	3.40	2.993
	Dwarf crocodile	*Osteolaemus tetraspis*	135	127	56	40	6	0.57	23057	32281	5912	8277	1.716	4.41	2.235

	Monitor lizard	*Varanus niloticus*	21	13	14	8	4.2	0.65	7093	13833	2598	5067	1.890	2.15	2.573
	Snake	(see table 2)	0	0	4	0	23.6	0.38	NA	13600	NA	887	NA	1.85	2.296 [z]
Rodent	Brush-tail porcupine	*Atherurus africanus*	2207	441	1467	784	3.2	0.60	7492	11195	3602	5382	2.001	4.65	2.282
	Giant pouched rat	*Cricetomys emini*	382	11	472	42	1.1	0.70	2692	2741	3765	3833	1.685	3.75	2.694
	Marsh cane rat	*Thryonomys swinderianus*	14	4	51	4	4.7	0.62	10364	12786	3392	4185	2.021	4.17	2.6
	Squirrel	(see table 2)	2	0	17	0	0.3	1.65	NA	NA	NA	NA	NA	2.65	NA
Ungulate	Blue duiker	*Cephalophus monticola*	2399	615	2075	898	4.8	0.49	7040	6998	2256	2243	1.995	4.14	2.097
	Red duiker (medium)	(see table 2)	201	142	311	224	17.8	0.20	35196	25631	3038	2212	2.007	3.78	2.545
	Red duiker (large)	(see table 2)	15	11	6	2	33.9	0.30	53127	57750	2415	2625	1.856	3.78	2.2
	Water chevrotain	*Hyemoschus aquaticus*	10	2	27	4	9	0.50	16500	15500	2821	2650	2.014	NA	2.261
	Dwarf antelope	*Neotragus batesi*	3	0	19	0	2.9	0.74	2500	4167	1326	2210	1.694	4.14	NA
	Red River Hog	*Potamochoerus porcus*	15	14	30	7	30.5	0.45	71450	69895	3604	3526	1.932	4.57	2.82
	Buffalo [8]	*Synceros caffer*	0	1	0	0	285 [b]	NA	NA	NA	NA	NA	NA	3.65	NA

[1] This is an estimate from the sample (data was collected on alternate days). Only data recorded as coming from Midyobo (rather than Midyobo and Teguete) was included, probably leading to an under-estimation of quantities.
[2] Taken from Kumpel (2006) unless otherwise specified. The weighted mass is used for groups of species.
[3] From Kumpel (2006). Prices are for adult fresh carcasses only (rather than all adult carcasses), so some variation from her thesis.
[4] Average adult carcass price for Bata markets, 2005.
[5] Price per dressed kilo calculated using price per carcass of fresh adult carcasses only. Dressed weight calculated as 65% of average fresh adult carcass weight.
[6] Preference score from Nick's masters (and book chapter – check if/when published). Respondents asked to give a score out of 5 for a range of foods (1 = hate, 5 = love). Average score is shown. N = 41.
[8] Excluded from analyses due to lack of price data.
[9] Guenons and mangabeys were combined due to a high frequency of misidentification (particularly of smoked carcasses). No mangabeys were recorded in 2005
[b] From (Kingdon 1997). [g] Average price for group, weighted by proportion of different species.
[i] Although there were some mandrills bought for equal to, or greater than the 2003 price, there were also a large number of low value mandrills. Even when the price of only fresh or alive adults was taken (i.e. excluding lower value smoked and rotten carcasses), the average was only 23,770 cfa. Similarly, although some red duikers are more expensive that the 2003 prices. Fresh adult average is 27,718 cfa. Some of the 2005 prices are lower than the 2003 prices. This is mainly because the prices in mundaosi market were generally lower than those in central market.
[z] Snake has a mark-up value for midyobo (despite 0 recorded in market) because one was recorded in the market, but in the cold wet season (when none recorded in village).

Table A 9.4. Species composition of groups referred to in Table A 9.3.

Birds	Black guinea fowl	*Agelastes niger*
	Black-casqued wattled hornbill	*Ceratogymna atrata*
	Black-and-white casqued hornbill	*Ceratogymna subcylindricus*
	Great blue turaco	*Corythaeola cristata*
	Scaly francolin	*Francolinus squamatus*
	Guinea fowl unknown	*Guinea fowl unknown*
	Plumed guinea fowl	*Guttera plumifera*
	Palm-nut vulture	*Gypohierax angolensis*
	Nkulengu rail	*Himatornis haematopus*
	Pigeon/DoveSpp	*Pigeon/DoveSpp*
	Africa grey parrot	*Psittacus erithacus*
	Hartlaub's duck	*Pteronetta hartlaubi*
	Crowned hawk-eagle	*Stephanoaetus coronatus*
Genets	Servaline genet	*Genetta servalina*
	Central african linsang	*Poiana richardsoni*
Mongooses	Marsh mongoose	*Atilax paludinosus*
	Black-legged mongoose	*Bdeogale nigripes*
	Cuisimanse	*Crossarchus platycephalus*
	Mongoose unknown	*NA*
	Long-snouted mongoose	*Herpestes naso (None in Sendje)*
Mangabey	Grey-cheeked mangabey	*Lophosebus albigena*
Great apes	Western lowland gorilla	*Gorilla gorilla gorilla*
	Chimpanzee	*Pan troglodytes*
Pottos	Potto	*Perodicticus potto*
	Golden angwantibo	*Artocebus aureus*
Snakes	Gabon viper	*Bitis gabonica*
	African rock python	*Python sebae*
Squirrel	Biafran bight palm	*Epixerus wilsoni*
	Rope squirrels	*Funisciurus spp*
	Red-legged sun squirrel	*Heliosciurus rufobrachium*
	African pygmy squirrel	*Myosciurus pumilio*
	African giant squirrel	*Protoxerus strangeri*
Red duikers (medium)	Peter's duiker	*Cephalophus callypigus*
	Ogilby's duiker	*Cephalophus ogilbyi*
	Bay duiker	*Cephalophus dorsalis*
	White-bellied duiker	*Cephalophus leucogaster*
	Black-fronted duiker	*Cephalophus nigrifrons*
	Yellow-backed duiker	*Cephalophus silvicultor*
Gorilla	Seen once in the wild near Midyobo, and possibly recorded in the market, but unconfirmed.	
Red duikers (large)	Bush buck	*Tragelaphus scriptus*
	Sitatunga	*Tragelaphus spekei*

Appendix 10. Product Lists: consumption and prices

Table A 10.1 Common agricultural food items

Shows the proportion of interviews where each agricultural food item was recorded as consumed (i.e. the proportion of sample days per household) for the most common agricultural foods, and the average price per unit for each village. Items are shown in order (most frequently consumed first).

Food item	Proportion of interviews where consumption recorded		Most Common Unit	Average price per unit (cfa)	
	Beayop	Teguete		Beayop	Teguete
Cassava (bar)	0.71	0.81	Bar	55	50
Chilli Pepper	0.59	0.53	Pile	25	50
Leaves (all types) *	0.58	0.46	Packet	170	147
Onion	0.83	0.39	Entire	94.1	83.6
Palm Oil *	0.29	0.36	Litre	500	500
Cassava (boiled)	0.28	0.28	Basin	150	150
Banana	0.04	0.27	Entire	19.5	16.7
Peanut	0.47	0.25	Sack50	11203	13461
Cassava leaves	0.28	0.18	Packet	100	100
Pineapple	<0.01	0.14	Entire		95
Calabaza	0.04	0.11	Sack50	20000	18661
Avocado	0.04	0.05	Entire	50	25
Maize	0.14	0.03	Basin	117	116
Plantain	0.26	0.03	Stalk	1527	1500
Tomatoes (fresh)	0.35	0.03	Plate	100	50
Cocoyam	0.06	0.02	Entire	25	
Yam	0.01	0.02	Entire	50	50
Orange	<0.01	0.02	Entire		31
Papaya	0.01	0.01	Entire	325	200
Sugar Cane	<0.01	<0.01	Sack50	2000	3000
Goat (fresh)	<0.01	<0.01	Entire		10000
Guinean potatoes	<0.01	<0.01	Entire	33	50
Eggs	<0.01	<0.01	Entire		100
Sugared peanuts	<0.01	<0.01	Piece		50
Banana bunuelo	<0.01	<0.01	Entire		7.1
Bread fruit	<0.01	<0.01	Entire		25
Herbs	<0.01	<0.01	Entire	16.6	25
Sugar cane wine			Litre	243	138
All agricultural products	***0.998***	***0.997***			

Table A 10.2 Common coastal food items

Shows the proportion of interviews where this item was recorded as consumed, and the average price per unit for each village, for the most frequently consumed items. Local names for fish species are given. The total includes rare and unspecified fish. Items are shown in order (most frequently consumed first).

Food item	Proportion of interviews where consumption recorded		Most common Unit	Average price per unit (cfa)	
	Beayop	Teguete		Beayop	Teguete
"Bifaka" (smoked)	0.29	0.12	Entire	62.9	43.4
"Celele" (smoked)	<0.01	0.15	Pile		101.4
"Abamikono" (smoked)	0.01	<0.01	Entire	550	
"Biconot" (smoked)	0.01	<0.01	Entire	71.43	
"Meneng" (smoked)	<0.01	<0.01	Entire	150	
All coastal products	***0.33***	***0.27***			

Table A 10.3 Imported food items

Shows the proportion of interviews where this item was recorded as consumed and the average price per unit for each village, for the most frequently consumed imported items. The proportion of sampe days consumed is not shown for alcoholic drinks, as these numbers are likely to be an underestimate. Items are in order.

Food item	Proportion of interviews where consumption recorded		Most Common Unit	Average price per unit (cfa)	
	Beayop	Teguete		Beayop	Teguete
Salt	0.94	0.85	Glass	100	100
Stock cubes (maggi)	0.89	0.72	Caldo	50.1	47.7
Rice	0.32	0.11	Glass	100	100
Vegetable Oil	0.32	0.09	Litre	980	1000
Mackerel (frozen)	0.32	0.08	Kg	795.1	785
Tomatoes (tinned)	0.13	0.07	Tin	101	144
Chicken (frozen)	0.12	0.05	Kg	1250	1275
Bunuelos (flour)	0.08	0.09	Entire	25.2	36.6
Sugar	0.03	0.03	Cube	6.3	5.6
Sardines (tinned)	0.03	0.02	Tin	302	324
Pig (frozen)	0.03	<0.01	Kg	1281.8	
Beef (frozen)	0.01	<0.01	Kg	1300	
Spagetti	0.01	<0.01	Packet	425	400
Turkey (frozen)	<0.01	<0.01	Kg	1300	
Spam	<0.01	<0.01	Tin	800	
Bonito (frozen fish)	<0.01	<0.01	Kg	800	
Caramelos	<0.01	<0.01	Entire	30	23.8
Leche en lata	<0.01	<0.01	Tin	600	625
Vino			Litre	686	780
Cerveza			Can	700	700
Conac			Small glass	100	125
All frozen fish	***0.346***	***0.083***			
All frozen domestic meat	***0.171***	***0.051***			
All imports	***0.975***	***0.905***			

Table A 10.4 Wild food items

Food item	Proportion Interviews where consumption recorded		Most Common Unit	Average price per unit (cfa)	
	Beayop	Teguete		Beayop	Teguete
Wild Animals					
Blue duiker	0.043	0.095	Entire	3657	2696
Giant pouched rat	0.027	0.062	Entire	1421	913
Bay duiker	0.005	0.057	Entire	10250	6735
Moustached monkey	0.005	0.048	Entire	3571	2694
Brush-tailed porcupine	0.004	0.045	Entire	5250	3751
Black colobus	<0.001	0.024	Entire		4094
Marsh cane rat	0.007	0.010	Entire	3778	3500
Pangolin	0.005	0.011	Entire	3132	1835
Putty-nosed monkey	0.002	0.013	Entire		3103
Snail	0.005	<0.001	Entire	50	
Mandrill	<0.001	0.005	Entire		11464
Sitatunga	0.004	<0.001	Entire	10000	
Snake	0.004	<0.001	Entire	4400	
Wild bird	0.005	0.003	Entire	800	625
Lizard	0.002	0.003	Entire	3625	3083
Genet	0.002	<0.001	Entire	2500	
African civet	0.002	<0.001	Entire	7000	
Dwarf antelop	0.002	<0.001	Entire	2177	
African palm civet	0.002	0.002	Entire	3167	2333
Cuisimanse	0.002	0.002	Entire	1000	2500
Tortoise	0.002	0.002	Entire	1938	1007
Red river hog	<0.001	0.002	Entire		35000
Squirrel	<0.001	<0.001	Entire	950	500
Chimpanzee	<0.001	<0.001	Entire		15667
Crocodile	<0.001	<0.001	Entire	1000	
Nkwa - jirafa	<0.001	<0.001	Entire	13000	16000
Onzem - titi	<0.001	<0.001	Entire	1500	
Giant Pangolin	<0.001	<0.001	Entire		25000
All wild animals	***0.122***	***0.359***			
Wild Fish					
Fresh water crabs	0.020	0.043	Entire	100	
'Ndo'	0.052	0.002	Entire	128	
'Mifiga'	0.020	<0.001	Entire	196	
'Mikeme'	0.009	<0.001	Entire	286	286
'Bifaka' (fresh)	0.005		Entire	27.3	
'Awom'	<0.001		Entire	49	
'Ndjobo'		<0.001	Entire		250
'Ndo'	<0.001	<0.001	Entire	67	100
'Ngo' (fresh)	<0.001	<0.001	Entire	334	333
'Ngo' (smoked)	<0.001		Entire	500	
'Nkara'	<0.001		Entire	27.3	

'Nkó'		<0.001	Entire		100
'Nva''		<0.001	Entire		62.5
All wild fish	***0.165***	***0.143***			
Wild Plants					
Chocolate	0.120	0.480	Escudilla	4125	3600
African Plum	0.013	0.059	Entire	35	7.5
Palm wine			Litre	200	107
Forest Fruits (all species)		0.037	Plate		50
All wild plants	***0.14***	***0.52***			

Table A 10.5 Average prices of non-food items, Beayop and Teguete

English Name	Most Common Unit	Average Price Beayop (cfa)	Average Price Teguete (cfa)
Wire	Metre	200	350
Fishing Hook	Entire	25	25
Gun cartridge	Entire	600	650
File	Entire	900	1000
Machete	Entire	2400	2500
Cigarette	Packet	494.7	496.5
Soap	Entire	171.9	138.6
Gasoline	Litre	350	353
Wicker basket	Entire	1750	1500
Fish trap	Entire		2000
Wicker dish	Entire	317	300
Raffia	Entire	200	