WILDLIFE HUNTING, ALTERNATIVE PROTEIN SOURCES AND BIODIVERSITY CONSERVATION ON THE BIRD'S HEAD PENINSULA OF WEST PAPUA, INDONESIA

Thesis submitted by

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M. Sc. (Animal Science), University of Philippines Los Baňos

December 2015

For the degree of Doctor of Philosophy

In the College of Marine and Environmental Science

JAMES COOK UNIVERSITY

Acknowledgements

The first acknowledgement is to Andrew; to whom I am greatly indebted for allowing me as his PhD student at James Cook University after Chris Johnson left for the University of Tasmania. I also appreciate he keeps Janice in the supervisory team together with Jeff and Intu make the team various in scientific background and add extra colour to my thesis.

My special gratitude also goes to AusAID – Australia Award Scholarships that enables me to pursue a doctorate degree and bring me to Townsville and later to Cairns. Alex Salvador, Catherine Elliot of the AusAID and the International Student Centre staff provided tremendous assistance during my time to produce this thesis.

I am also grateful to Universitas Papua, Manokwari, (Prof Frans Wanggai, Ir. Y.P. Karafir, M. Ec and Dr. Merlyn Lekitoo) for the support and assistance during my study. Benja Mambai from WWF Papua Program, Rudi Wondiwoy (Late) helped me with the information and profile data of the study sites.

Head of Abun and Amberbaken District, the village chiefs and people from 11 villages, I owe them for permitting me to conduct research along the coastal landscape of the Bird's Head Peninsula. I thank my respondents who allowed us to disturb their activities with the interviews and questionnaires that significantly enriched this thesis. Nixon Karubaba, Demianus, Michael Maryen, Yowel Momo, Yudi and their family members, special thanks for your generous and hospitality during my field work.

The data collection would not have been possible without assistance from Bastian Maryen, Yusuf Burako and Nerius Sai who were very supportive throughout the 2011-2013 field work. A horde of volunteers also assisted the data collection at different times: Yohan Mofu, Leo, Zulkifly, Aris, Kartika, Stenly and Adel.

My journey in Cairns would have been possible without a constant support from the Cairns Presbyterian Church members, George Dimara and family, Bruce McKay and family, Peter Hitchcock and family and the kid's beloved "Aunty Atha" who always there and actively taking part for the parenting responsibilities. I also wish to thank my fellow Indonesian friend and family for companionship during our journey in Cairns.

Last but not least, I am thankful to my mother M.M. Apituley, my father J.J. Pattiselanno and Oke – my younger brother, for their constant support and encouragement.

My mother in-law and the whole family also help us during my study. Deep gratitude should go to my wife Agustina, who sacrifice her study and share the parenting responsibilities during my absence in Cairns. I thank my children Abigail, Goura and Edgar for their understanding and support - I love you guys.

Statement of the contribution of others

Chapters 1, 3, 4 and 5 in this thesis are manuscripts that are being prepared for submission. Several researchers have made contributions in different capacities and it is necessary to recognise their contributions. The draft thesis was proofread by Rae Wiseman and Dr. Victoria Nelson. Jeff Sayer and Intu Boedhihartono helped with the initial drafts, Andrew Krockenberger and Janice Lloyd edited the manuscripts. Will Edwards and Susan Yacups both helped me with the statistical analysis. Others who helped with data collection were: B. Maryen, K Zohar, N Sai, S Wairara and Y. Burako, Adel Batlaubun, Yohan Mofu, Leo Warmetan, Zulkifli and Nixon Karubaba.

Chapter 1 in this thesis is a literature review on the importance of wildlife and factors driving hunting in the tropics. In particular, this chapter provides background to the study focusing on specific aspects relevant to the study sites, including road development, human population and available alternative protein sources. This chapter is being prepared for submission as: Pattiselanno F, Sayer J, Boedhihartono A, Lloyd, J, and Krockenberger A, "Indigenous hunting in the tropics: the importance of wildlife and factors affecting hunting at the Bird's Head Peninsula", *Biotropica.* F Pattiselanno conceived the main idea, analysed the data and wrote the manuscript. A Krockenberger, J Sayer, A Boedhihartono and J Lloyd helped with developing the idea and writing.

Part of Chapter 3 is being prepared for submission as: Pattiselanno F, Sayer J, Boedhihartono A and Krockenberger A, "Farmers in coastal West Papua, Indonesian hunt introduced species to supplement their livelihoods", *Biological Conservation.* F Pattiselanno conceived the idea, analysed and wrote the paper. J Sayer and A. Boedhihartono helped with conceiving the idea and writing the paper. A Krockenberger conceived the idea, commented on the draft and helped with writing.

The second part of Chapter 3 was published at *Traffic Bulletin* May 2015, (Pattiselanno, F & Mambai, BV, "Commercialization of hunting at the Bird's Head Peninsula, West Papua"). F Pattiselanno conceived the main idea, collected and analysed the data and led the writing; BV Mambai helped conceive the idea and gave comments on the manuscript.

Chapter 4 is being prepared for submission as: Pattiselanno F, Lloyd J and Krockenberger A, "The impact of road development on indigenous hunting in the coastal

landscape of the Bird's Head Peninsula, West Papua, Indonesia", *Biological Conservation*. F Pattiselanno conceived the main idea, analysed and wrote the paper; J Lloyd helped in writing the paper; A Krockenberger helped with conceiving the idea and writing the paper.

Part of Chapter 5 is being prepared for submission as: Pattiselanno F, Lloyd J, Sayer J and Krockenberger A, "Wild meat consumption and indigenous hunting at the Bird's Head Peninsula West Papua, Indonesia" *Animal Conservation.* F Pattiselanno conceived the idea, analysed and led the writing; J Lloyd helped with conceiving the idea and writing the paper; J Sayer helped with conceiving the idea and the initial draft; A Krockenberger helped with the writing.

The second part of Chapter 5 is being prepared for submission as: Pattiselanno F, Ziembicki M, Nasi R and Krockenberger A, "Target, Technique, Tenure and Timing: The Four T's limiting the impact of traditional hunting in Indonesia's Papua" *Ecology and Society.* F Pattiselanno conceived the idea, analysed and wrote the paper. M Ziembicki and R Nasi developed the idea and helped with writing; A Krockenberger conceived the idea and helped with writing.

The third part of Chapter 5 was published in *Hayati Journal of Bioscience* 21, 180–186 in December 2014 as F. Pattiselanno & M.I. Lubis "Hunting at the Abun Regional Marine Protected Areas: A link between wildmeat and food security." F Pattiselanno conceived the idea, analysed and wrote the paper. MI Lubis helped with statistical analysis, developed the idea and worked with ARC GIS for the map.

My study at the James Cook University was supported by the Australian Award Scholarships. Research funding was received from the Skyrail Foundation, Rufford Small Grant for Nature Conservation, the SEARCA Seed Fund for Strategic Research and Training Program, The West Papua Province and James Cook University Graduate Research Scheme.

This study received human research ethics approval from the JCU Human Research Ethics Committee (H4203, 29 June 2011). A copy of my data is stored in a Dropbox folder, one copy has been given to A Krockenberger and access is available upon request.

Abstract

The main reason for hunting in tropical forests is because wildlife is the most accessible animal protein especially for those in rural areas. Little appears in the scientific literature about the importance of wildlife in West Papua with the exception of some information on the traditional uses of wildlife and its contribution to household diets. Different major drivers of hunting were identified, and in West Papua, there is an urgent need to address factors that increase pressure on hunting, including access to forest sites, increases in human population and available alternative protein sources. Using data from 1020 hunters from 11 villages interviewed between June 2011 and July 2013, this thesis explores indigenous hunting practices in the context of village livelihoods. Information on the distances that hunters travel and hunting offtakes during 387 hunting excursions, combined with offtakes from 33 hunters over seven months provides details of hunting effort and strategies and the socio-economic factors influencing hunting. A survey of meals in 696 households also provides in-depth information on consumption patterns, in particular of wild meat.

As well as being important in providing food, road-side hunting was conducted for cash income. Hunters are also involved in trapping to maximise harvest rates from particular prey such as deer and pig for trading purposes. Although roads increase wild meat trading, road connection provides more options to find meals for household consumption and decreases the reliance on wild meat as a protein source for family tables.

Increased human population growth increases people's reliance on agriculture. The production of crop lands (tuber crops and bananas) satisfies people's needs for carbohydrates, but not for animal protein. In villages with larger populations, hunting was mostly performed for family consumption.

I hypothesised that marine protected areas (MPAs) would reduce the supply of fish in some villages. Alternatively, agriculture and might be a more important livelihood than fishing regardless of the MPA. For many rural households along the coast of the Bird's Head Peninsula wild meat is not a luxury or resource they only turn to in times of hardship; it is a vital source of animal protein, and a commodity that can be sold.

This study is the first detailed investigation of how road development, increased human population and availability of alternative protein sources affect indigenous hunting

along the coastal landscape. It shows that road connections shift livelihood options from subsistence-based to market-based, influencing hunting of introduced species for alternative income and provides more access to alternatives. Population density impacts on hunter's livelihoods, shifting intermittently between formal and informal occupations for cash to supplement crop-related incomes. Availability, or not, of alternative protein sources such as marine resources, did not appear to significantly affect hunting practices along the coast of the Bird's Head Peninsula. From a practical standpoint, policy to tackle reliance on wild meat in this context will require several strategies in tandem, such as: providing alternative livelihoods for revenue; improving agricultural infrastructure; offering economic opportunities and employment; and educating hunters and buyers.

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Chapter 1 Subsistence hunting in the tropics: the importance of wildlife to people and factors affecting wildlife hunting

Figure 1.1: Group of hunters using different hunting techniques to obtain meat for consumption and to gain cash income for families in Arui Island of Napan, Papua, Indonesia

1.1 Background

Tropical forest people in Africa and Southeast Asia have been hunting wildlife for food for at least 40,000 years (Bennett, 2002). In Latin America hunting has been carried out for at least 10,000 years. Many people across the tropics (Figure 1.1) today continue the practice (Bennett, 2002). Wildlife hunting is important in satisfying people's need for meat as a source of dietary protein as well as being of economic value to communities. Hunting may also offer forms of income generation such as sale of bushmeat products (Milner-Gulland et al., 2003), obtaining ingredients for human medicine and other traditional uses (Williamson, 2002; Mockrin et al., 2005). Furthermore, wild animals are hunted to obtain trophies (skins, teeth, antlers and horns) that are used as cultural artefacts or for personal adornment (Fa & Brown, 2009).

Wildlife products are valuable commodities, and wild meat is considered as premium value because it has a high value per unit weight compared with other forest products (Williamson, 2002). The preferences for different wildlife species are usually influenced by economic activity, access to domestic meat, ethnic origin, geographical isolation, local wildlife availability and the biological attributes of species that are hunted (Naranjo et al., 2004). In addition, other factors influence prey preference, such as the social, cultural and political characteristics of the ethnic groups that hunt (Fa et al., 2002a).

Ready access to undisturbed and remnant forests as a result of the spread of roads (Figure 1.2) and forest fragmentation are factors affecting the exploitation of bushmeat (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). Access affords hunters and traders the ability to connect with each other and sell wildlife at town markets. This in turn increases harvest rates and income-generation opportunities for local communities (Rao & McGowan, 2002), but can also impact sustainability of the harvests (Bennett & Robinson, 2000; Fa & Brown, 2009).

Pembukaan Jalan Trans Papua Barat

Hewan Buruan Berkurang

Manokwari- Dampak negatif pembukaan jalan trans papua barat kini mulai terasa. Akibat pembukaan itu, tingkat kunjungan masyarakat perkotaan untuk berburu hewan liar kian meninggi. Masyarakat sekitar mulai mengeluh karena jumlah hewan liar yang merupakan kebutuhan pokok mereka terus berkurang secara drastis.

Hal ini seperti dituturkan Veronika dan Erik, warga distrik Senopi, Kabupaten Manokwari. "Kita mulai rasa sejak jalan trans manokwari-sorong dibuka," kata Veronika.

Ia mengaku, sebelum jalan trans papua barat dibuka beberapa tahun lalu, kebutuhan daging buruan tetap terpenuhi secara baik.

Hal itu berubah drastis saat pembukaan jalan terjadi. Warga sering mendengar letupan senapan mengaung ditengah hutan tiap kali berburu. "Padahal dulu kita jarang dengar," kata ibu ini kepada *Cahaya Papua*, kamis, (17/2).

Ia menaksir bunyi letupan senjata itu berasal dari aparat yang bertugas di PT 84. "Mereka sering berburu di lahan warga."

Berkurangnya jumlah hewan buruan ternyata membuat beban ekonomi mereka makin berat. "Sudah begitu, kita kaya rasa tambah susah karena hasil kebun banyak yang busuk," tambah ibu yang memiliki sembilan anak ini.

Erik, warga Senopy lainnya membenarkan hal tersebut. "Kitong sudah dua kali ke PT 84 untuk lapor. Tapi tidak ada tindakan lanjut," katanya.

Dua warga Senopy ini berharap, pemerintah daerah dapat memberi solusi secara tepat dan cepat agar hasil buruan mereka kembali normal. "Tong harap pemerintah perhatikan masalah ini," harapnya mengakhiri. (cr-47)

Figure 1.2: This article from "Cahaya Papua" a local newspaper in Manokwari, West Papua published on 19 February 2010 reports a complaint by local communities about the impact of road development on hunting prey density at Kebar District of Tambrau Regency

The requirement for an animal protein source to meet human population growth in some tropical areas is another factor affecting the exploitation of wildlife. Sustainable hunting will not be achievable if the harvest of wildlife resources constantly exceeds maximum sustainable offtakes. Increasing harvest rates above this level threatens wildlife populations and affects long-term protein sources for local communities. If wild, or bush, meat is the sole source of animal protein, tropical forests can sustainably support the protein needs of approximately one person per square kilometre (Robinson & Bennett, 2000). However, tropical landscapes are also heterogeneous in wildlife abundance and productivity. Availability of alternative protein from marine sources and from increases in livestock and aquaculture production can greatly lessen the consumption of bushmeat (Rowcliffe et al., 2005).

This review aims to synthesise existing knowledge and identify areas that are fundamental to understanding indigenous hunting, focusing on access to forest sites, increases in human population density and availability of alternative protein sources.

1.2 Factors affecting wildlife hunting

Several reasons have been identified for the increase of hunting pressure on wildlife populations. Hunting pressure has often been associated with greater access for hunters and traders to undisturbed and remnant forests as a result of the spread of roads, and forest fragmentation may also be a factor that affects the exploitation of bushmeat (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). The construction of the Maxus road and other oil infrastructure in the Yasuní National Park in north-eastern Ecuador led local communities like the Waorani to leave their semi-nomadic life styles and settle along the road. The settlement allowed them to access the Pompeya market and to purchase hunting supplies sold in the market. Consequently, the Waorani people increased their hunting efficiency and extended access to a much larger hunting area to supply the market demand for bushmeat (Suárez et al., 2009).

Established road networks not only bring hunters closer to hunting sources, but also link the resources directly to markets (Robinson et al., 1999). For example, improvements in the highway connections between North Sulawesi and other provinces such as Gorontalo and Central Sulawesi have led to increased importation of wild meat to meet market demand (Lee, 2000) and increased hunting of native forest rats for the Sulawesi market by 1,500 per week (Clayton & Milner-Gulland, 2000).

Hunting pressure has often been associated with the boost in demand for wild meat, along with an increase in the human population (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). Bennett (2002), citing the World Bank Atlas (1998), showed that the average number of people per square kilometre of remnant forest is 46 in Latin America, 99 in West and Central Africa, and 522 in south and Southeast Asia. Bennett (2002) also found that human populations are increasing by an average annual rate of 1.52% in Latin America, 1.65% in Asia, and 2.66% in African tropical forests (data from www.wri.org). In reality, hunting not only provides meat to rural populations, but also services the demand for

bushmeat by urban inhabitants (Fa et al., 2005). For example, wildlife hunting provided more than 100,000 kg of wild meat every year for 80,000 townspeople at Bioko Island of Equatorial Guinea (Fa, 2000).

Limited or no access to alternative sources of protein is another factor influencing wildlife hunting, and consequently in some cases people still rely on wild meat and cannot readily make the switch to other sources (Bennett, 2002). One reason is that people, particularly those in isolated areas, may lack the skills for raising livestock. Others practice swidden agriculture for cultural reasons and deliberately manage fallows with a slash-and-burn technique. This technique aims to increase the abundance of crop plants that attract game species (Smith, 2005), but leads farmers to rely on wild meat from hunting. This scenario tends to occur in the most remote areas, practiced by traditional forest people (Bennett, 2002). In contrast, Bennett and Rao (2002) asserted that people who lived near coastal sites in Southeast Asia and West Africa were able to find alternative protein and decreased their dependence on wild meat, supported by Brashares et al. (2004) finding of an inverse correlation between bush meat consumption and access to marine fish.

The physical configuration of human land uses across the landscape because of infrastructure development and increase in human population influences wildlife populations (Nasi et al., 2008). Studies from different parts of the world have shown that alteration of a forest's landscape through logging, mining and agriculture had a significant impact on wildlife populations through direct disturbance and modifications of the structure and composition of wildlife habitat (Nasi & Van Vliet, 2009). Land use change has also provided easy access for hunters to areas, which influences sustainability of hunting (Robinson & Bennett, 2000). Change in land use configuration can also bring hunted areas closer to market and other commercial centres, which decreases sustainability of hunting (Auzel & Wilkie, 2000; Bennett et al., 2000). Prospecting roads built by logging companies not only cause indiscriminate fragmentation of forests but also provide commercial hunters, supported by advanced hunting technology, with virtually unlimited access to remote areas. This creates a bushmeat tragedy of the commons, forcing rural families that lack the knowledge to restrict hunting to harvest as much as possible before others do (Redmond et al., 2006).

Advances and changes in hunting technology such as guns, portable lights and vehicles have made wildlife hunting more efficient and therefore greatly increased harvest rates (Robinson & Bennett, 2000; Fa et al., 2002a; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). Blake (1994) revealed that the estimated rate of return for hunters using motorised vehicles was higher (3.7 kg/man-hour) than for those conducting on-foot hunting (2.0 kg/man-hour) and concluded that advanced hunting technology results in more pressure on prey animal populations. In Papua New Guinea, for example, when the use of modern hunting technology such as the shotgun increased, the harvest rate of cassowary rose to double that of traditional methods (Johnson et al., 2004).

In summary, factors that have contributed to increased hunting pressure and experienced by local communities across Afrotropical and the Neotropical forests include greater access to undisturbed forests and to markets, increases in human population and wild meat importation, restricted access to alternative sources of protein, changes of landscape and the use of advanced hunting techniques (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa & Brown, 2009; Nasi & Van Vliet, 2009). Understanding how different factors contribute to subsistence hunting along the coast will give insights into the impact of access, population density and availability of alternative protein sources on subsistence hunting in Bird's Head Peninsula of West Papua.

1.2.1 Access to forests and markets

Greater access for hunters and traders to undisturbed and remnant forests as a result of the spread of roads and forest fragmentation is a critical factor driving the exploitation of bushmeat (Robinson & Bennett, 2000; Rao & McGowan, 2002; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). Anthropogenic landscape factors determining hunting practices include the presence of camps, trails and roads (Van Vliet et al., 2010). Blake (1994) found that hunters who spent more time travelling on concession roads at night had a higher rate of return (3.7 kg/man-hour) than those who hunted closer to the settlement (2.8 kg/man-hour). This is because animal densities increase with distance from settlements and easy access near the settlement leads to increased hunting pressure that makes hunting unsustainable, leading to declining yields.

Logging in the forests of northern Congo has (1) created an extensive system of primary and secondary roads in once-isolated forest blocks, (2) increased local demand for bushmeat, (3) provided bushmeat hunters with easier access to isolated forests and markets, and (4) increased the export of bushmeat from the forest (Wilkie et al., 2000). This accords with Robinson and Bennett (2000), who showed that an advanced network of road connections creates easy access for hunters and traders to remnant forest and triggers elevated hunting pressure on prey species.

Habitat modification through extractive industries such as mining, logging and plantation forestry plays a pivotal role in the relationship between indigenous peoples and wildlife. Forest clearance not only destroys habitat for many species, but also creates entry points to hunters into forest sites and provides access to markets (Laporte et al., 2007).

Extractive activities have had major impacts through land use modification, establishment of education and health care infrastructure and job creation (Eves & Ruggiero, 2000; Olupot et al., 2009). Soon after logging companies settle in an area, heavy machinery and company workers begin to affect the wildlife (Nasi & Van Vliet, 2009). For instance, in the Congo Basin, all leading industries including logging and mining urge village households to sell agriculture and hunting products to the industries' workers (Eves & Ruggiero, 2000; Olupot et al., 2009). Settlements linked to forestry company infrastructure and camps attract large numbers of people (workers, family members and traders) into areas that were formerly sparsely populated (Wilkie & Carpenter, 1999; Laurance et al., 2006; Poulsen et al., 2009).

Within logging concessions, large numbers of workers create a massive demand for bushmeat and provide an in-situ market for hunters to sell meat. As a result, some of the most lucrative hunting settlements are those established within logging townships (Redmond et al., 2006). In reality, families living in logging communities eat two to three times more bushmeat than rural communities because very few logging concessions provided food for their work force (Wilkie & Eves, cited by Redmond et al., 2006).

In many cases, extractive initiatives also overlap with vulnerable indigenous territories where the absence or weakness of local governments and the lack of economic alternatives often result in impacts that go well beyond ecological or

environmental modifications to include drastic social changes that affect both the livelihoods of local groups and the wildlife upon which they depend (Suárez et al., 2009). For example, different techniques of land use development at different times in various West African ecosystems had an effect on korrigum (*Damaliscus lunatus*), an African antelope, in West Africa (Sayer, 1982).

However, at relatively low human population densities, the creation of cultural landscapes that include a mix of anthropogenic and natural habitats can provide benefits to other species (Smith, 2005). Despite the negative impacts of logging and hunting on wildlife, which are well documented, the role of logging or mining concessions as "potential wildlife reservoirs" compared with unmanaged land is also increasingly recognised (Meijaard et al., 2006; Clark et al., 2009; Diamond, 2011). These areas become potentially important for hunting, as they provide suitable habitats for particular game species such as rats, paca and armadillo (Smith, 2005) and deer, pigs and peccaries (Bennett & Robinson, 2000).

In addition to affecting access to the forest, road connections affect the time spent to transport animals to the market and thus facilitate bushmeat trading (Mendelson et al., 2003). Established road networks not only bring hunters closer to hunting grounds, but also link resources directly to markets (Robinson & Bodmer, 1999). Improvements to the highway connection between North Sulawesi and other provinces of Sulawesi such as Gorontalo and Central Sulawesi have also led to increased importation of wild meat from other parts of Sulawesi to meet demand in Manado and Minahasa (Lee, 2000), and elevated hunting pressure on wildlife populations (Clayton & Milner-Gulland, 2000).

Studies on hunting in Sulawesi have explored the patterns of hunting, wildlife trade and market and the impact of hunting on habitat and prey populations (O'Brien & Kinnaird, 1996, 2000; Alvard, 2000; Clayton & Milner-Gulland, 2000; Lee, 2000). These studies concluded that the majority of hunting activities on Sulawesi are unsustainable, and serving wild meat to meet human demand affects the wildlife population on this island. Data from a 1990–1991 survey revealed that 50–60 pigs were sold in Langowan market, and that increases in the consumption of wild pig meat triggered hunters to hunt more to meet the demand (Clayton & Milner-Gulland, 2000). In addition, the market demand for bats at Minahasa, due to the decline of fruit bats in

mainland North Sulawesi, increased the importation of fruit bats from Karakelang on Sangihe Island (Riley, 2002) and led to the decline of fruit bats in this area (O'Brien & Kinnaird, 1996; Lee, 2000).

Terrestrial vertebrate species such as monkeys, pigs and bats are more affected by hunting than non-terrestrial vertebrates because hunting is widely conducted for both subsistence and market. This applies particularly in North Sulawesi Province, where the majority of the population is Christian and does not have religious constraints on consumption of non-halal foods. Therefore, wildlife hunting in some districts like Bolaang Mongondow and Sangihe Talaud has increased to meet the wildlife market demand in North Sulawesi (Lee, 2000). Availability of markets for wild meat has increased hunting in the tropical forest areas around the world.

The influence of markets on wildlife hunting is well documented. Integration of hunting with the market increases harvest rates and decreases hunting sustainability (Robinson & Bennett, 2004). Commercialisation of indigenous hunting in Zaire's Ituri forest, for instance, increased net harvest intensity of duiker by around 300% (Hart, 2000). Access to the market not only increases hunting on frequently hunted target species such as tapir, but also threatens other species including collared peccary (*T. tajacu*) and agouti (*Dasyprocta* spp.) (Bodmer & Puertas, 2000). Fa, Yuste and Castelo (2000) found that the number of species sold in a bushmeat market changed considerably from 14 species in 1991 to 21 species in 1996 because the availability of the market in Bioko Island increased. Consequently, extension of the wild meat market outside the area also increases wild meat consumption (Bennett et al., 2000). Thus, throughout much of Asia, the commercial wildlife trade is vast, but is now mainly supplying a luxury, urban market, both for meat and for body parts for traditional medicines (Bennett & Rao, 2002; Corlett, 2007).

Historical evidence suggests that hunting has increased over time and has become a regional problem due to the development of markets and associated trade routes in supplying regional and international trade networks. With the change from subsistence to trade also comes technological change in rural communities. For instance, rural hunters can easily access shotgun cartridges for ammunition and can reach the available market.

Hunting modality has an important effect on the overall take. Hunting weapons such as traditional or western weapons, snares, spotlights etc. impact strongly on hunting success and wildlife populations (Robinson & Bennett, 2000; Fa et al., 2002b, 2005; Milner-Gulland et al., 2003; Refisch & Koné, 2005; Corlett, 2007). Fa and Yuste (2001) examined the mode of harvesting for commercial bushmeat in the Monte Mitra forest of Equatorial Guinea and found that though hunters use both firearms and cable snares, snare hunting was most common because it is very effective. The study found that 86.3% of animals were snared compared to 7.9% killed by gun and 5.8% by other methods. Similarly, in subsistence hunting in western Tanzania, 53.81% of mammals (n=127) were killed using firearms, with the remainder captured by traps (19.1%; n=45), spear (11.01%; n=26) or killed by dogs (16.1%; n=38) (Carpaneto & Fusari, 2000).

However, in New Guinea using dogs in hunting is very effective because dogs are a major aid to finding and killing prey. About 42.4% of the kills in the Crater Mountain Wildlife Management Area (CMWMA) of the Eastern Highlands of Papua New Guinea were made with the help of dogs (Mack & West, 2005). Other techniques were also commonly used; for example in other parts of New Guinea, such as north-east Papua, over 70% of hunts use bow and arrow (Pangau-Adam et al., 2012), while at CMWMA more than half of the kills are made with bow and arrow (Mack & West, 2005). Majnep and Bulmer (1977) acknowledged that bow and arrows were the traditional method of killing game throughout New Guinea. Hunting with dogs and spear are the most widespread hunting practice in tropical Asia (Corlett, 2007).

Indigenous hunting in West Papua mostly uses traditional hunting techniques such as bow and arrrow and spears that are commonly made from natural forest materials (Figure 1.3); some ethnic groups have strictly banned the use of guns (Pattiselanno, 2003, 2006). Similarly, Iyai (2002) found that blade, spear, bow and arrow and “dodeso” hand-made rope snares are used to hunt monitor lizards in Napan. This species is only consumed by small numbers of households in Napan, and hunting is conducted temporarily when people have no fishing activity.

Figure 1.3: A hunter using a combination of different hunting techniques: bow and arrow + nylon for trap and dog in Tanah Rubuh, Manokwari of West Papua (Picture by Iriansul)

According to Sillitoe (2002), while any method may catch a range of animals, there is a trend for certain animals to succumb to specific tactics. Hence, the most appropriate method can be used for particular species-specific behaviour. Different hunting techniques yield different numbers of target animals. Smith (2005) found that hunting yields are conditional on numerous factors, including availability of and proximity to markets. To supply market demand, hunters try to maximise their harvest by using the most efficient hunting methods. Diverse hunting techniques are employed by hunters in different tropical sites, and once hunters gain access to the market/s, they may shift from using traditional techniques to 'advanced techniques' (such as gun) to maximise harvest rates.

Currently, the development of Papua and West Papua provinces by road connection (Figure 1.4) creates new settlement areas along the road and more entry points closer to forest sites. Spatial analysis shows that from 2000 to 2020, new roads will extend to 2,700 km and about 25% of protected areas in both provinces will be

located less than 20 km from established road connections (Anggraeni & Watopa, 2004).

Figure 1.4: Compacted dirt road in Amberbaken District of the Bird's Head area

There has been no study on the impact of road development on subsistence hunting in West Papua, but evidence from other tropical forests suggests that increases in road connections within West Papua are likely to transform local communities and the way they use forest resources, including reducing the sustainability of hunting. Determining the relationship between road access, availability of wildlife markets and hunting techniques along the coast will allow us to predict their ongoing effects on subsistence hunting in the Bird's Head Peninsula, where road connections are currently being developed.

1.2.2 Human population density

Increased access to remote forest sites through road connection is often followed by a rapid increase in the human population, which has also been identified as a major threat to wildlife (Robinson & Bennett, 2000; Bennett et al., 2002). Higher human populations increase wildlife harvests and decrease the sustainability of hunting (Fa, 2000). Increasing use of wild meat for human consumption contributes significantly to

the harvest rate, and it is calculated that the current annual harvest rate of wild meat is 1–5 million tonnes in Central Africa (Wilkie & Carpenter, 1999), 67,000–164,000 tonnes in the Brazilian Amazon (Peres, 2000) and 23,500 tonnes in Sarawak (Bennett, 2002). In CMWMA, Papua New Guinea, Mack and West (2005) found during a seven-month study that a total of 696 individual vertebrates were hunted, representing 135 species with a total biomass of 1,840,257 g. Supuma's recent study of bird harvesting for subsistence and cultural purposes raises concerns regarding intensification of harvest and reduction in sustainability as human population and market demand increases (Supuma 2018). While there is no precise estimation of the amount of wild meat taken to the urban market, it is significant in North Sulawesi, with trading estimated at more than 90,000 animals per year to supply an urban market in North Sulawesi Province of Indonesia (Clayton & Milner-Gulland, 2000). A survey at a single market showed that approximately 3,848 wild pigs were sent to market each year between 1993 and 1995; a third to half of the pigs were the endangered and legally protected babirusa. Other mammal species offered to that local market included macaques (50 to 200 a year), forest rats (50,000 to 75,000 a year), bats (up to 15,000 a year), and cuscus and tarsiers traded intermittently (Clayton & Milner-Gulland, 2000).

If wild meat is the sole source of protein, tropical forest can support protein needs sustainably at human densities of approximately one person/km^2 (Robinson & Bennett, 2000). Data from World Bank Atlas (1998) and Treves and Weber (2001) (cited in Bennett, 2002) showed that in remaining tropical forest countries, the average of number of people per square kilometre ranged from 46 in Latin America, and 99 in West and Central Africa to 522 in South and Southeast Asia, well above sustainable levels for wildlife hunting. Human populations of tropical forest countries are also growing rapidly by an average of 1.52% p.a. in Latin America, 1.65% p.a. in Asia and 2.66% p.a. in Africa (Bennett, 2002).

In areas with high-density human populations such as lowlands and valleys where soils are more likely to support agriculture, wildlife populations are suppressed. This is because the most accessible prey near human settlements and gardens are harvested first, and as a result wildlife populations near human habitation tend to be extirpated (Robinson & Bennett, 2000). Hunting may also be a part of traditional farming activity in gardens and fallows. For example, Semiadi and Meijaard (2006)

reported that past hunting pressure on pig predators have increased pig populations, allowing pigs to become agriculture pests. Therefore, at present, hunting on Java and Bawean Island in Indonesia is mostly for wild pig because the individual economic losses suffered from crop raiding are high and farmers are poor and are rarely compensated for their losses. This is particularly true in developing countries (Smith, 2005; Linkie et al., 2007). Similarly, Fa and Brown (2009) argue that abundance of non-game or crop-raiding species may rise if their competitors or predators are harvested or decrease if their prey is hunted.

Human–wildlife conflicts commonly occur in tropical landscapes due to competition for space (Madhusudan & Karanth, 2000; Linkie et al., 2007). Human population density differs among coastal villages in West Papua and is likely to grow, so it is important to identify the effect of human population density on subsistence hunting in the Bird's Head Peninsula of West Papua.

1.2.3 Alternative protein sources

The decision to hunt or trade wildlife depends not only on the hunter's nutritional and economic status, but also on other opportunities available for food and income generation (Milner-Gulland et al., 2003). In tropical areas world-wide, the meat of wild animals has long been part of the staple diet of forest-dwelling peoples (Fa & Yuste, 2001). Consumption of wild meat as a source of animal protein in rural areas is very important; for instance families in the Congo Basin consume ten times the amount of wild meat compared to those in urban sites (Wilkie & Carpenter, 1999). In addition, Rao and McGowan (2002) indicated that wild meat contributes significantly to rural communities in Asia, Africa and Latin America because it is more easily accessible than cultivated meat, and is often the most available dietary protein. Wild-harvested meat comes from diverse forests, consequently diversity in target species is normal in subsistence hunting within tropical forests. For example, in Sarawak, rural hunters hunt 26 mammal, 12 bird, and five reptile species (Bennett et al., 1995). Similarly, 37 mammal, 14 bird and four reptile species are consumed by local communities on Bioko Island, West Africa (Fa et al., 2002b).

Human populations within remote forest areas who have difficulty accessing markets and alternative suppliers are particularly dependent on wild meat from hunting

(Bennett, 2002; Hilaluddin et al., 2005). Prescot-Allen and Prescot-Allen (1982) suggested that people in as many as 62 countries are primarily dependent on wild animal meat as their protein source, and thus they are dependent on hunting. On the other hand, with the development of transport infrastructure (generally roads), villagers have a choice: they can travel to earn money by other means for their living, and thus make the switch from wild meat to domesticated meat more easily (Bennett et al.,1995). This suggests that roads and access could have complex effects, potentially increasing or decreasing hunting pressure on tropical forests.

In any area, hunting is clearly not sustainable when the harvest of wildlife resources consistently exceeds maximum sustainable offtakes (Robinson & Bennett, 2004). Wilkie and Carpenter (1999) found that in Central Africa approximately 645 kg/year of wild meat is extracted from each square kilometre of forest. The maximum sustainable production of wild meat from tropical forests is around 102 kg/km^2/year (Robinson & Bennett, 2000), indicating that the harvest rate from the forest is more than six times the sustainable rate (Bennett, 2002). In the Neotropics, Diamente and Yomiwanto hunters harvested *Tapirus terstris* (tapir) at 14.1 and 10.6 kg/km^2/year respectively (Alvard et al., 1997), double to triple the maximum sustainable rate of 4.47 kg/km^2/year (Robinson & Redford, 1991 cited by Alvard et al., 1997). Because reliance on bushmeat is increasing and hunters harvest more than the maximum sustainable yield, preliminary data compiled from a number of different studies suggests that hunting is generally no longer sustainable in tropical forests (Robinson & Bodmer, 1999).

Even with improved access to markets, people may still depend on wild meat because it is cheaper than domesticated meats. The price of bushmeat is determined primarily by the weight of the edible portion and not by the species of the animal on sale, provided that the resource is readily available (Wilkie & Godoy, 2001). Patterns of wild meat consumption in rural areas in Latin America, particularly Central and South America, indicate that wild meat contributes to 30–50% of a persons's protein intake (Bennett, 2002). Remote inland communities in Sarawak obtained 67% of their diet from wild meat (Bennett et al., 2000). Therefore, there is an urgent need for affordable alternative protein to substitute for bushmeat, otherwise unsustainable harvests will

progressively deplete the resource and have serious deleterious effects on long-term human livelihoods and food security of the communities in the region.

In Papua New Guinea, many species are hunted by a variety of ethnic groups. Hunting activities in different areas, including Southern Highlands Province in Papua New Guinea, encompasses a wide range of animals. These include *sab* (large mammals), which includes cuscuses, bandicoots and ringtail possums, tree kangaroos and echidnas; *honez* (small mammals), which includes small marsupials and rodents; and *sor* (birds), such as cassowaries and birds of paradise. Other game species that are hunted include e*jiya* (frogs), *wen* (fish) and the occasional large reptile, notably *burun* (pythons). The hunters consider all these animals to be *acha* (edible fauna) (Dwyer, 1983; Sillitoe, 2001). In other parts of Papua New Guinea, *bus* (wild meat) also includes a wide variety of fauna. In the CMWMA of Eastern Highlands Province, hunting was conducted for mammals and birds broadly (Mack & West, 2005). These included a wide variety of species, but more than 80% were of a handful of genera including *Sus* (NB, pigs, *Sus scrofa,* are introduced to the island of New Guinea, Flannery, 1995)*, Phalanger, Spilocuscus, Dendrolagus, Zaglossus* and *Casuarius* (Johnson et al., 2004). Based on hunting returns, it has been concluded that numerically, cuscus and bandicoots are the main source of game, while the estimates of maximum sustainable production versus annual extraction rates indicates that long-beaked echidna, tree kangaroos and cuscus are most at risk from over-hunting (Cuthbert, 2010).

In terms of protein source, wildlife hunting is also closely linked to many cultures throughout the world's tropical forests. Fa and Brown (2009) assert that, apart from uses as a food source, hunting of wild animals can also be associated with medicine for human therapies and other traditional uses (most hard and soft body parts are used in some way). Throughout the Asian region, hunting of indigenous wildlife is mostly conducted to supply the needs of traditional medicine (Corlett, 2007). For that reason, the preferred prey of hunters in northern Myanmar are tigers, bears and pangolins (Rao et al., 2005) rather than food species like deer, pigs, primates and porcupines found in the same area.

In Africa, some studies have identified other important roles of wildlife that have strong connections with differing cultures'spiritual health (Ntiamoa-Baidu, 1997). For instance, it is common that particular wildlife species are not hunted because they

are considered sacred; they have special respect or sometimes are given special value for cultural and religious reasons. For instance, hunting and the associated rapid decline of Hose's langur (*Presbytis hosei*) populations in Kayan Mentarang National Park of East Kalimantan is due to the use of bezoar stones for medicinal purposes (Nijman, 2005). Therefore, although hunting can capture a variety of wild animal species, some species may be favoured over others. Certain species are less preferred because of socio-cultural or religious barriers (Njiforti, 1996; Fa et al., 2002b). Under these circumstances, wildlife are categorised as totem species, taboo species or sacrificial and/or ceremonial species (Ntiamoa-Baidu, 1997).

Little appears in the scientific literature about the importance of wildlife in West Papua with the exception of some information on the traditional uses of wildlife and its contribution to household diets (Figures 1.5, 1.6; MacKinnon, 1984; Beehler, 1985; Petocz, 1994; Pattiselanno, 2006; Pattiselanno, 2008; Pattiselanno & Arobaya, 2013).

Figure 1.5: (a) Meat of bandicoot from the oil palm plantation in Prafi, (b) Cuscus from the secondary forest in Napan being processed for consumption

Figure 1.6: (a) Wild pig and (b) Deer from the lowland coastal forest of Bird's Head area being processed for consumption

Acquisition of animal parts as cultural artefacts, for personal adornment or for hunting trophies (most often skins, teeth, antlers and horns) is still a widespread practice throughout tropical forest regions and the rest of the world (Bennett & Robinson, 2000; Fa & Brown, 2009). Culture plays a significant role in animal trophies obtained for cultural artefacts or for personal adornment in Papua New Guinea (Kwapena, 1984). Equally, native Papuans also acknowledge feather, skins and teeth as cultural artefacts (Figure 1.7), which are attached to traditional costumes among different ethnic groups (MacKinnon, 1984; Beehler, 1985; Petocz, 1994).

Figure 1.7: a) A male dancer with a combination of birds feathers on his head (b) A female dancer wearing traditional costume composed by wildlife from Kayu Pulo,

Jayapura during the presentation of traditional dance in the Papuan Cultural Event (Picture by Geofrey Daimboa)

Apart from cultural preferences for particular species, traditional controls over hunting and the technology used have also played an important role in limiting the hunting take. In West Papua, hunting of bower birds by the highland Kebar people is traditionally not allowed during the mating period of the birds (Sokoy, 2004).

From a food security perspective, limited access to animal protein supplied by domestic livestock due to geographical barriers, and availability of food sources from wildlife are the major reasons to acquire wild animals for consumption in Papua (Pattiselanno, 2004, 2006). Consumption of monitor lizard meat for example, is common among the people of Warkapi, with lizard meat usually found on the menu (Homer, 2004).

Despite the practice of some traditional beliefs, contemporary changes in beliefs and violation of religious taboos can increase threats to particular wildlife species. Pangau-Adam and Noske (2010) argue that the gradual break-down of certain traditional beliefs drives hunters to illegally hunt birds of paradise and cassowaries, and increases pressure on some endemic birds in Nimboran and Kemtukgresi in Northern Papua. Because cultural values differ among ethnic groups, it is also important to understand how changing cultural values towards wildlife in West Papua, along with access, population density and alternative sources of protein, impact on indigenous wildlife hunting along the coast of Bird's Head Peninsula.

Bennett and Rao (2002) argued that the percentage of people able to find alternative protein is high in Southeast Asia and West Africa because those areas are located near coastal sites where fish are available as the main dietary protein. Brashares et al. (2004) showed that wild terrestrial mammals were the second source of animal protein in Ghana, after fish. Some villages in this study are located within a marine protected area (MPA, Fig 2.10) designed to protect vulnerable marine turtles and coral reefs. This is part of a broader aim to regulate harvesting of marine resources to support an overall marine resource management program in Indonesia (Alder et al., 1994). If this happens, access to marine resources will be limited, with potential flow-on effects on the consumption (increase) of wild meat (Milner-Gulland et al., 2003). Rowcliffe et

al. (2003) agree that fish availability affects bushmeat consumption. Nothing is currently known about the effect of availability of alternative protein sources on wildlife extraction in West Papua; therefore, study is crucial to understanding changes in impacts on biodiversity associated with inevitable changes in protein alternatives available to indigenous people in this region.

Comparing the situation in Africa, South America and Asia with previous research from the island of New Guinea, particularly Indonesian sites, hunting and trading of wild animals are clearly different in context. Each situation varies as a consequence of its unique ecological and cultural context. Notably, in the case of Indonesian New Guinea, there are few large native mammals and the largest potential hunting targets are introduced species, Rusa deer and pigs (Pattiselanno, 2006, 2012; Pangau-Adam et al., 2012). Rusa deer were first introduced by the Dutch to Merauke on the Fly river plains in 1928 and later to Manokwari on the Vogelkop Peninsula (Flannery, 1995). Although there is some debate regarding timing, pigs were probably introduced by Austronesian speakers within the past 3500 years (Haberland and Seyfarth, 1974 as cited by Hide, 2003). Cultural attitudes to consumption of animal species varies; Muslims not only avoid pork, but also other species if they are not certain that they are "clean". This study will further consider the importance of this difference and how it might impact future biodiversity conservation in West Papua.

1.3 Conclusion

The depletion of wildlife in tropical forests has a strong correlation with food security and the livelihood of numerous rural tropical forest-dwelling peoples. This literature review has identified several important factors that can lead to unsustainable hunting. These include access to the forest site (clearing, land use changes and road development), increases in human population and availability of alternative protein sources (traditional uses of wildlife including religious traditions, prescriptions and restrictions on wildlife consumption).

In West Papua, with 80% of forests still intact, gathering and hunting activity still continues. To date, there has been no research on wild animal exploitation and its impact on biodiversity. In addition, the significance of hunting and its importance in household economies is poorly documented. Therefore, research and monitoring of

hunting on indigenous wildlife will help to understand how access to the forests, population density and availability of protein sources affect subsistence hunting for further assessment of the long-term sustainability of wildlife populations in West Papua.

1.4 Objectives and significance of the research

This project aims to evaluate subsistence hunting and the current use of wildlife on Bird's Head Peninsula, Papua. The construction of the Trans-Papua Highway, which has been postponed for various reasons since its commencement in 2013, is now being re-started. The 571-km stretch of the Trans-Papua Highway along the coast of the Bird's Head Peninsula willl connect villages along the coast and is expected to help farmers to transport agricultural produce to urban markets. Rapid development through oil palm industries, logging and mining has also created easy access to forests and changed the landscape along the coast.

There is a significant increase in human population in both Abun and Amberbaken districts (Badan Pusat Statistik Kabupaten Manokwari, 2011; Badan Pusat Statistik Kabupaten Sorong, 2012). Human population varies among the coastal villages in West Papua, and will likely grow over time. The central statistics agency of Indonesia (Badan Pusat Statistik, BPS) placed West Papua in the top five provinces for population growth rate within Indonesia. Preliminary classification of land areas conducted by Fakultas Kehutanan Universitas Negeri Papua (2012) has allowed the classification of villages into low- (between 0.1 and 1.5 people/km^2) or high-density villages (> 1.5 people/km^2).

The current 12 MPAs on the Bird's Head Peninsula form part of a connected network of MPAs across the seascape from Kaimana to Raja Ampat, to the Abun leatherback turtle MPA in Tambrau to the Cendrawasih Bay National Park of Teluk Wondama and Nabire. The total of nearly 3.6 million hectares is now managed through the MPA network. Assuming that sites within the network have limited access to alternative coastal protein sources, people may look for other options to satisfy the need for animal protein.

The current situation along the coast of the Bird's Head Peninsula has affected the use of natural resources including subsistence hunting and the use of wildlife in West Papua. Therefore, it is important to understand how access, population density and

availability of alternative protein sources affect hunting pressure on wildlife along the coast of West Papua. This study thus has following three specific aims.

1. To assess the effect of human population size on subsistence hunting at the village scale. As the human population dependent on subsistence hunting increases, the demand for wild meat will also increase, increasing hunting pressure.
2. To evaluate the impact of improved access to the forest on subsistence hunting. Road access should increase both the ability of hunters to access wildlife across a broader area and the ability to transport their catch to market. The consequence of either or both of these is likely to increase hunting take.
3. To assess the effect of availability of alternative protein sources on subsistence hunting at the village scale. Use of animal protein derived from the sea should decrease the demand for wild meat; conversely, the restrictions on harvest of ocean resources will increase dependence on wild meat.

I consider the research aims with respect to the dynamics of subsistence hunting by local communities, its impacts on prey species in the study site, the socio-economic condition of housholds related to subsistence hunting and other livelihoods.

As research on wildlife hunting in West Papua is extremely limited and disparate, this study will provide a information on subsistence hunting and current use of wildlife by local communities. This information will improve our knowledge of the effect of indigenous hunting on hunted species, prey composition and harvest rate.

Identifying hunted species by the method of hunting and effort spent in hunting will illustrate the relationship between dynamics of hunting and wild animal populations. This important to more reliably estimate the interaction between humans, animals and their habitat in relation to ecological approaches. Equally, identifying the current uses of hunted species, particularly as food and trade items, will assist understanding of the contribution of hunting to local livelihoods. Observing how wild animal species respond to subsistence hunting will also give insight and allow more reliable prediction of the likely dynamics of wildlife species in tropical forests in response to other threats, e.g. climate change, especially in regions where forest conversion to other purposes increases over time.

This research will contribute to knowledge of the role of forest and forest products in coastal livelihoods and will allow comparison with other studies in the western part of Indonesia and with the neighbouring Papuan communities in Papua New Guinea.

1.5 Structure of thesis

This study is designed to improve understanding of how access, human population and availability of alternative protein sources interact with indigenous hunting along the coast of the Bird's Head Peninsula.

Chapter 1 – Subsistence hunting in the tropics: the importance of wildlife to people and factors affecting wildlife hunting

This chapter provides the background to the study. It briefly explains the importance of wildlife to communities and factors driving hunting in the tropics. It focuses on how hunting is affected by increased access to rural sites through development, increased human population density and the availability of alternative protein sources. Lastly, it presents the theoretical basis of the study and research questions to be answered.

Chapter 2 – General methods and study sites

This chapter presents historical, cultural and economic information about West Papua Province. In particular, this chapter describes biodiversity richness, some threats, conservation programs and current information about hunting. It also briefly describes the chosen study villages.

Chapter 3: Human populations, hunting practices and rural livelihoods

This chapter describes the relationship between human populations, hunting practices and livelihood production. It presents the demand for current hunting practices along the coast in relation to household production. It further discusses the implications of human population increase on hunting practices and sources of livelihoods.

Chapter 4 – Access to forest sites and subsistence hunting

This chapter investigates how access – in this study, road development and forest fragmentation – affect indigenous hunting strategies in the study site, including

hunting techniques, hunting patterns and hunting frequency. The relationship between average catch and wild meat use is also explored. In addition, this chapter provides an analysis of the relationship between road access and hunting effort, and how it affects harvest rate along the coast.

Chapter 5: From bush to the table: availability of alternative protein and subsistence hunting

This chapter investigates the role of wild meat as a source of animal protein to households. It further compares MPA and non-MPA sites, assuming that MPA sites reduce access to marine resources for protein source, and assesses how this contributes to indigenous hunting at the site. This chapter also provides information on the impact of availability of alternative protein on consumption patterns and the reliance of people on wild meat.

Chapter 6: Impacts of access, population and availability of alternative protein

This last chapter presents a synthesis of the study findings and discusses the effect of access, human population and alternative protein sources on indigenous hunting along the coast of the Bird's Head Peninsula. It concludes with recommendations for future research and to encourage sustainable hunting.

Chapter 2 General methods and study sites

Figure 2.1: Researchers survey a group of hunters from Samfarmun of Amberbaken about their travel to hunting sites

2.1 Context

This chapter provides brief historical, cultural and economic background on study sites in Tambrau Regency, West Papua Province (previously part of Papua Province), and information on the methods of the study (Figure 2.1). This chapter also focuses on particular issues relevant to natural resources and biodiversity that are currently under pressure from various factors including development.

Tambrau Regency in West Papua Province is in transition. Until a few decades ago the majority of the human population lived through hunting and gathering, with only limited cultivation of subsistence crops and fishing. Recently, new roads have been built, connecting communities to markets, and employment is available in industrial tree-crop plantations as well as government projects. Hunting is still important for people's livelihoods but the nature of that importance is changing. Hunting pressure may be increasing and wildlife populations may not be able to sustain the offtake. This has profound implications for the livelihoods of the people and for the future of the populations of rare and endangered wildlife.

2.2 Study sites

2.2.1 Political history

The total area of the island of New Guinea is 892 000 km^2 (Mansoben, 1994). Based on The Hague treaty of 16 May 1895, New Guinea was divided into western and eastern sectors. The western part was controlled by the Dutch East Indies government, called Netherlands New Guinea, while the eastern part was sub-divided into the Wilhelmstad territories controlled by Germany, and the remaining areas controlled by the British (Government Gazette No. 1895 Indie van Netherlands 220 and 221).

An agreement was signed in New York on 15 August 1962 ending Dutch rule over Netherlands New Guinea and government was provided by the United Nations Temporary Executive Authority from 1 October 1962 until 1 May 1963. After that, the western region of New Guinea became an Indonesian province, Irian Jaya, while the eastern part became the independent State of Papua New Guinea (Mansoben, 1994).

Following the 1998 commencement of reforms across Indonesia, Irian Jaya and other Indonesian provinces, greater regional autonomy was established in these areas. In

2001, "Special Autonomy" status was granted and the province name was changed from Irian Jaya to Papua Province. The region was administered as a single province until 2003, when it was split into the provinces of Papua and West Papua. A local government was installed in Irian Jaya Barat in February 2003, and was later renamed Papua Barat (West Papua) on 7 February 2007 and a governor was appointed in November of that year (King et al., 2011). West Papua became the 34th province of Indonesia and covers the Bird's Head (Doberai) and Bomberai peninsulas and the surrounding islands of Raja Ampat. Currently, West Papua Province has internal sub-divisions of 12 regencies and one town, specified as part of the process of special autonomy that has been given to the province (Badan Pusat Statistik Papua Barat, 2011).

2.2.2 Socio-economic indicators in West Papua

The economy of West Papua Province is growing relatively slowly (Table 2.1). In the first quarter of 2014 the economy of West Papua Province grew by 1.54%, substantially lower than the national economic growth in the first quarter of 2014 at 5.21% (Bank Indonesia, 2014).

Table 2.1: The gross domestic product (GDP) of West Papua for each quarter (2012–2014) available for the period of the study (Bank Indonesia, 2014)

GDP growth of West Papua	**2012**				**2013**				**2014**
	1	2	3	4	1	2	3	4	1
Agriculture	0.55	2.20	0.06	3.09	2.41	3.98	5.84	2.12	0.97
Mining and quarrying	14.96	7.69	1.10	-0.83	-3.87	-0.93	2.84	2.99	1.78
Manufacturing	89.85	52.04	2.30	1.46	13.40	-0.79	9.58	28.23	-3.25
Electricity, gas and clean water	10.08	8.25	7.63	9.34	8.68	10.03	9.48	8.37	8.33
Building	10.58	10.39	11.99	15.99	12.03	11.51	11.31	10.74	15.75
Trade, hotel and restaurant	8.77	8.02	9.81	12.96	12.51	12.87	11.11	10.75	9.39
Transportation and communication	13.13	11.08	10.21	11.93	10.28	11.12	10.65	8.90	9.30
Finance, leasing and corporate services	9.12	11.05	1.03	3.46	10.90	13.20	9.57	14.85	10.65
Services	12.90	10.11	8.39	16.19	10.71	10.94	7.43	6.19	5.75
Total GDP	**35.83**	**24.63**	**3.87**	**5.23**	**9.54**	**3.51**	**8.53**	**15.74**	**1.54**

External investment in agriculture, forestry and mining has been the main driver of the economy. The export performance of West Papua Province in the first quarter of 2014 grew by 1.12%. West Papua imports grew by 4.3%, lower than the 16.8% in the previous quarter. A new gas field has now been discovered and expansion of gas exploitation is expected in the future (Bank Indonesia, 2014).

The agricultural sector is the main source of employment, providing 48.7% of jobs, followed by the services sector at 19.9%. Although the agricultural sector provides the highest labour force, the industrial sector is growing rapidly with increasing employment in oil and gas processing, wood processing and cement manufacture (Bank Indonesia, 2014).

2.2.3 Human population dynamics

West Papua is the least populous province in Indonesia, with only 0.32% of the total national population (BPS Papua Barat, 2011). The population of West Papua more than tripled from 221,457 in 1971, when West Papua was part of Papua Province, to 760,422 in 2010 when it had become a separate province (Table 2.2).

Table 2.2: Population size of West Papua Province at censuses between 1971 and 2010 (as a part of Irian Jaya Province)

Year	Population size
1971	221,457
1980	283,493
1990	385,509
2000	529,689
2010	760,422

West Papua has the fourth highest population growth in Indonesia (3.69%), behind Papua Province (5.39%), Riau Islands Province (4.95%) and East Kalimantan (3.81%). In the 1990 census the total population had reached 385,509, an average population growth of 2.38% annually. In the following years, growth continued and by 2000 the population had reached 529,689 with annual growth of 3.98%. At the last census in 2010, the population of native Papuans was 53% compared to non-Papuans (47%). The 47% of non-Papuans also included migration from other parts of Indonesia

to West Papua Province (BPS Papua Barat, 2011). Transmigration from other parts of Indonesia to Papua was discontinued with the implementation of the autonomy law (http://nasional.kompas.com/read/2015/06/07/15520261/), so while transmigration contributed sharply to population growth in the recent past, it does not at present.

2.2.4 Development and industries

Jointly Papua's (Papua and West Papua provinces) greatest comparative advantage is its natural resources. However, while abundant, these natural resources are finite; their exploitation is having impacts on the environment and may not be sustainable in the long term. Papua is rich in copper, gold, silver, oil, gas, timber and marine products. The extraction of natural resources by corporations is the primary source of income in the Papuan economy (GRM International, 2009). Mineral and coal mining concessions (green inFigure 2.2) and oil and gas concessions (brown in Figure 2.2) are distributed across West Papua Province (Centre of Excellence Universitas Papua, 2016). The Freeport mine provides nearly 50% of Papua Province's gross domestic product and is the largest tax payer to the Indonesian Government (Resosudarmo & Jotzo, 2009).

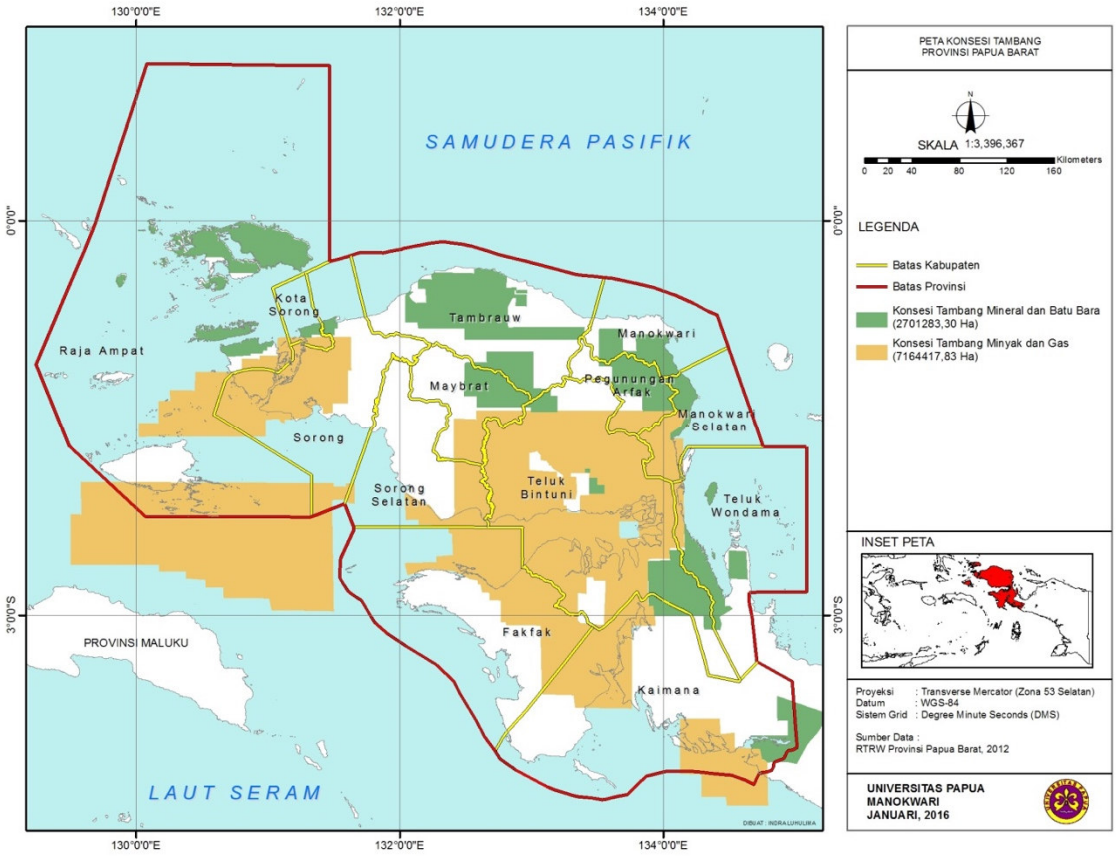


Figure 2.2: The distribution of mining concessions in West Papua Province (from Center of Excellence Universitas Papua, 2016)

Currently, the largest gas project in West Papua, 'Tangguh Liquefied Natural Gas', is extracting natural gas from fields in the Bintuni Bay area for export to countries outside of Indonesia. With reserves of 14.4 trillion cubic feet, this gas field is predicted to generate US$3.6 billion for the government of West Papua and US$8.7 billion for the national government over the next 20 years (GRM International, 2009). In the oil and gas sector, exploration and development activities continue in the Berau Gulf area in Fakfak regency (GRM International, 2009).

Forestry is another important extractive industry with around 19 large-scale timber concessions (Figure 2.3) that cover over 5.4 million hectares of land, 56% of the total forest area of West Papua Province (Center of Excellence Universitas Papua, 2016). The government has allocated a total of 10,442,780 ha, 83% of the forest area, for logging industries (Abood et al. 2014).

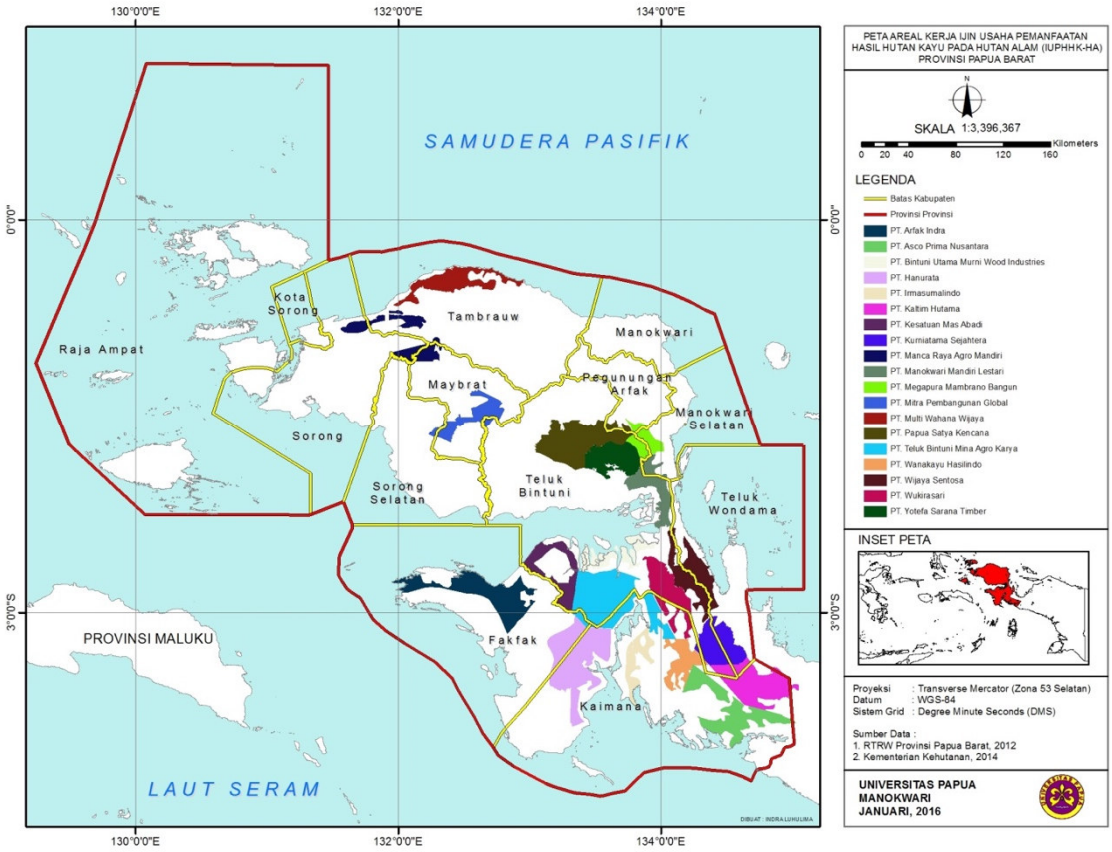


Figure 2.3: Distribution of commercial logging concessions in West Papua Province (from Center of Excellence Universitas Papua, 2016)

Expansion of oil palm plantations is a priority of both the central government and the government of Papua. The area of oil palm plantations has increased rapidly in Papua from 11,367 ha in 1991 to 50,000 ha in 2005 (GRM International, 2009). There is a significant and well-established oil palm plantation on the south coast of Bintuni Bay in West Papua and there are plans for extensive expansion of oil palm in Kaimana and Fakfak regencies. Indonesia is expected to establish another 5.6 million hectares of oil palm plantations over the next 13 years.

Most of this expansion is expected to occur in Sumatra, Kalimantan and Papua. The Indonesian Government is keen to develop oil palm plantations in Papua and is offering investors the opportunity to establish concessions of up to 200,000 ha. Over 50,000 ha of oil palm has already been planted in Papua and permits have been allocated to develop another 500,000 ha (GRM International, 2009). Abood et al. (2014)

indicated that the total areas allocated for oil palm in Papua is approximately 500,000 ha or 3.3% of the total forest area allocated for industrial use.

Papua has significant fisheries exports to Japan and Europe. Tuna, shrimp, crabs, sea cucumbers, pearls and aquarium fish are all exported. The Indonesian Government and the Papuan Government both appear to be encouraging investment in fisheries in the seas of Papua and the rest of eastern Indonesia because they consider these seas to be underexploited. Bintuni Bay in West Papua has a very significant shrimp fishery; large numbers of trawlers operate around the western coasts of Papua and are considered to be over-exploiting the resource (GRM International, 2009).

2.2.5 Biodiversity of West Papua

West Papua contains one of the highest flora and fauna diversity and endemism in Indonesia with 146 mammals, 329 reptiles and amphibians and 650 birds inhabiting the diverse ecosystems of the province. These 1,125 species comprise more than 50% of Indonesia's terrestrial vertebrate fauna (Conservation International, 1999).

Papua (both Papua and West Papua provinces) has four biogeographic zones, each with a distinctive biota (GRM International, 2009). The fourth zone, Vogelkop (or Bird's Head), falls within the province of West Papua, and is connected to the rest of New Guinea by a rugged narrow and curving isthmus with a number of isolated mountain ranges punctuating the lowlands. It has a complex and, in places, ancient geology which leads to huge variation in the biophysical environment and natural resources.

Extensive flooded coastal lowlands — sago palm swamps, *Melaleuca* (kayu putih)-dominated savannahs and mangroves — contribute to high productivity fisheries but also to nutrient impoverishment of the coastal waters (Beehler, 2007). Indonesia's largest mangrove ecosystem is nestled at the head of Bintuni Bay, which separates the Vogelkop (Bird's Head) Peninsula from the more southerly Bomberai Peninsula. Elsewhere in Papua, swamps can be found in many alluvial localities where drainage is impeded, around lowland rivers, and in and around Yos Sudarso Island in the far south (Beehler, 2007).

The altitudinal and geological variation contributes to isolation of specific ecosystems with a very high level of endemism in terrestrial biodiversity.

Approximately 85% of Papua and West Papua provinces are still covered with intact forests. Significantly, over 47% of Papuan forests are classified as lowland rainforest, making Papua Province home to the largest remaining tracts of lowland forest in Indonesia. Large areas of mangrove forest (3.3% of forested land), swamp ecosystems (17.08% of forested land) and montane forest (12.3% of forested land) are also found. There are also several other ecosystem types, each of which comprise less than 3% of Papua's total area (GRM International, 2009).

Botanically, Papua is remarkably rich and is estimated to house more than 15,000 species of vascular plants, notably more than 2,000 species of orchids, more than 100 rhododendrons, two species of the ancient *Araucaria* conifers — Papua's tallest tree — as well as magnificent and valuable kauri pines (*Agathis* species). Dipterocarp trees that dominate the forest further west in the archipelago are generally relatively uncommon, but appear in abundance in certain patches, presumably as a result of some natural disturbance regime. Other important timber trees include *Intsia bijuga* (merbau), *Pometia pinnata* (matoa), *Pterocarpus indicus* (rosewood) and *Dracontomelon* (black walnut) (Beehler, 2007).

Birds dominate the Papuan terrestrial vertebrate fauna, with more than 600 species recorded. This includes more than 25 species of birds of paradise, three species of cassowaries and some two dozen species each of parrots, pigeons, raptors, and kingfishers (Beehler, 2007). Mammals are less in evidence, mainly because of chronic hunting and their nocturnal habits. Fruit bats, insectivorous bats, tree kangaroos, possums and rats are the best represented among the 180 or so mammalian species. Amphibians include more than 130 species of frogs. Reptiles include two crocodiles, 83 snakes, and 141 lizards (Beehler, 2007).

The Bird's Head seascape lies in the centre of biodiversity for seagrass (Short et al., 2007), with 11 species reported by McKenzie et al. (2007). The Bird's Head seascape also boasts the highest diversity of corals, reef fish and stomatopods in the world (Huffard et al., 2009; Allen & Erdmann, 2009). The area, which occupies the extreme western end of New Guinea, contains the world's most diverse assemblage of coral reef fish. The current checklist, which includes both historical records and recent survey results, includes 1,511 species in 451 genera and 111 families. Respective species totals for the three main coral reef areas – Raja Ampat Islands, Fakfak–Kaimana

coast and Cenderawasih Bay – are 1320, 995, and 877 (Allen & Erdmann, 2009). Surveys have recorded over 577 species of scleractinian corals (75% of the world's total), with individual reefs hosting up to 280 species per hectare (Veron et al., 2009; Wallace et al., 2011). The main reef types found in the region are fringing and patch reefs, and to a lesser extent seamounts, atolls and barrier reefs (Donnelly et al., 2003; WWF, 2003).

Major nesting beaches for green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) turtles are found on the coasts and small islands of the Bird's Head Peninsula. Among these are regionally significant nesting beaches for leatherback and olive ridley turtles at Jamursba Medi and Wermon in Abun MPA (Hitipeuw et al., 2007; Benson et al., 2007). The Bird's Head area also maintains healthy populations of several shark species that are not targeted for their fins, including tasseled wobbegongs (*Eucrossorhinus dasypogon*) and the three species of epaulette or "walking" sharks (*Hemiscyllium freycineti, H. galei*, and *H. henryi*) considered endemic to the Bird's Head area (Allen & Erdmann, 2008).

The Bird's Head area has been indicated as a cetacean 'hotspot' and supports diverse and healthy populations of numerous species on the IUCN Red List. Of the 31 cetacean species recorded in Indonesian waters (Rudolf et al., 1997; Tomascik, 1997), 15 have been recorded in the Bird's Head area including Bryde's, false killer, killer and sperm whales, and Indo-Pacific humpback, pan tropical spotted and Fraser's dolphins (Rudolf et al., 1997; Kahn, 2007).

2.3 Tambrau Regency

2.3.1 Geography

Tambrau Regency was established by Law No. 56 Year 2008 as part of a district development program in Indonesia. A report of Fakultas Kehutanan Universitas Negeri Papua (2012) states that Tambrau Regency consists of seven districts, namely Sausapor, Kwoor, Abun, Yembun, Feef, Syujak and Miyah. It has a total area of 5188.64 km^2 (Figure 2.4). As part of a regional planning exercise in West Papua Province in 2009, four sub-districts from Manokwari were also added to Tambrau district, doubling the total area to 10 564.46 km^2.

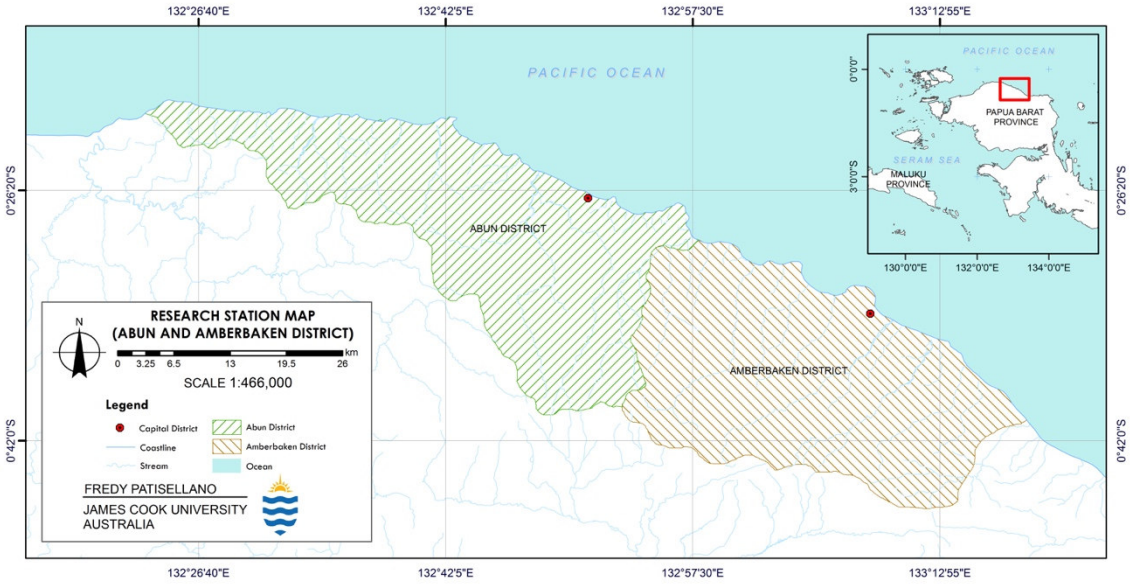


Figure 2.4: Map of Tambrau Regency showing the location of districts after four sub-districts from Manokwari Regency were added to Tambrau (from Fakultas Kehutanan Universitas Negeri Papua, 2012)

Tambrau Regency is located in the northern part of the Bird's Head region, West Papua Province at 0^{o} 36' 18.36" S, 132^{o} 29' 56" E. To the east, Tambrau shares a border with Manokwari to the east, Sorong to the west and Maybrat to the south. The northern border is the Pacific Ocean.

2.3.2 Climate

The equatorial location of the Bird's Head Peninsula means that the main seasonal influence is the monsoon, with two distinct seasons driven by the annual movement of the inter-tropical convergence zone which moves between15° north and south of the equator (Prentice & Hope, 2007). The northwest monsoon extends from November to March and is characterised by warmer sea surface temperatures, occasional strong winds and ocean swell predominantly from the north. The southeast monsoon from May to October is characterised by cooler sea surface temperatures, persistent winds and strong ocean swells from the south. There is a transition period of one to two months between seasons characterised by variable and lower winds. Although annual rainfall in Papua averages 2500–4500 mm (Prentice & Hope, 2007), rainfall in Bird's Head coastal villages is lower and ranges 100.9–657.2 mm monthly

(Figure 2.5). Inter-annual variability in rainfall changes significantly with the El Niño Southern Oscillation (Prentice & Hope, 2007).

The climate in Tambrau is generally hot and humid (Fakultas Kehutanan Universitas Negeri Papua, 2012). Based on data from the Bureau of Meteorology station and the Geophysics Agency (BMG) in Sorong, the nearest station to the study sites, the average maximum temperature in Tambrau is 30.9° C with a minimum temperature of 24.7°C. Average humidity varies between 81 and 85%. There is no distinctively dry season; Tambrau has an average monthly rainfall of 195.4 mm and 13 rainy days per month.

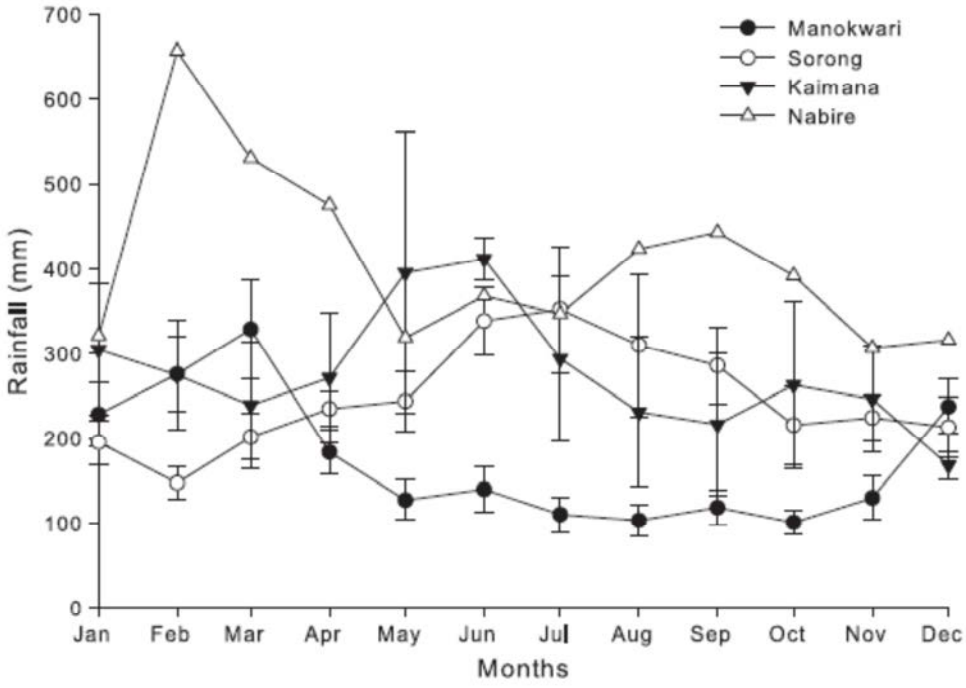


Figure 2.5: Average monthly rainfall patterns at four sites on the Bird's Head Peninsula (from Mangubhai et al., 2012)

2.3.3 The importance of Tambrau for conservation

There are two nature reserves in the highlands of Tambrau (Figure 2.6): North Tambrau Strict Nature Reserve covers 368,355 ha including Tambrau and Tohkiki Mountains; and South Tambrau Strict Nature Reserve covers 247,875.30 ha stretching between the Merangi and the Arfak Mountains (Fakultas Kehutanan Universitas Negeri Papua, 2012).

The most important conservation site along the coast is the Abun Jamursba Medi Regional Marine Protected Area, which covers 169,158.015 ha. Nine villages are contained within the area: Waibem, Wau, Warmandi, Saubeba, Kwoor, Werur, Werbes, Hopmare and Weyaf. The Regional Marine Conservation Area at Abun has the two most significant nesting beaches for leatherback turtles (*Dermochelys coriacea*), Jamursba Medi and Warmon (Fakultas Kehutanan Universitas Negeri Papua, 2012).

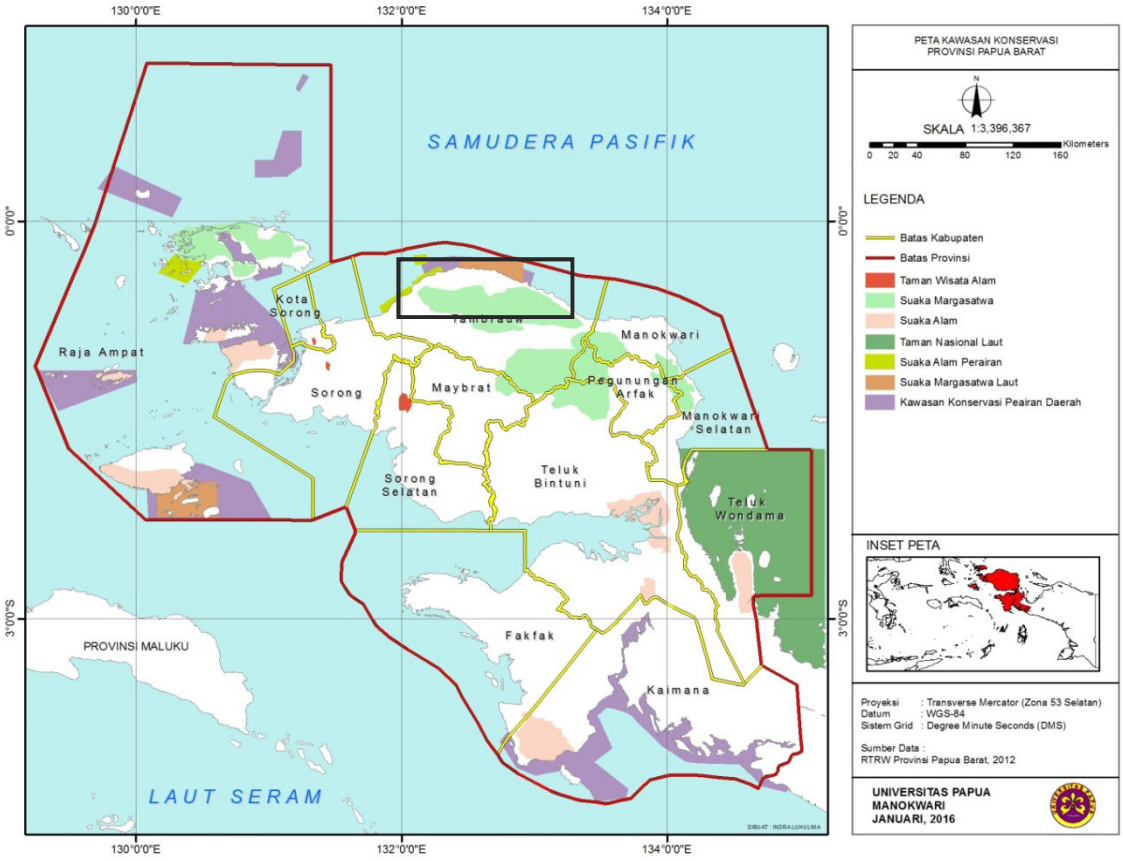


Figure 2.6: Locations of protected areas in West Papua (Badan Planologi Kehutanan, 2002, modified by Indra N. Luhulima). Study sites are in the area within the black frame. MPAs are coloured purple.

2.3.4 Study site districts

Abun and Amberbaken districts on the Bird's Head Peninsula were selected as study sites to address the research framework outlined in Chapter 1 based on road access, population density and location of the marine protected areas.

Spatial analysis of road development in Papua (Figure 2.7), estimated that the national and provincial network of roads is 2 700 km long (Anggaraeni & Watopa,

2004), including more than 1,250 km only recently developed (Mertens, 2002). For example, the 571 km road development of the Trans-West Papua Highway has connected West Papua's main cities on the Bird's Head Peninsula, Manokwari and Sorong (Pattiselanno & Arobaya, 2013). Within the Tambrau Regency this has connected some villages in the Amberbaken District (133°09'37" E 0°33'92'7" S) with roads, while others still have no road access. In Abun District (132°44'47" E 0°27'48" S), however, no villages have yet been connected by road.

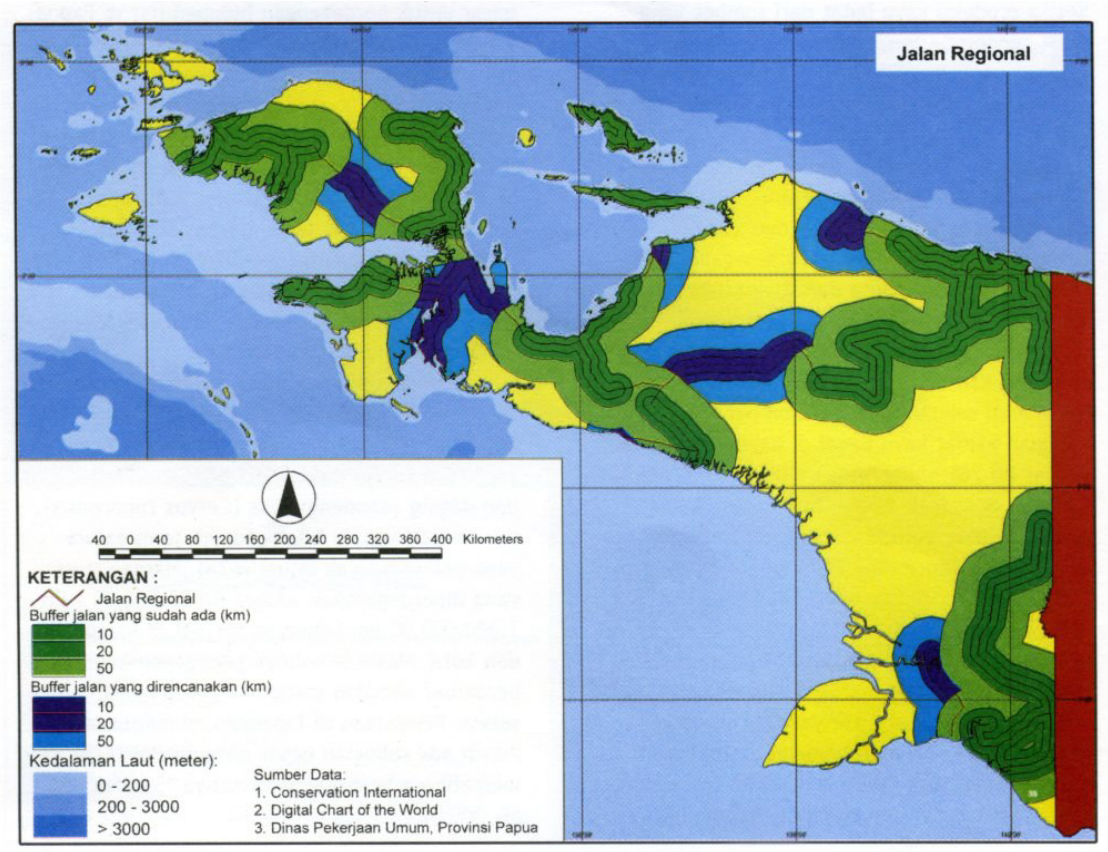


Figure 2.7: Spatial analysis showing current and planned roads in Papua (taken from Anggraeni & Watopa, 2004). Green colour represents different layers of the existing road buffer; blue represents layers of planned roads and yellow areas are the remaining land covers

In 2012, the population of Abun District reached 592 people (Badan Pusat Statistik Kabupaten Sorong, 2012), while Amberbaken had 1876 people (Badan Pusat Statistik Kabupaten Manokwari, 2011). The latest data shows a significant increase in population in both districts.

Several studies have used number of people per square kilometre to determine the sustainability of hunting in meeting human needs (Robinson & Bennett, 2000; Bennett, 2002). The current study was conducted in Tambrau, a new regency created in West Papua in 2008. The new district is inhabited by several ethnic groups with different land tenure arrangements and it took a long time to reconcile land claims and establish village boundaries. Accurate maps and data on village borders and sizes was not available at the start, so I initially categorised the 11 villages involved in this study based on population size. Preliminary data on land areas that is now available (Fakultas Kehutanan Universitas Negeri Papua, 2012) has allowed classification of the villages into low density (between 0.1 and 1.5 people/km^2) or high density (> 1.5 people/km^2).

In the early 1990s marine conservation initiatives for management and protection were initiated by WWF and IUCN. Today, there are 12 MPAs (Figure 2.8) in the Bird's Head area (Mangubhai et al., 2012).

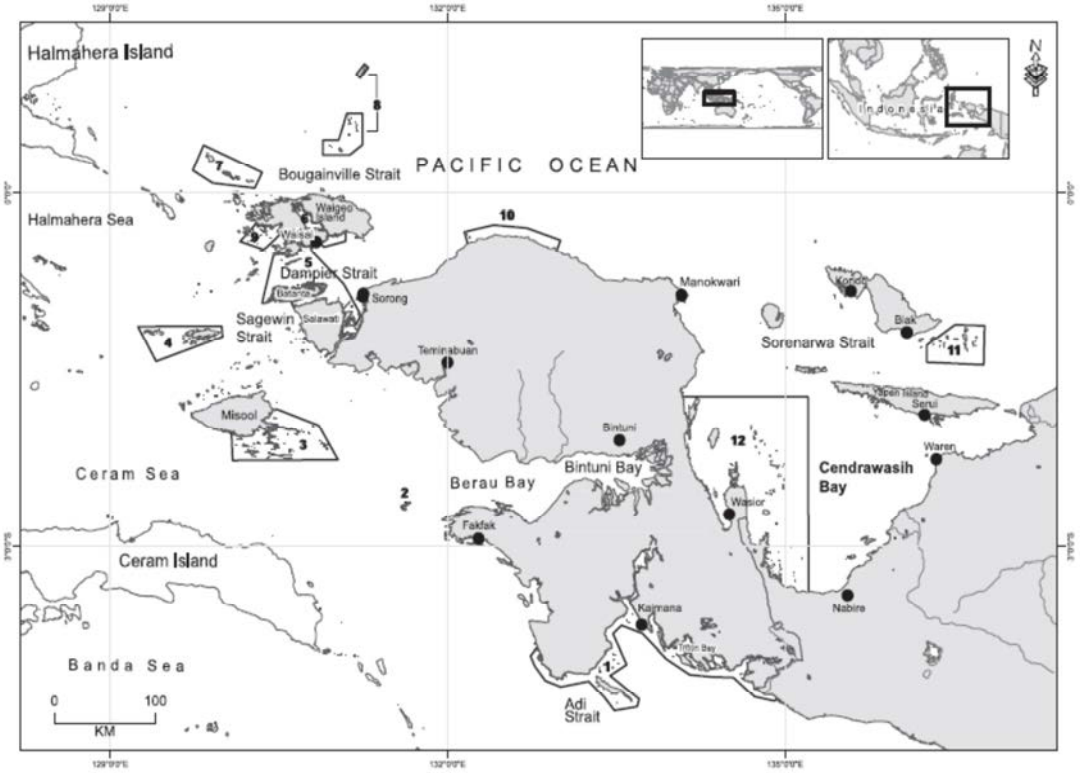


Figure 2.8: The Bird's Head Peninsula, showing the locations of major towns, islands and marine protected areas (from Mangubhai et al., 2012). MPA 10 is the relevant protected area for this study- note that this map shows the basic location only, the relevant MPA is not actually a single undivided unit.

An ecologically connected network of MPAs across the seascape from Kaimana to Raja Ampat, to the Abun leatherback turtle MPA in Tambrau to the Cendrawasih Bay National Park of Teluk Wondama and Nabire means that nearly 3.6 million hectares are now managed as MPAs.

Our study sites were located along the Bird's Head Peninsula. Villages in Abun District (Waibem, Wau, Warmandi and Saubeba) are included in the MPA because of the importance of nesting beaches for leatherback, olive ridley, green and hawksbill turtles. Karon was the origin ethnic group across the MPA villages. However, no villages in the Amberbaken District (Arupi, Wekari, Saukorem, Wasarak, Wefiani, Samfarmun and Imbuan) are associated with MPAs. Mpur was the origin ethnic group in Amberbaken. In both Abun and Amberbaken there are also mixed Papuans (Biak, Serui, Wondama and Sorong) and non-Papuans from Jawa, Sulawesi, Mollucas and other parts of Indonesia.

2.3.5 Demographics and livelihood systems

The average household size in the study sites is five people; the maximum household size is 12. The majority of villagers are Christians, and there is a church in each village. From the last socio-economic surveys by WWF and Universitas Negeri Papua (WWF, 2002), many improvements have been made in the villages since 2008 (mostly from government) and nearly all respondents feel their economic status is improving. There has been an increase in ownership of "luxury" goods (TVs, telephones, generators, etc.), though these are owned by only a handful of households. There remains a majority of households that continue at basic subsistence level.

All households engage in farming, and while most of the products are consumed within the village, some are sold in markets in Sorong and Sausapor and some to a boat that visits the villages approximately once a month or to the logging and mining companies (Gjertsen, 2011). In addition, before 2010, some households earned money from poultry and pigs, from hunting, and from paid labour (mainly conservation patrollers or contract work for the mining company). Detailed information on livelihoods is presented in section 4.3.1.2.

Some people live for less than US$ 2 per day but not for under US$ 1 per day. Household food is mostly sourced from crops planted (not purchased) and almost all

households own their own house so do not pay rent for their housing (WWF, 2002). From a preliminary survey, 87% of respondents own their own house and the remaining 13% live with their parents (Gjertsen, 2011).

Several generators have been purchased by the villagers, but the government also provides a generator for each village, so many homes now have electricity for lighting. Villagers cook with wood that they collect near their farms. Most homes obtain their drinking water from communal outdoor faucets, some obtained from shared wells, apart from one household with its own well. Households have plots of lands for farming.

Education is of great importance to the villagers, and financial constraints prevent those few from attending schools. The local school only teaches students up to 6th grade, then children must leave the village to study elsewhere. This is much more expensive, as parents must pay school fees as well as transportation and living expenses for children to live outside of the village.

Importantly, Abun and Amberbaken districts have different access to marine resources — non-MPA sites provide alternative marine sources of protein for local communities whereas people living adjacent to MPAs are denied access to these resources. Limited access to marine resources at the MPA sites indicates lack of alternative protein sources.

Villages have been selected across these districts to provide comparisons of varying access, population density and availability of marine resources as an alternative protein source. There are no villages within the MPA that also have road access, resulting in six levels across the three factors and 11 replicate villages (Figures 2.9, 2.10) to address the following research questions:

1. How does human population density affect hunting?
2. How does access to the forests affect hunting?
3. How does available alternative protein affect hunting?

These research questions are further discussed in Chapters 3, 4 and 5 respectively.

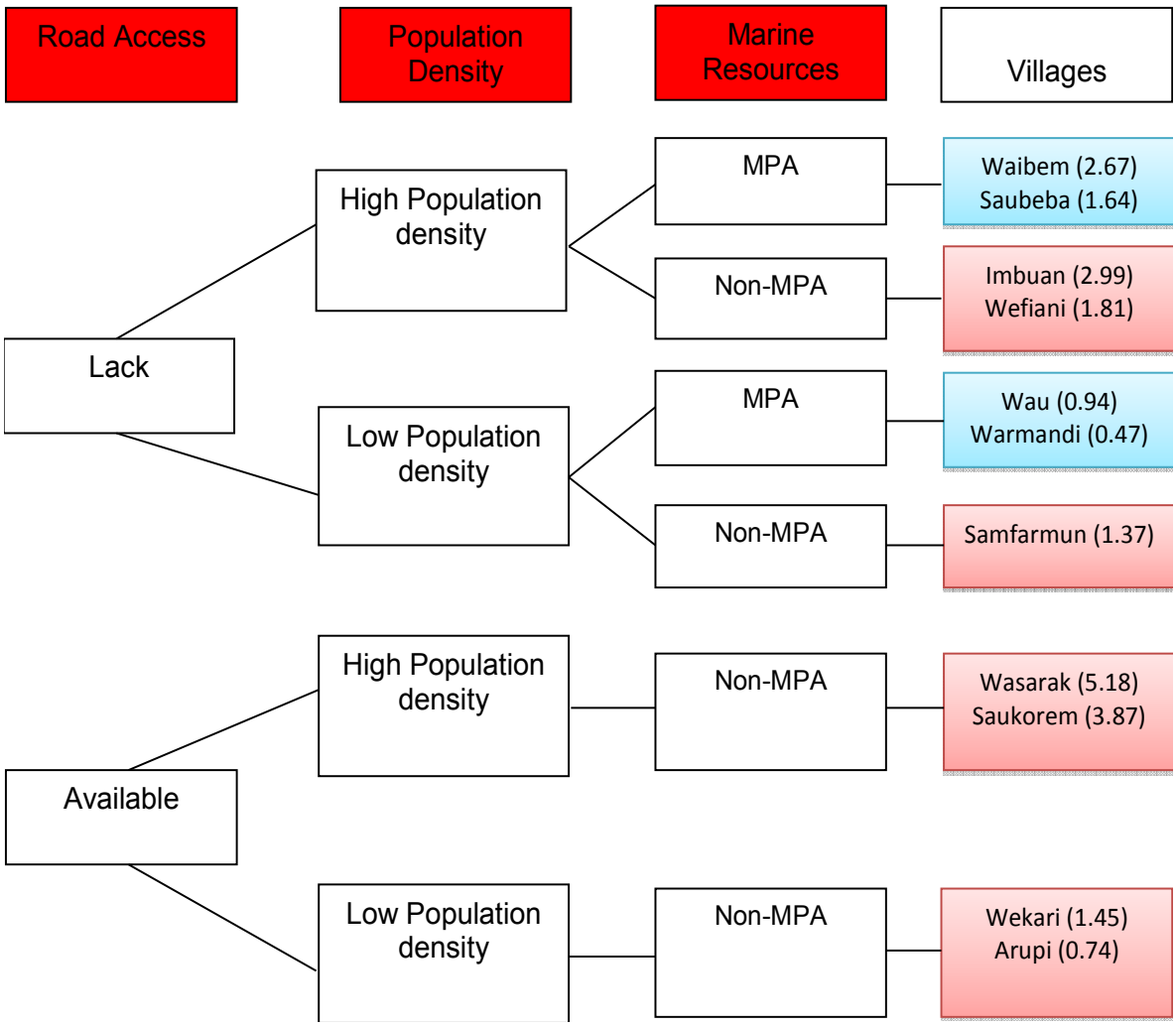


Figure 2.9: Experimental design of the study shows the comparison of three factors (access, population density and availability of marine resources) with 11 replicate villages. Population density (people/km2) is given for each village in parentheses

I acknowledge that spatial distribution of the villages and variation in population size and hunters as well as cultural diversity may influence the categorisation. However, given the nature of the study sites that closely relate to the purpose of the study, this categorisation could be used as an approach to a more detailed investigation of how road development, increased in human population and availability of alternative protein sources affect indigenous hunting along the coastal landscape.

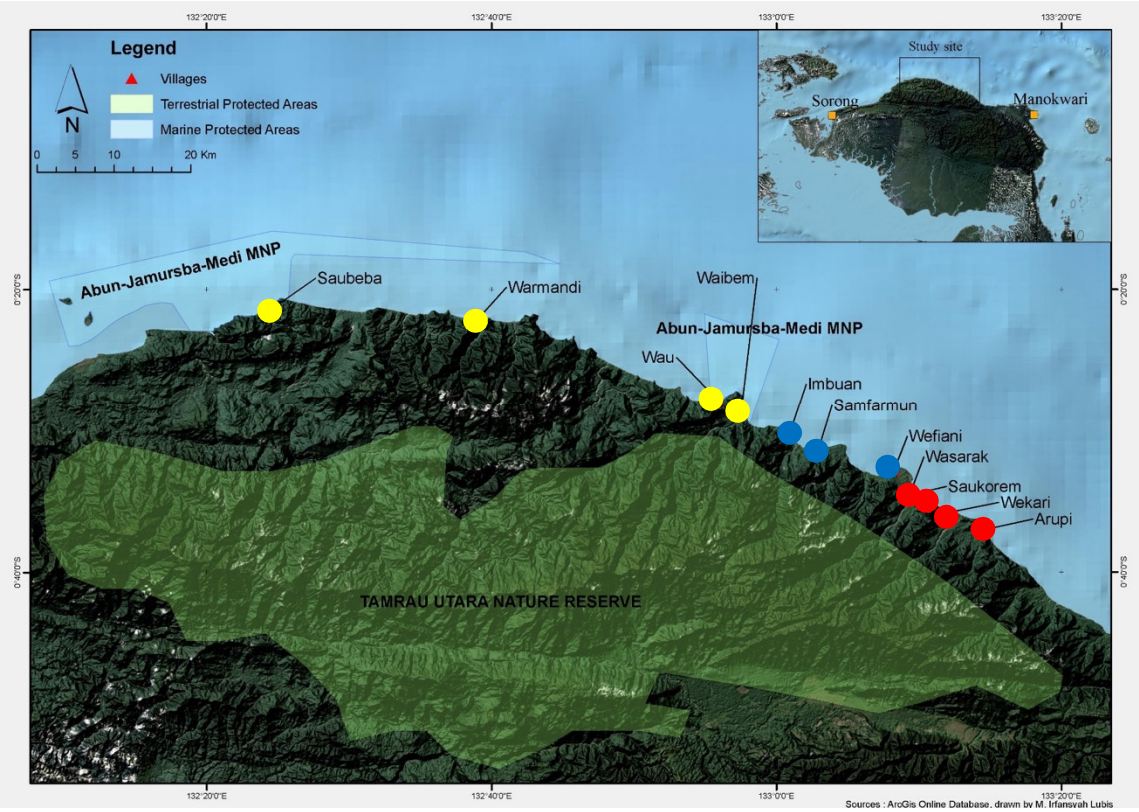


Figure 2.10: Location of the Bird's Head Peninsula study sites. These consist of four villages that have been connected by roads (red dots) and three villages without road access (blue dots), all in Amberbaken District (non-MPA site). Yellow dots represent four villages in Abun Districtu (MPA site) that do not yet have any roads.

2.3.6 Overview of data collection

To address the research questions explored in the study (see section 1.6) data was collected from 11 villages during three different time periods: (1) June to September 2011; (2) May to October 2012; and (3) April to July 2013. Data was collected on:

1. Indigenous hunting practices and the current use of wildlife
2. Hunting effort and harvest rate
3. The contribution of wild meat to household consumption
4. The socio-economic characteristics and sources of livelihood for households

In this general methods section I provide an introduction to the field set-up and outline the main data collection. The use and analysis of these data to answer the specific research questions is explained in each subsequent chapter.

2.3.7 Community participation

The protocol for this study was approved by the JCU Human Ethics Committee (Approval H4203). The involvement of local communities in this project was critical. Connection and credibility with the communities was established over a decade before the study was commenced during my involvement in a biodiversity assessment study in collaboration with WWF Papua in Jayapura and Forest Research Institute in Manokwari in 2001 in Amberbaken District (which is part of the study area for the present research). Furthermore, I have worked with animal/veterinary science extension programs to local communities with the Manokwari Regency Government in 2005, and also worked with Nixon Karubaba, a graduate of Universitas Negeri Papua (UNIPA), who worked in Amberbaken District as a livestock and veterinary extension officer from 2007 to 2008 on a series of livestock health and improvement programs. These activities provided me with basic knowledge of the area and strong links with local communities. Apart from my personal links there was a strong institutional relationship between UNIPA and local communities.

Villages within the Abun District are located within MPAs designed to protect vulnerable marine turtles and coral reefs (Figure 2.11). Communities in the Abun District worked with the Fishery and Marine Sciences department of UNIPA in managing MPAs in coastal areas adjacent to the study sites. This collaboration was supported by the WWF Papua Program and was later strengthened through the establishment of a memorandum of understanding (MoU) between WWF and UNIPA in 2009 and the consequent renewal of the MoU in 2012. The MoU facilitated the involvement of staff from UNIPA in outreach programs for community development and research programs on livestock production in the community. Note that fishermen from villages at the edges of the MPA, eg. Wau and Waibem, could have travelled laterally to fish in waters outside the MPA. It is also clear that the MPAs are focused on immediate near-shore resources, and do not extend more than approximately 4km from the coast, so while access to marine resources were restricted, it is still possible that fishermen could access fish by travelling further.

During the visits for data collection associated with this study I approached community leaders, religious leaders and key people in the villages to explain the overall study plan. When the study began in June 2011, I held meetings with local communities in each village.

I introduced the research team and described the proposed program. I was accompanied by ex-student Nixon Karubaba as my contact person in the district and Bastian Maryen, a current student from the Department of Animal and Veterinary Science, UNIPA. We held question and answer sessions to make sure that information we delivered was understood and accepted by the community.

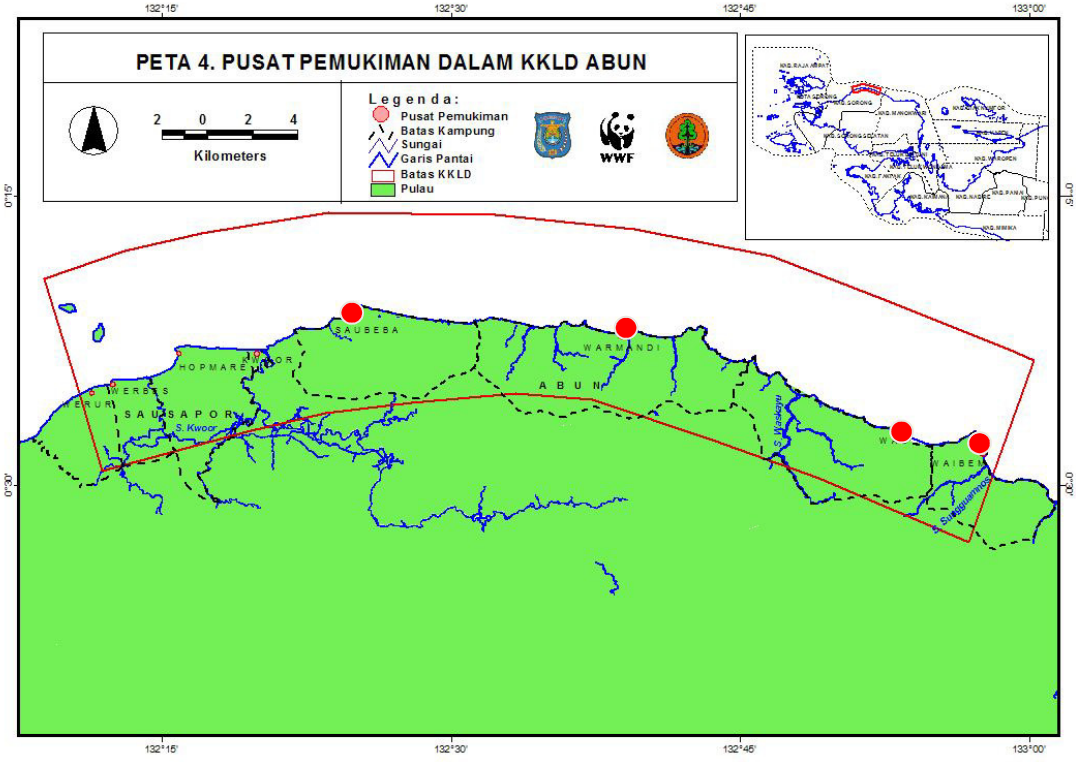


Figure 2.11: Four villages (Waibem, Wau, Warmandi and Saubeba; red dots) in the Abun Marine Protected Areas located on the border with Sorong Regency. This site represents villages with limited access to alternative protein sources from the coast and is referred to in this thesis as the MPA site (Source: WWF Indonesia Papua Program)

During the study, a series of meetings with local communities were scheduled to keep people informed and sort out any difficulties that might arise during data collection. Confidentiality and anonymity of the participants was assured; people were not identified by name during the study and data was coded accordingly.

Generally, hunters and other community members agreed to be involved in the program because of their understanding of the importance of the contribution of hunting to family consumption and income. Participants were not paid, but to compensate hunters for their time (particularly the 33 hunters involved in the detailed offtake study), we gave them cigarettes, coffee and sugar for consumption during hunting excursions. We also often had informal discussions to convey important information regarding hunting activities with small groups of hunters (5–10). During these meetings coffee, cigarettes and biscuits were served to thank them for spending their time with us.

2.3.8 Field guides and assistants

Three adult men were employed in each village as field guides during our visits. The field guides accompanied us throughout visits to the hunting areas. Field guides were chosen by the village chief (and elders) based on the clan ownership of the areas we visited. This is a common practice in the region — local customs require that outsiders only enter the forest sites when accompanied by local guides. Each field guide was paid a monthly wage equivalent to that of an agricultural worker in the village (600,000 Indonesian rupiah [IDR]), and they were involved in all aspects of fieldwork.

Two field assistants (both UNIPA students), were recruited and were based in the village to collect data on hunting trips. These field assistants kept records of all animals brought back to the villages. Each field assistant was paid the minimum monthly wage (IDR 1,720,000) based on national labour wage policy.

In June and July 2011, field assistants were trained in the use of questionnaires for hunting and socio-economic interviews. They were also taught to use a GPS and given instructions on basic data recording techniques. A pilot survey was held with two farmers, two fishermen and two hunters in each village. Results of the pilot test were used to finalise the questionnaire before the main phase of data collection.

In each village we visited some hunting sites at the beginning of the data collection period. We held meetings with hunters to explain the definitions of terms used in the questionnaires such as hill, river, secondary forest, primary forest and cropland.

We adopted the Food and Agriculture Organization (FAO) definition of forest (FAO, 2000; criteria 1–3 below)). Criterion 4 was modified using a Poverty

Environment Network (PEN) questionnaire developed by scientists at the Centre for International Forestry Research in Bogor, Indonesia.

1. Primary forest: natural forest — consists of indigenous (native) tree species. It is managed only to a very limited degree, that is, one may practice "tolerant forest management in which the native vegetation is largely conserved or reconstructed through successional processes". Or indigenous species with only limited management.
2. Secondary forest: managed forest — consists predominantly of indigenous vegetation, and with active management to increase the frequency and productivity of beneficial species. The management may include felling (trimming, thinning in addition to regular harvesting) and planting of indigenous and/or exotic species.
3. Plantation: consists of forest stands established by planting and/or seeding in the process of afforestation or reforestation. They are composed either of introduced species (all planted stands) or intensively managed stands of indigenous species, which meet all the following criteria: one or two tree species planted, even age class, regular spacing.
4. Forest along riverside: agricultural land temporarily (up to 15 years) not being used for crops or pasture located along or nearby a river.

Each time we interviewed hunters and household members we reconfirmed these categories. To ensure the process of interviewing was consistent, the following procedures were used to conduct meetings.

1. Regular meetings: after the interview session every night the research team met to discuss results of the interviews and learn any lessons for future interview sessions.
2. Weekly meetings: every week we met to discuss the progress of our work and assess merits and problems of approaches and responses from hunters and household members.

2.4 Data collection

Data was collected through four survey instruments — hunting surveys from 220 focus respondents; village surveys (800 respondents); village socio-economic surveys (11 villages); household surveys (696 respondents) — and 387 individual

hunting trips. All questionnaire data that could be quantified were entered into a database and analysed using log-linear models following León and Montiel (2008) in S+ package for analysis of biological data (Jones et al., 2012). Log-linear models are concerned with the analysis of cross-classified data and they allow analysis of the relationship between two or more categorical variables.

The log-linear model is a specialised case of generalised linear models for Poisson-distributed data. Log-linear analysis is an extension of the two-way contingency table where the conditional relationship between two or more discrete, categorical variables is analysed through single summary statistics. Models can handle more complicated situation and analyse the simultaneous effects of multiple variables, including mixtures of categorical and continuous variables.

2.4.1 Hunting surveys

In each of the 11 villages, our team approached the village chairman to provide orientation to the study and request permission to conduct the work. In addition, we asked the village chairman or village secretary to identify 20 hunters as focus respondents and those who were active hunters in each village (Kaltenborn et al., 2005). This approach was also applied for all other interview processes during the study. See Appendix A for full list of questions.

2.4.1.1 *Focused respondent surveys*

Information about hunting was gathered through interviews with 220 hunters (focus respondents; 20 hunters in each of the 11 villages). They were interviewed using the Wildlife Conservation Society hunting questionnaire (Rao et al., 2005) in Indonesian language by me as well as trained students from UNIPA (see section 2.3.7).

Hunters were interviewed to obtain data on the dynamics of hunting including hunting frequency, techniques and participation. More specifically, hunters were asked their reasons for hunting, time of start and end of hunt, frequency, number of hunters participating, weapons, spears and traps used, numbers and species of animal hunted, use of the hunted animal, hunting areas and distance from the village (see Rao et al., 2005; Franzen, 2006). Information on individual hunters was gathered to obtain a

detailed picture of hunting excursions and personal information about each hunter such as occupation and purpose of hunting (Noss, 1998; Rao et al., 2005; Smith, 2005).

We only recorded the major hunting purpose; if hunters had multiple reasons for hunting, we asked which was the main reason and this was recorded as the purpose of hunting. Similarly, we only recorded prey species that were brought home on the last hunting excursion (within three weeks) prior to the interviews. Hunters might have killed smaller things but ate them or gave them to their relatives along the way and thus did not bring them home. This may bias our data. Thus, to reduce the bias, information from interviews was further clarified with collaborating hunters.

To clarify the results from interview, three collaborative hunters from each village were recruited and trained to complete an information sheet for each hunting trip. This information included whether or not they were successful, and if so, how many individuals per species were killed and their common names (after Carpaneto & Fusari, 2000; Fusari & Carpaneto, 2006). The information was triangulated by having informal discussions and interviewing key respondents such as elders and community leaders during that time, so we had similar information from each collaborating hunter.

2.4.1.2 *Community hunting surveys*

In order to gain an overall picture of hunting from different tribes and clans with different occupational backgrounds in the sampled villages, one hundred questionnaires consisting of seven multiple choice questions were distributed to random respondents excluding the 20 “focus respondents” in each of the 11 villages. Eight hundred questionnaires were returned for further analysis. See Appendix B for full list of questions.

2.4.1.3 *Accompanied hunts*

Data about hunting effort were collected from different respondents. Results from interviews with 220 focus respondents (see section 2.4.1) were used to gain information on harvest rates, average time spent in hunting and average distance to the hunting sites. To cross-check the results from interviews, we accompanied hunters to their hunting grounds. This was important to verify the distance that hunters travelled from the villages to their hunting sites and we recorded hunting takes from each of the

hunting excursions. Team members accompanied hunters on a total of 387 hunting trips. We also used the opportunity presented by site visits to confirm results from interviews related to hunting tenure, hunter behaviour and hunter effort. A GPS was used to record the location of hunting camps and hunting sites. We recorded the numbers of individual prey species killed, including when there was no catch from the excursion (i.e. zeroes were recorded), to determine harvest rates.

2.4.2 Village socio-economic surveys

We interviewed village and local government officials and held informal meetings to obtain economic data and an overview of village conditions as per Chambers' 1984 and 1994 survey methods. A modified Poverty and Environment Network (PEN) questionnaire (Centre for International Forestry Research, 2007) was used to identify the socio-economic status of the households, including information on (1) personal profiles of household size, levels of education, occupations and income and (2) ownership of houses, land, and livestock (Lee, 2000; Kaltenborn et al., 2005). See Appendix C for a full list of questions.

2.4.3 Household surveys

The qualitative importance of wild meat to rural populations was determined using data obtained from focused respondent surveys (section 2.4.1.1). Direct observation of household food consumption was also made by random visits to sample households within each village during the period of time that researchers were resident.

We recorded animal protein, diets and the composition of diets in four categories: (1) meals containing wild meat, (2) meals containing fish, (3) meals containing livestock meat, and other animal protein such as eggs and purchased tinned meat and (4) meals containing vegetables and noodles (after Bennett et al., 2000; Rao et al., 2005). See Appendix D for a full list of questions.

Household meal surveys were conducted to determine the level of consumption of wild meat and other food items (e.g. fish, meats, eggs, canned meat and vegetables including noodles). The surveys consisted of interviews with those responsible for food preparation in the household. Recordings that could not be made within 48 hours of consumption were omitted. People were asked about the kinds of meals that were

served each day and how often per week those meals were consumed. This information provides an indication of the amount of meat consumed by households.

Chapter 3 Human populations, hunting practices and rural livelihoods

Figure 3.1: A local market provides daily needs for the community in Saukorem in Amberbaken District. The market operates two days a week (Tuesday and Thursday) and provides village women the opportunity to earn income by selling products from their garden (areca nuts, betel, tomato, chili, vegetables) and homemade bread for local consumption

.

3.1 Introduction

Human populations in tropical forest countries are growing rapidly by an average 1.52% p.a. in Latin America, 1.65% in Asia and 2.66% in Africa (Bennett 2002). Increased hunting pressure results from growth in demand for wild meat following increases in the human population (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005).

Several studies have linked hunting pressure to the density of human populations living in forest areas (Robinson & Bennett, 2000; Bennett, 2002). This chapter considers the importance of human population density by comparing hunting practices across villages in areas with high and low population densities. This chapter also further assesses the link between human population, hunting practices and sources of livelihood.

3.1.1 The world's human population

The current world population of 7.2 billion is projected to increase by 1 billion over the next 12 years and reach 9.6 billion by 2050. Most of that growth will be in developing countries, with more than half in Africa (United Nations News Centre, 2013). It was not until the early 19th century that the world population reached its first big milestone: 1 billion people (World Population Review, 2013). Then, as the industrial revolution took hold and living standards improved the rate of population growth increased considerably. Over the past 100 years, the planet's population has more than tripled in size. This massive increase in human population is largely due to improvements in diet, sanitation and medicine, especially compulsory vaccination against many diseases (World Population Review, 2013). These improvements may impact the population density that leads to increase the demand of wild meat, especially in tropical forests (Milner-Gulland et al., 2003). Robinson and Bennett (2000) demonstrated that if wild meat is the sole source of protein, tropical forest can support protein needs sustainably at human densities of approximately one person/km^2, but above that level it rapidly becomes unsustainable.

3.1.2 Threats to natural resources

Humans benefit from wild nature in many ways: aesthetically and culturally; via the provision of ecological services such as climate regulation, soil formation and nutrient cycling; and from the direct harvest of wild species for food, fibres and pharmaceuticals (Balmford et al., 2010). As human populations and their consumption increase, basic resources are depleted; this leads to environmental degradation (Durham, 1992). Currently, natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines affect many areas (Steffen et al., 2015). This excessive human population should signal a call for action concerning resource use and management. For example, the food availability worldwide is becoming critical.

There are growing concerns about continued rapid growth in population size and the deterioration of natural resources and the environment caused by human numbers and activities (Ehrlich & Ehrlich, 1990; Holdren, 1992). The Food and Agriculture Organization (FAO) estimates a 70% increase in food production is needed to feed a projected population of 9.1 billion people by 2050 (FAO, 2009). Further to this estimation, Kullander (2010) explained that about 1 billion people are chronically undernourished; for them, food security is still far away. The question is whether agriculture can provide sufficient edible biomass for food for an expanding world population.

3.1.3 Human population: increasing hunting pressure

The requirement for an animal protein source to meet human population growth in some tropical areas is an important factor impacting the exploitation of wildlife. The rapid growth of human populations has played a significant role in increasing hunting pressure in tropical forests (Robinson & Bennett, 2000). Furthermore, different sets of factors such as the failure of national and regional economies to provide market access and support for alternative livelihoods (Figure 3.1), also drive rural people to hunt (Ling et al., 2002). Hunting pressure has often been associated with the boost in demand for wild meat, along with the increase in the human population (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005).

Hunting cannot be sustainable if the harvest of wildlife resources constantly exceeds the maximum sustainable offtakes (Robinson & Bennett, 2000). Increasing harvest rates above this level threatens wildlife populations and affects long-term protein sources for local communities. Alternative protein from marine sources and from increases in livestock and aquaculture production can greatly lessen the consumption of bushmeat (Rowcliffe et al., 2005).

3.1.4 Hunting and other household livelihoods

As the human population increases, the need for a food supply for the family also increases and people take advantage of hunting activities (Ntiamoa-Baidu, 1997). Previous studies have shown that hunting is often an "alternative" activity. Most hunters work full time on other jobs and hunt on a part-time basis (Ntiamoa-Baidu, 1997; Mendelson et al., 2003; Naranjo et al., 2004). In Ghana, for example, commercial hunters work full time and rely on selling bushmeat as their primary source of income. Farmer-hunters, however, hunt part-time to supplement cash crop incomes (Mendelson et al., 2003). Similarly, in Latin America, a hunter may also be a farmer, a smallholder, a settler, a farm worker, a fisherman or a miner. Workers derived their major income from full-time occupations and did part-time jobs to gain extra income for the household. They combine their formal and informal occupations to gain extra income because they are very poor (Stearman, 2002; Naranjo et al., 2004).

Hunting plays an important role as a source of cash for households living in extreme poverty with per capita income of less than $1 per day during lean agricultural seasons (Shively, 1997; Mendelson et al., 2003; Hilaluddin et al., 2005). Hunting income also contributes significantly to payment of local taxes (Loiboki et al., 2002).

3.1.5 Hunting and population in West Papua

The central statistics agency of Indonesia placed West Papua in the top five provinces for population growth rate within Indonesia. Between 2000 and 2010, the growth rate in West Papua was 3.71% p.a. (Badan Pusat Statistik Indonesia, 2014) an exceptionally high figure by world standards.

Human population varies among the coast villages in West Papua, and will likely grow. The migration rate from other parts of Indonesia has increased over

time.The number of people who migrated into West Papua between 1971 and 2000 reached 718,866, or about 47% of the total population of the province in the 2010 census (Badan Pusat Statistik Papua Barat, 2011). I investigated the importance of population density and hence the long-term effects of the increase in population by comparing hunting practices across villages in areas with high and low population densities and the link between hunting, human population and source of livelihoods.

This study fills a number of gaps in our knowledge. Specifically, I assess the effect of human population on subsistence hunting. As the human population density dependent on subsistence hunting increases, the demand for wildmeat will increase, increasing hunting pressure.

3.2 Methods

The study site is situated on the Bird's Head Peninsula of Papua between Manokwari and Sorong in the Tambrau Regency (see section 2.3.4 for description). Seven villages (Waibem, Saubeba, Imbuan, Wefiani, Wau, Warmandi and Samfarmun) were selected with no road access and four villages (Wasarak, Saukorem, Wekari and Arupi) with road access (Figure 2.9).

In each village we collected information on hunting practices from 220 focus respondents (section 2.4.1.1) and 800 community surveys (section 2.4.1.2), hunting effort and harvest rates from 220 respondents (section 2.4.1.1).We confirmed the results by accompanying hunters in 387 hunting excursions (section 2.4.1.3) and investigated consumption patterns by conducting random visits to 696 households to observe the types of meals consumed in a visit and to ask how often within a week those meals were consumed (section 2.4.3).

In this chapter I used log-linear analysis after León and Montiel (2008) in the S^+ package (Jones et al., 2012) to examine the effect of human population density on response variables including hunting practices, hunting effort, harvest rates and consumption patterns among respondents in the study sites. Does population density affect practices in hunting, effort, harvest rates and consumption patterns?

3.2.1 Hunting practices and livelihood activities

Data on hunting practices were: reasons for hunting, hunting frequency, hunting techniques, hunting tenure, group size in hunting and hunting takes from the last trips (three weeks prior to the interviews). For details of the statistical methods and response variables for the log-linear analysis of hunting strategies and detailed methods used for the data collection, see section 2.4.1 and Table 3.1.

3.2.2 Socio-economic survey

Data on the socio-economic background of the respondents was obtained from interviews with focus respondents (N = 220) (section 2.4.2). Other relevant information including trading dependence and trading place were gathered from both focused and community surveys. The response variables are described in Table 3.1.

Table 3.1: Response variables for the log-linear analysis of the impact of population density on socio-economic status of the respondents

Variables	n	Type	No. of categories	Categories (units)
Age	1020	Continuous		(Years)
Gender	1020	Categorical	2	Male; female
Education level	1020	Categorical	3	Tertiary; secondary; primary
Occupations	1020	Categorical	6	Farmer; government staff; wage labour; fisherman; student; forest gatherer
Household size	1020	Continuous		Number of individuals
Monthly income	220	Continuous		Amount of money (IDR)
Land ownership	220	Continuous		Width of land (m^2)

3.2.3 The demand for wild meat along the coast

The contribution of wild meat to household consumption was also identified with regards to variation in population size across the villages. More specifically, we extended our study to gain a better understanding of consumption among the villages with high and low populations along the coast of the Bird's Head Peninsula (section 2.2.3).

Harvest rate

We used seven months of intensive data from 33 focal hunters (Section 2.4.1.1) to determine the importance of wild meat to household livelihoods (Table 3.2).

Table 3.2: Response variables for log-linear analysis of harvest rates from 33 focal hunters during the seven-month observation periods

Variables	N	Type	No. of categories	Categories/units
Number of catches	33	Continuous		Individual animals
Individuals per species	33	Categorical	3	Deer; pig; native species
Take per month	33	Continuous		Number of individuals/month

3.3 Results

3.3.1 Socio-demographic background and livelihoods

3.3.1.1 *Socio-demographic background of the respondents*

Hunters ranged in age between 16 and 76 years. Of the hunters interviewed, 1.56% were below 20, 68% were 20–40 years old, 28% were 40–60 and 1.17% above 60. Most of the respondents (66%) had completed primary school, 32% completed secondary school and 2% had diplomas or had attended a tertiary education. On average, the households in the study sites had four family members. Hunters also kept livestock such as chickens, goats and pigs. Almost all households (94%) were connected to subsidized electricity, with supply from 6pm to 12pm.

3.3.1.2 *Livelihood activities*

A number of subsistence activities including shifting cultivation, cultivation of trees and palms, smallholder husbandry (pigs, goats and chickens), fishing and hunting were practiced by households along the coast. In this study, hunting was not generally a primary source of income. Most hunters worked full time on another job, e.g. farmers, fishermen, government staff, paid labour (as mining and conservation workers) and students who hunt part-time to gain extra income (Table 3.3). They hunted during leisure time, time off from their jobs, or after planting and harvest for farmers. Despite

the coastal location of the study villages, the majority of respondents in this study were farmers, thus they only hunted on a part-time basis.

Table 3.3: Major occupations of respondents in the studied villages

Village category	Population	Occupation					
		Farmer	Civil servant	Paid labour	Fisherman	Student	Forest gatherer
High-density villages							
Waibem	200	62	6	11	2	9	0
Saubeba	195	68	3	9	8	7	0
Wefiani	444	63	7	6	12	11	1
Samfarmun	105	55	1	6	7	5	1
Imbuan	284	75	4	6	11	8	3
Saukorem	495	72	8	3	10	10	2
Wasarak	524	113	10	5	9	6	2
Sub-total		508	39	46	59	56	9
Low-density villages							
Wau	132	49	5	10	8	11	0
Warmandi	86	31	4	8	5	2	0
Arupi	212	55	3	9	1	12	5
Wekari	210	61	4	6	2	9	3
Sub-total		196	16	33	16	34	8

People were mostly reliant on agriculture for their livelihoods and own different sizes of crop land (coconut, cacao, banana, peanuts, tuber crops, areca nuts, betel and vegetables) from 250 to 10,000 m^2. They categorised themselves as farmer-hunters who work part-time and hunt for cash to supplement cash crop incomes.

Monthly income varied among households, although it was not solely obtained from agriculture. Hunters in the villages with high populations had median monthly income of IDR 1,300,000 (US$99), significantly higher than those across the villages with low populations who had median monthly income of IDR 1,100,000 (US$84) (Kruskal-Wallis test $\chi^2 = 7.93$, df = 1, $P < 0.004$).

From Monday to Friday, hunters were committed to their main jobs but hunted on weekends to gain extra cash. We had no data on the amount of time devoted to other household activities, but on average, hunters in the villages with high human populations spent (11 ± 3.27 (SD) hours, N = 120) hunting, similar to those in the

villages with low human populations at (10.55 ± 3.56 hours, N = 100), (log-linear test χ^2 = 0.34, df = 1, P = 0.55). The amount of crop land (m^2) owned by hunters influenced the time hunters spent in hunting (Table 3.4; t = 9.94, df = 219, P = 0), with larger land ownership associated with decreasing hunting time.

Table 3.4: Maximum land ownership and time spent hunting by focus hunters in the sampled villages

Land size category (m^2)	Maximum ownership (m^2)	Maximum time spent hunting (hours)
< 5,000	5,000	20
5,001–10,000	10,000	17
>10,000	50,000	14

3.3.2 Why do people hunt?

The reasons for hunting were similar between villages with high and low population density: for food, sale and other purposes. In villages with high population density hunting was mostly for household consumption (51%) compared to 46% in the low population density villages (Figure 3.2; log-linear test χ^2 = 149.18, df = 1, P < 0.0001). Those who hunted to supply market demand for wild meat were similar at 43% and 44% in the villages with high and low populations respectively.

Figure 3.2: Percentage of hunters hunting for consumption, trade or other purposes. N = 642 responses from six villages with high population density and N = 378 responses from five villages with low population density; $\chi 2 = 149.18$, df = 1, $p < 0.0001$

3.3.2.1 *Hunting techniques*

Several hunting techniques were used and typically hunters used more than one technique on hunting excursions. More hunters practiced active hunting techniques (such as using bows and arrows, spears, machetes and guns) in the villages with high populations (Figure 3.3; log-linear test, $\chi^2 = 136.23$, df = 1, $P < 0.0001$). In villages with low population, the use of active and passive techniques was similar at 75%.

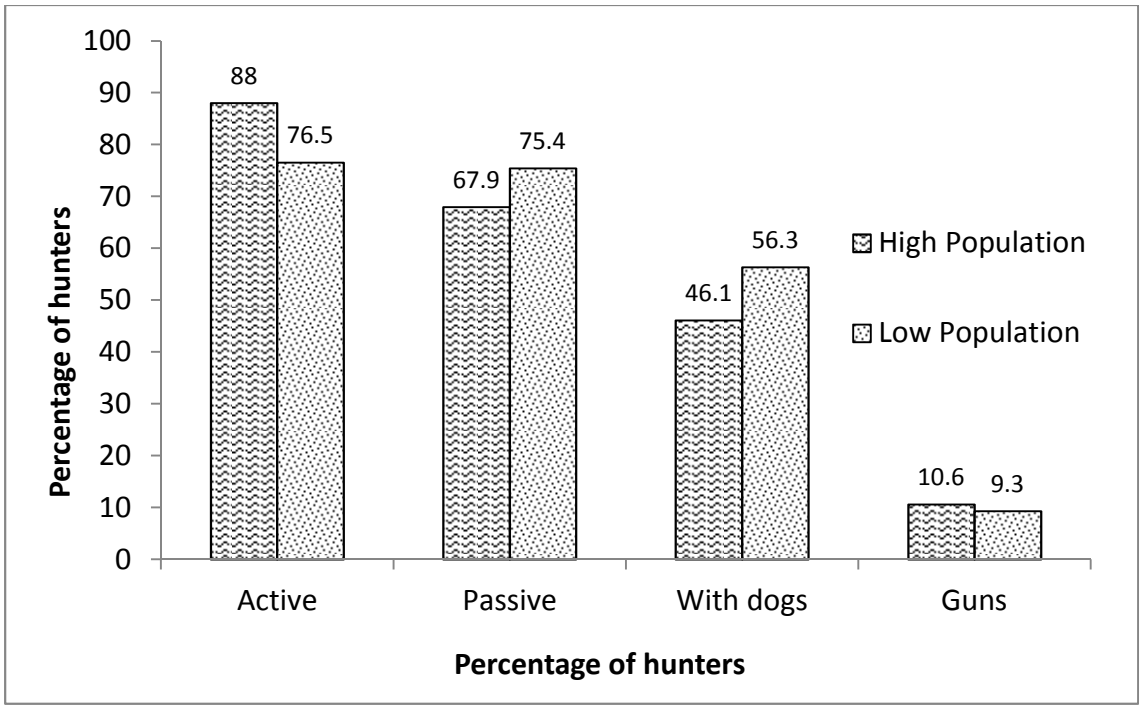


Figure 3.3: Percentage of hunters employing different hunting techniques in villages with high and low population density. Percentages do not add to 100 because typically hunters used more than one technique, $\chi 2 = 136.23$, df = 1, $p < 0.0001$. Dogs and guns are active techniques, but are separated for analysis.

3.3.2.2 *Hunting tenure*

Most of the harvest was made in primary forests (73.4% and 67.5% within villages with high or low populations respectively; Figure 3.4; log-linear test, $\chi^2 = 108.77$, df = 1, $P < 0.0001$), although hunters from villages with a low population hunted more in other tenures (secondary forests, riversides and crop lands).

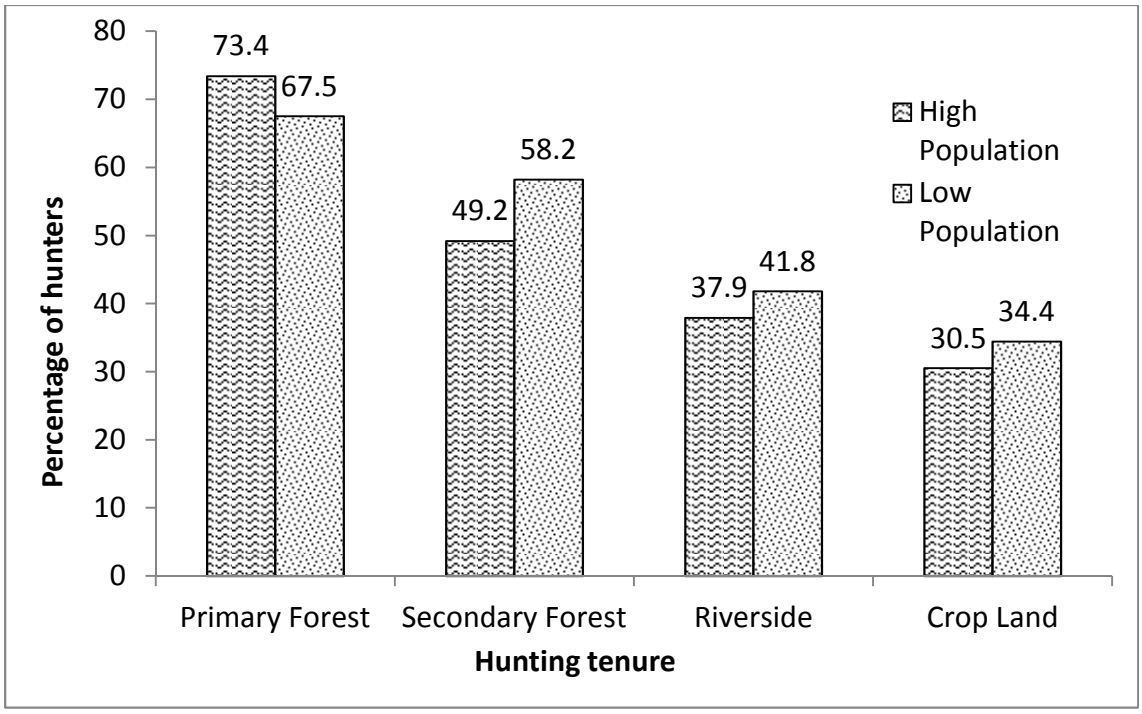


Figure 3.4: Percentage of hunters hunting in different types of land use by high and low population density. Percentages do not add to 100 because hunting was conducted in two or more locations, $\chi 2 = 48.95$, df = 1, $p < 0.0001$

3.3.2.3 *Hunting effort*

In villages with higher populations, the average distance hunters travelled was smaller (4,000 ± 1,651 m, N = 215) than hunters in villages with low human population at (4,458 ± 2,398 m, N = 172) (Figure 3.5; log-linear test $\chi^2 = 5.72$, df = 1, P = 0.01).

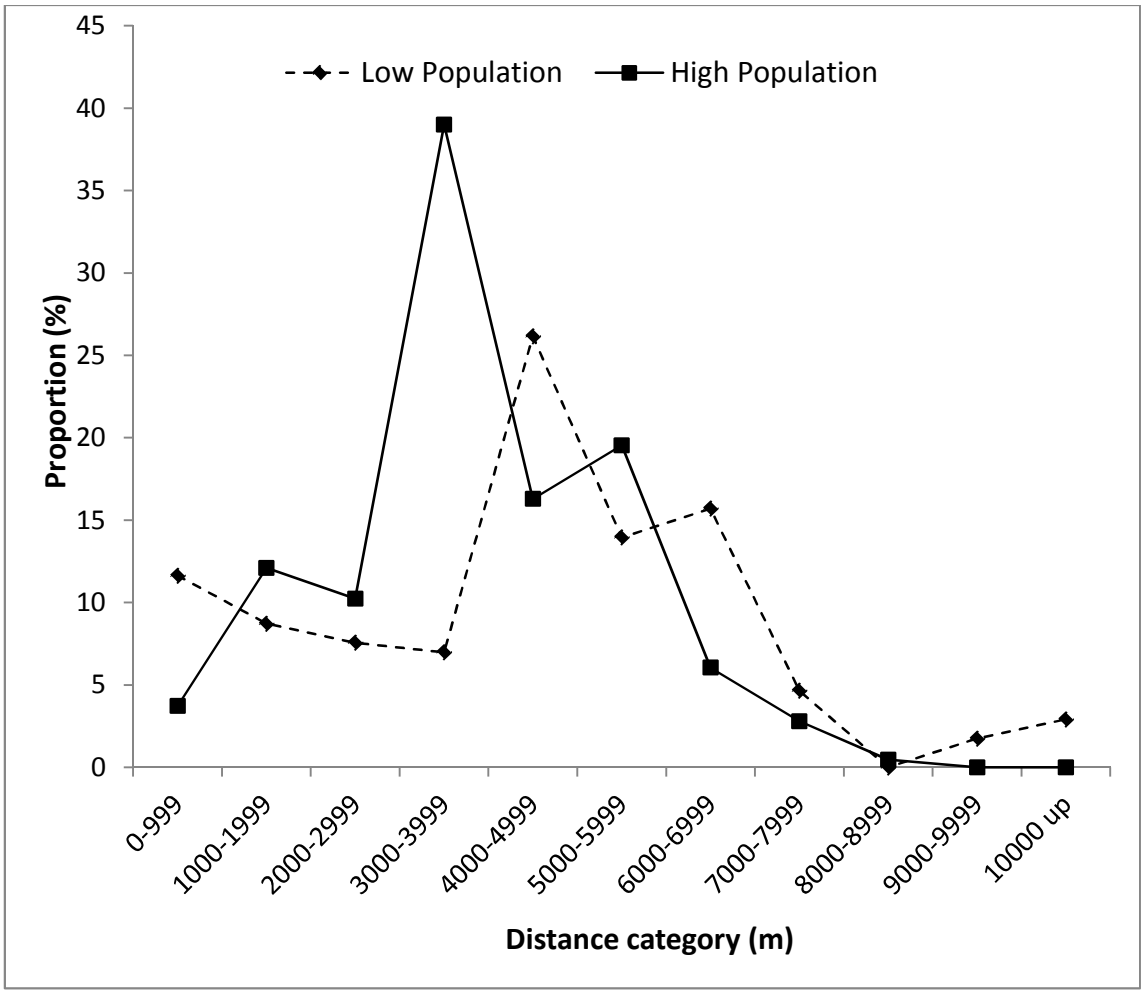


Figure 3.5: Distances hunters travelled to hunting sites from villages with high and low population density (N = 215 for high-density and N = 172 for low-density villages)

3.3.2.4 *Hunting yield and its value*

The harvest from 33 focal hunters during seven months of observations confirmed the results of the broader interviews. The total reported harvest was 301 animals, annual offtake was 516 animals (Table 3.5), and hunting returns did not differ between villages with high and low populations (log-linear test, $\chi^2 = 0.83$, df = 1, P > 0.5).

Throughout the observed period a total 11,475 kg of dressed weight of deer and wild pig were harvested. The local price per kilogram was IDR 25,000 (US$ 1.89) for venison and IDR 15,000 (US$1.13) for pork. The hunting take was valued at IDR 230,625,000 (US$ 17,435) in total, an average of US$ 473.76 (N = 18) in the high-

density villages and US$ 593.86 (N = 15) in the low-density villages (t = -0.55, df = 1.50, P > 0.5).

Table 3.5: Seven-month hunting yield reported by 33 collaborating hunters in study villages

Scientific name	Common name	Average weight (kg)[1]	Total individuals	Annual offtake[2]	Dressed weight (kg)[3]	Average price/kg (IDR)
Rusa timorensis[4]	Timor deer	65	150	257	5850	25,000
Sus scrofa[4]	Wild pig	75	125	214	5625	15,000
Thylogale brunii[4]	Dusky pademelon	4	9	15	21.6	-
Dendrolagus inustus[4]	Grizzled tree kangaroo	12	7	12	50.4	-
Spilocuscus maculatus[4]	Common spotted cuscus	4.5	10	17	27	-
Total			301	516	11,574	230,625,000

[1]Data provided by hunters and from Flannery, 1995
[2]Average catch per month is extrapolated to obtain annual offtake
[3]Dressed weights harvested (the weight of an animal after eviscerating, weight loss of 40%, see Auzel and Wilkie, 2000; Albrechtsen et al., 2006)
[4]Hunting take during seven-month survey period. Note that this does not include all species reported as hunted in Table 4.5, but only those taken during the 7-month survey

3.3.2.5 *Hunters and population*

In this study there was a strong linear relationship between number of hunters and village population (Figure 3.6; $F_{1, 9} = 19.02$, $P < 0.001$).

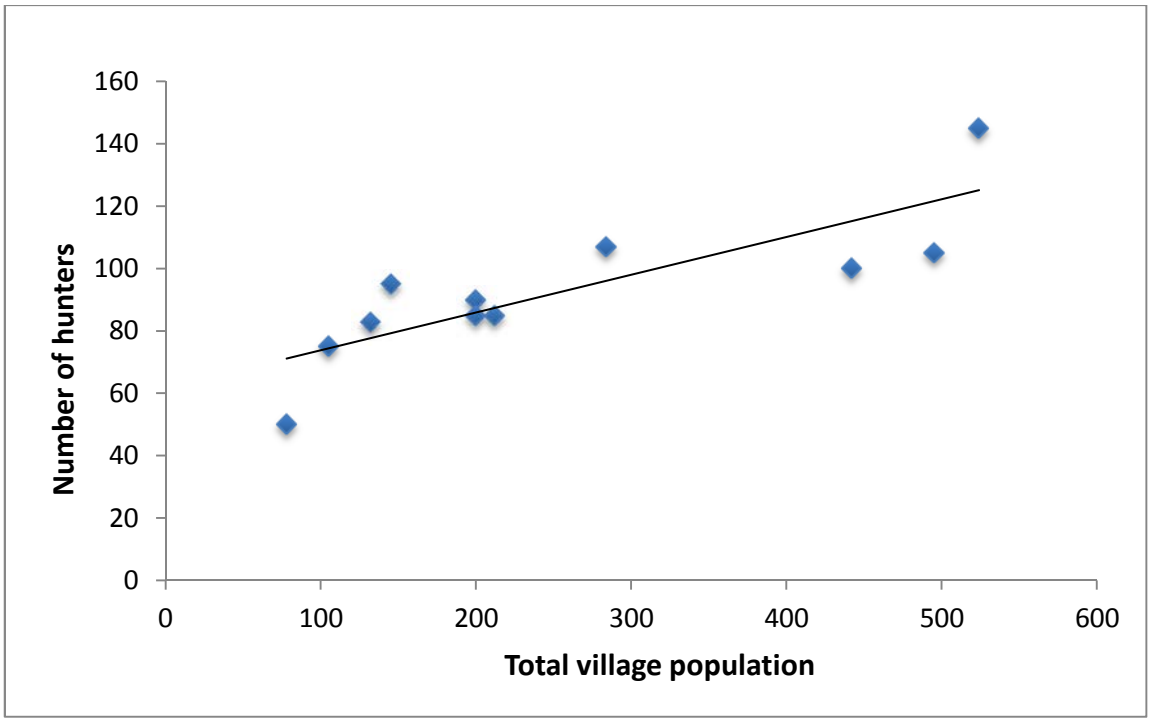


Figure 3.6: The relationship between village population (adults of both sexes) and number of hunters living in that village in the study area (y = 0.1211x +61.704 R2 = 0.68; F1, 9 = 19.02, p < 0.001)

As expected from the relationship between number of hunters and population there is also a strong linear relationship between number of hunters and population density (Figure 3.7; $F_{1,9} = 34.07$, P < 0.001).

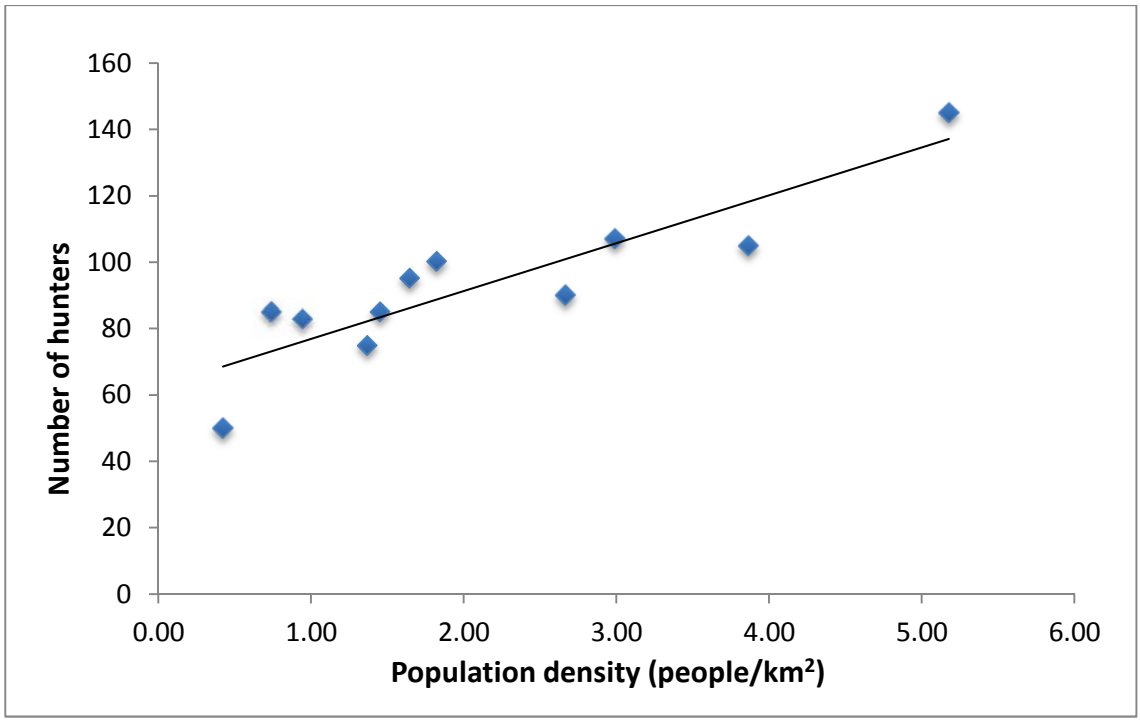


Figure 3.7: The relationship between the number of hunters per village and population density in the study area (y = 14.426x +62.415 R2 = 0.79; F1, 9 = 34.07, p < 0.001)

This study also found a strong linear relationship between percentage of hunters and village population (Figure 3.8; $F_{1,9} = 44.07$, P < 0.0001).

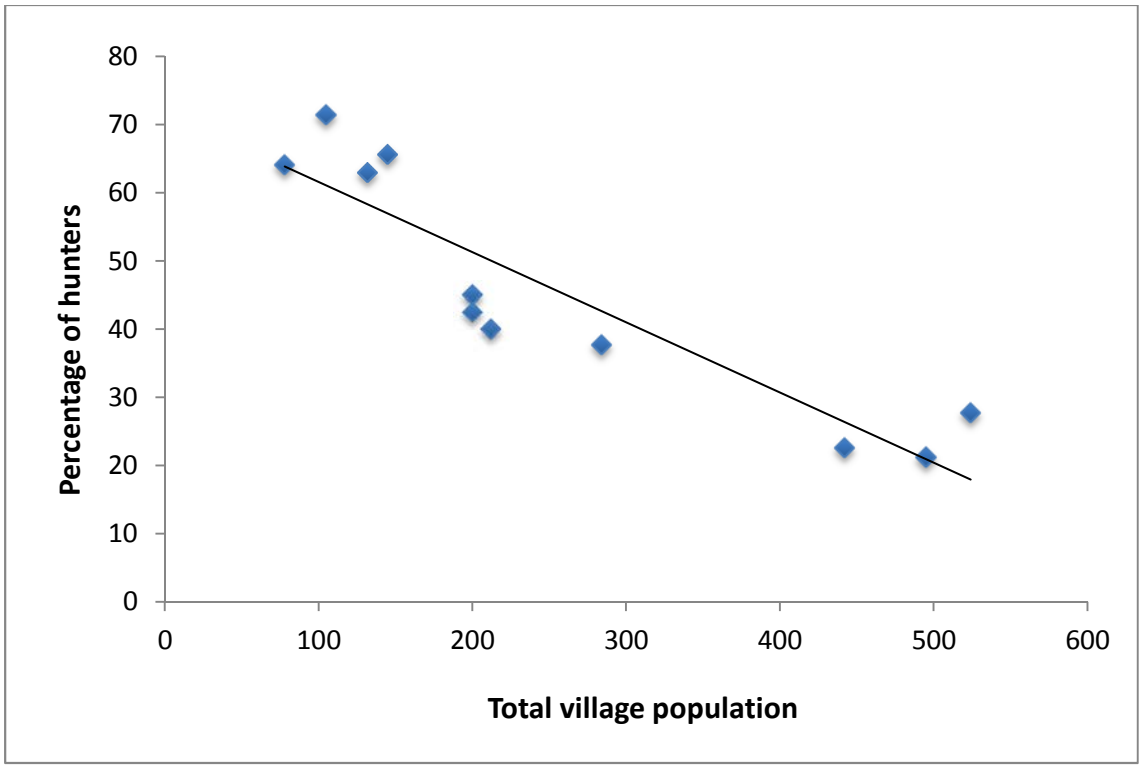


Figure 3.8: The relationship between village population (adults of both sexes) and the percentage of hunters living in that village in the study area (y = -0.103x +71.887 R2 = 0.8304; F1, 9 = 44.07, p < 0.0001)

3.3.3 The contribution of wild meat to household consumption

Half of the respondents hunted to obtain meat to fulfil household consumption (section 3.3.2) and 40% of respondents had wild meat in their meals. The consumption of livestock products in villages with both high and low populations was almost the same, about 11% and 12% respectively. Meals based on fish and vegetables were mostly consumed in household of villages with high human population density (Figure 3.9; log-linear test $\chi^2 = 88.85$, df = 1, P < 0.0001).

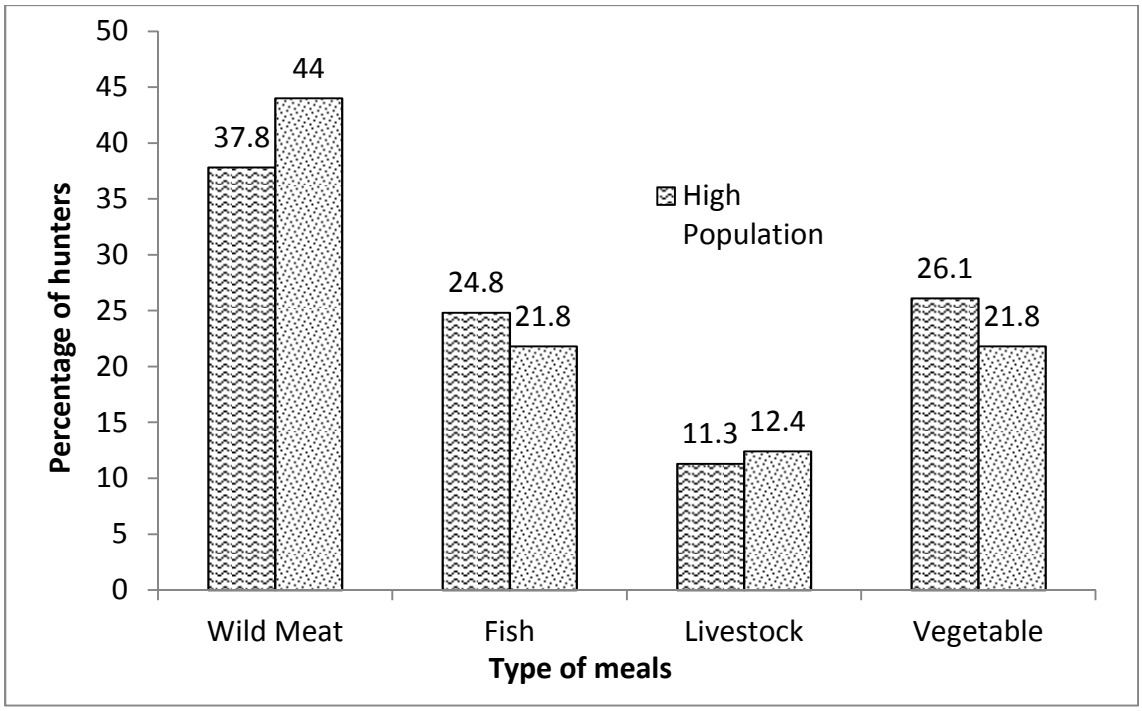


Figure 3.9: Household meal components in villages with high (N = 471) or low (N = 225) populations, log-linear $\chi 2 = 88.85$, df = 1, $p < 0.0001$

3.4 Discussion

3.4.1 Hunting as a source of livelihood

In this study, coastal inhabitants derived income and sustained their livelihoods from a variety of sources, among which agricultural crops played a significant role as the primary source of income (Table 3.4), but engaged in hunting during lean agriculture seasons for an alternative income. In doing so, they shifted intermittently between major and temporary occupations for cash to supplement crop-related incomes.

Limited access markets to sell their agricultural harvest creates difficulty for farmers to create income to support their households. As in this study, rural farmers in other tropical regions derive an alternative source of income by hunting part-time. According to Nasi et al. (2008), many people in south-east Asia do not depend on wildlife resources as a full-time source of food and income, but as a buffer to see them through times of hardship (e.g. unemployment, illness of relatives, crop failure), or to gain additional income for special needs (school fees, festivals, funerals).

The same applies in Africa, where only very few people hunt as their sole occupation; most hunters work full time on another job, e.g. as farmers or artisans, and only hunt on a part-time basis (Ntiamoa-Baidu, 1997). Similarly, Noss (1998) found that most snare hunters in Central Africa shifted intermittently between formal and informal occupations that included hunting, fishing, diamond mining, farming and logging. In Latin America, a subsistence hunter will commonly also be a farmer, a smallholder, a settler, a farm worker, a fisherman, a miner, etc., and they are classified as part-time hunters (Mendelson et al., 2003).

Our data also suggests that there were no strictly commercial hunters at our study sites; however, the tendency to sell meat from hunting at market gave a strong signal that hunters took advantage of the market demand for wild meat along the coast. Difficulties in marketing their agricultural products (Figure 3.10) and low prices compel part-time hunters to gain extra income from trading wild meat. Compared to other products, wildlife products are valuable commodities as the price-to-weight ratio of wild meat is typically higher than for any agricultural crops (Milner-Gulland et al., 2003; Nasi et al., 2008; Williamson, 2002).

Figure 3.10: Vegetables (a), taro and betel nut (b) sold in the Amberbaken market that operates two days a week. Women from the nearest villages Wekari, Wasarak and Wefiani brought products from their garden to the market in Saukorem

The main reason for hunting is to provide food for household consumption but hunting for trading is also important. Forty percent of interviewees declared that they hunted mainly for trading purposes. Although there is no formal market for wildlife products, the sale of wild meat to traders provides cash to hunters. A survey by the

Conservation International Indonesia Program indicated that several bird species and wild-caught products such as antler and deer jerky were formally traded in traditional markets in Manokwari and Jayapura (Suryadi et al., 2004).

3.4.2 Age and gender of hunters

The youngest participant in this study was 16 and the oldest was 76 years (Figure 3.11). Our data showed that the extreme top and bottom age classes only accounted for 5% of hunters with the majority of hunters aged between 20 and 60 years old.

Children were involved in hunting from early ages. They generally join their parents after school, and all family members work in their garden. They also work to transport vegetables, tuber crops and other garden products for their meals back to the villages. While working in the garden women and children took the opportunity to hunt small prey such as bandicoots (Figure 3.12) or birds.

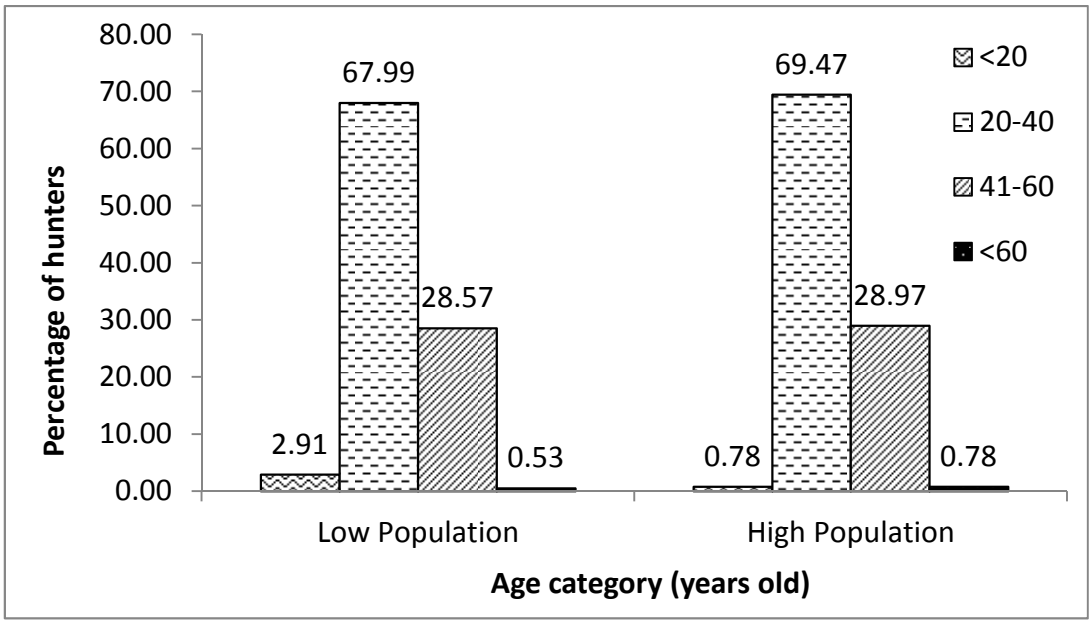


Figure 3.11: Ages of hunter respondents in low- (N = 378) and high-population (N = 642) villages

Figure 3.12: Child with a bandicoot captured during gardening

In Arunachal Pradesh, India, people begin hunting from the age of 10–12 years and most continue hunting while their health permits. However, most hunters were in the middle age classes, with 53% of hunter respondents between 40 and 60 years old and 43% between 20 and 40 years old (Aiyadurai et al., 2010).

The involvement of children and women in hunting during this study was largely opportunistic. Opportunistic hunting mostly occurred during work on farms and in this study, 20% of hunter respondents were women (see section 4.3.1 for detail information). Consequently, although they did not kill large animals, captures brought home by women and children were a significant contribution to family consumption.

Hunting success was 96%; women accounted for 1% of unsuccessful trips, compared to 3% of men (Figure 3.13). Hunting success was influnced by the techniques used in hunting, hunting target, hunting tenure and activities women were involved. Section 4.4.1.2 provides more detail explanation on women involvement.

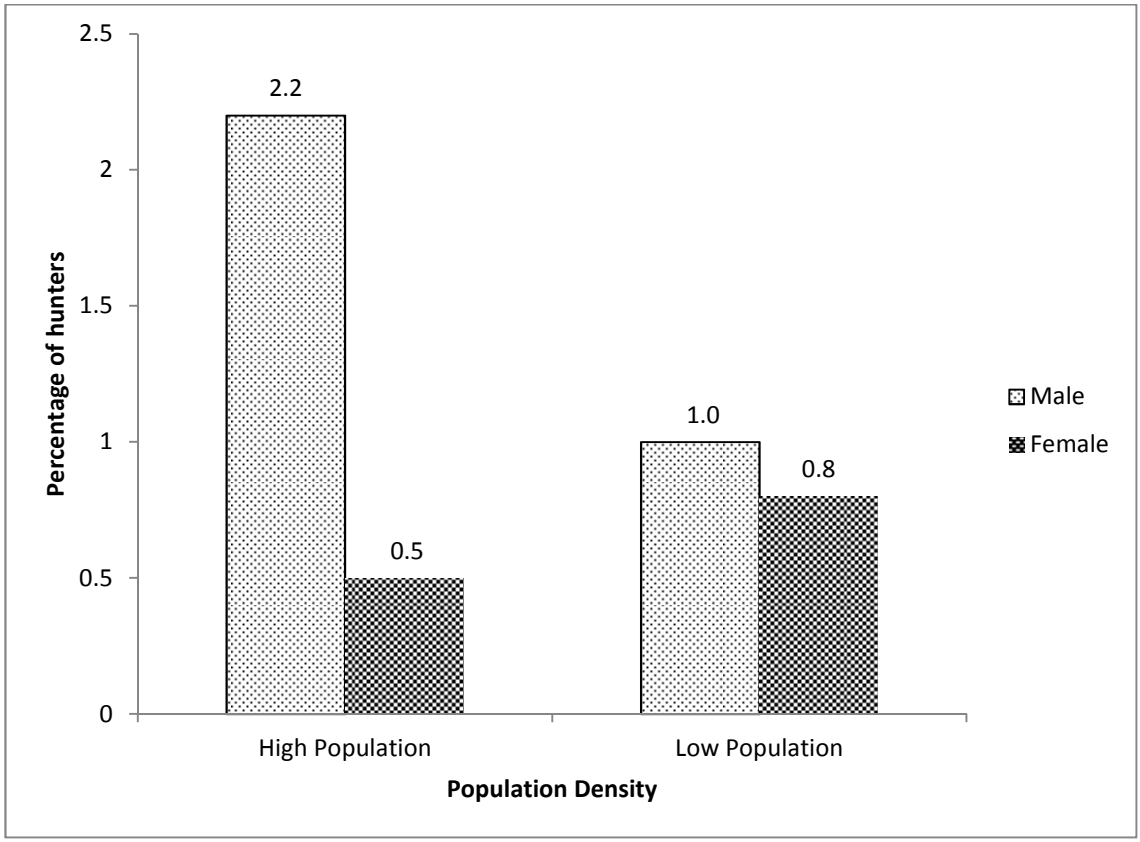


Figure 3.13: Unsuccessful hunting by gender in villages with high or low population density

3.4.3 From subsistence-based to market-based hunting

Livelihood options are increasingly market-based rather than forest- or subsistence-based (Rigg 2006). In reality, rural people who move from a subsistence lifestyle to a cash economy have relatively few options for generating income. They can sell agricultural or pastoral produce, work for a cash wage in agriculture or industry, or sell retail goods in local or regional markets (Table 3.3). However, for those without access to capital, land or livestock, the harvest of wildlife resources may offer the best return for effort in household livelihoods (Nasi et al., 2008). This study found that, economically, both subsistence and commercial hunting were more common along the coastal area of Bird's Head Peninsula than cultural hunting or hunting to reduce damage to crops.

The species caught during the study were similar across the villages and were dominated by deer and wild pig (Table 3.5). This indicates the importance of both species for trading and consumption (see also section 4.4.1.2). Spiny bandicoot, northern cassowary, Papuan hornbill and Pinon's imperial pigeon were not recorded during the study and hunters acknowledged that they focused on particular species that contributed significantly to household livelihoods for both trading and consumption.

The people we studied were mainly hunting introduced species in degraded habitats and there was little evidence of hunting of native species or those of conservation concern (Pattiselanno & Koibur, 2008; Pattiselanno & Arobaya, 2013). Our data recorded only 26 individuals of native species or 9% of the catch were brought home during the seven months of observation (Table 3.5). This may be because native species are more susceptible to hunting and have already experienced severe population declines, or that the larger, introduced species are strongly preferred. In addition to responding to biophysical changes such as road access, forest conversion and demographic changes, wildlife communities (e.g. species composition including native species and relative abundance) are also changing within the new landscapes (Fitzherbert et al., 2008). Overall, our survey suggests that hunting is not exerting pressure on native species.

Average yield per month varies between 3 and 6 animals while offtake per hunter was between 7 and 14 animals (Table 3.6).

Table 3.6: Monthly yield and offtake per hunter reported by 33 collaborating hunters in study villages

Village	Category	Month							Tot	Av	Offtake per hunter
		Jul	Aug	Sep	Oct	Nov	Dec	Jan			
Waibem	High	3	2	5	3	2	3	3	21	3.00	7.00
Saubeba	High	3	5	3	3	2	7	3	26	3.71	8.67
Wefiani	High	5	3	4	3	2	4	3	24	3.43	8.00
Imbuan	High	3	5	3	4	4	7	4	30	4.29	10.00
Wau	Low	3	2	6	4	1	6	2	24	3.43	8.00
Warmandi	Low	3	1	5	1	4	5	3	22	3.14	7.33
Samfarmun	Low	5	3	4	4	3	8	4	31	4.43	10.33
Saukorem	High	3	3	5	4	1	4	5	25	3.57	8.33
Wasarak	High	4	2	4	3	3	4	2	22	3.14	7.33
Arupi	Low	4	6	7	3	5	9	8	42	6.00	14.00

Wekari	Low	3	4	6	5	2	7	7	34	4.86	11.33

Offtake per hunter was similar between villages with high and low population density (Kruskal-Wallis test $\chi^2 = 1.7528$, df = 1, P = 0.1855).

3.4.3.1 *The value of bushmeat trade*

Despite the importance of hunting for consumption, our data shows that hunting for sale is also essential for local livelihoods in villages with both high and low population density. The estimated income from bushmeat sales based on the seven-month hunting returns (Table 3.5), not only contributes to the local economy, but is important to household income in the study sites. Sometimes, venison was transported to the nearest district where the meat was sold to non-Papuans, mostly Muslim, at the transmigrant settlements. In this study, the harvest rates of particular species were also more likely to be influenced by market demand and consumer preference for particular bushmeat. Bushmeat was rarely sold to other villagers within a village. Wild pig meat, on the other hand, was transported to the city and sold at the local markets. In north-east Papua both wild pig and deer were sold for US$ 30–50 each, equivalent to the monthly salary of a locally employed permanent worker (Pangau-Adam et al., 2012).

The median income ranged between IDR 1,100,000 in low-population villages and IDR 1,300,000 in high-population villages (section 3.3.1.2). In this study, income of non-hunters was not collected. Per capita monthly income from selling bushmeat alone during the seven-month hunting period reported by 33 focal hunters was IDR 895,238 (US$ 68; N = 18) or 59% of monthly income in high-population villages and IDR 1,122,143 (US$ 85; N= 15) or 89% of monthly income in low-population villages.

In contrast to studies in Africa and South America, the bushmeat trade in this study was a relatively small ecocomic activity. Estimates of the national value of the bushmeat trade range US$42–205 million across countries in West and Central Africa (Davies, 2002). In the Congo Basin the scale of the meat trade reached about 5 million tonnes/year or more than US$ 250 millions annually (Wilkie & Carpenter, 1999). In the Amazon Basin the value exeeds US$ 175 million per year, and in Côte d'Ivoire it was estimated to be US$ 200 million (Rao & McGowan, 2002).

For poor hunters in high- and low-population villages from this study, increased hunting yields provide important cash income for household livelihoods. Thus,

providing an alternative source of income to the household may lessen the reliance of people on hunting.

3.4.3.2 *Hunting practices in villages with different population densities*

Hunting techniques

In this study, the most popular hunting technique was active hunting using spears, blades and bows and arrows. The finding shows that hunters at these study sites mostly relied on traditional methods of hunting based on cultural practices. Normally, native Papuans use traditional hunting weapons made from forest materials. Various kinds of timbers, bamboo, lianas, palm leaves and plant fibres are used to build traps, bows and arrows and spears (Pattiselanno, 2006).

In contrast, hunting with guns (Figure 3.14) was the least used technique in villages with both high and low human populations. Despite relying largely on traditional hunting techniques, 10% of the prey was killed using guns.

Figure 3.14: Local huters in Arui using guns to kill cuscus to provide meat for cultural ceremonies in the village

Radical sociocultural changes seemed to be underway in the study villages through the presence of new and advanced technologies that affected their lives and livelihoods such as the ownership of a generator, televisions, compact disc players and outboard motors. The associated changes, especially in hunting, are demonstrated by a

shift from traditional hunting techniques to modern techniques using firearms. Wadley et al. (1997) explained that settled farmers have greater access to new technologies such as guns and flashlights. As shown in other studies, the use of guns has increased because they are a very powerful and effective way to kill large animals (Carpaneto & Fusari 2000; Fa & Yuste 2001; Bennett et al., 2002).

Some hunters also used dogs to chase and catch animals, based on cultural practices in Papua (Pattiselanno, 2006). Currently, hunting with dogs and spears is the most widespread hunting practice in tropical Asia (Corlett 2007). Using dogs in hunting is very helpful, because dogs are a major aid to finding and killing prey. In the Crater Mountain Wildlife Management Area of the Eastern Highlands of Papua New Guinea, 42% of the kills were found with the help of dogs (Mack & West, 2005).

Hunting tenure

When rural human population densities are growing rapidly, there is a tendency to expand agricultural land more extensively (Achard et al., 2002). In areas with high-density human populations such as lowland and valleys, where soils are more likely to support agriculture, wildlife populations are suppressed. This is because the most accessible prey near human settlements and gardens are harvested first, and as a result wildlife populations near human habitation tend to be extirpated (Robinson & Bennett, 2000). This would explain why, despite requiring greater effort (travel distance), hunting was mostly conducted in primary forests by hunters from villages with both high and low human populations.

In villages with low human population density the proportion of hunting on non-primary forest tenures (secondary forests, riversides and crop lands) was higher than in those with high human density, indicating both that hunting may be part of traditional farming activities in gardens and fallows and that lower population densities allowed hunted species to persist in those land uses, although that was not borne out in the longer distances that hunters from low-density villages travelled to hunting sites. Increased population has no direct relationship with the number of hunters. However, working as farmer was dominant in the study sites (section 3.3.1.2) and people considered themselves as farmer-hunters. Therefore, increased population may affect hunting. Different land tenures also supported different prey species, which affected game hunting especially in the study areas that are currently connected by roads.

Smith (2005) argued that garden hunting was a productive activity that was complementary to many other aspects of the hunter's culture and economy, and it may be true in the lower population densities represented in this study. If so, then as the human population grows in the study area, hunting within garden areas will become increasingly non-viable and the focus will shift further to primary forests.

Hunting pressure

In this study higher population was related to a higher number of hunters in the study villages (Figure 3.6), which has been identified as a major threat to wildlife elsewhere (Robinson & Bennett, 2000; Bennett et al., 2002). Studies worldwide have shown that hunting pressure has often been associated with a boost in demand for wild meat, along with an increase in the human population and easy access to the hunting tenures (Robinson & Bennett, 2000; Milner-Gulland et al*.,* 2003; Fa et al., 2005; Refisch & Koné, 2005). In this study we found that increased access to remote forest sites through road connection (section 4.4.2.2) is followed by a rapid increase in the human population. Thus, availability road access also give more access for people migration into mew places. The availability of road access facilitates the flow of transportation and explosion of population growth in the new regencies and towns (http://tabloidjubi.com/16/2013/12/13/pemekaran-dan-migrasi-penduduk-di-tanah-papua/).

A strong relationship between number of hunters and population density (Figure 3.7), even though complicated with other factors (access, markets and prey), indicated that population density was a good predictor of hunting pressure and conversely the sustainability of hunting and its potential to meet human needs. There is a link between human population density and hunting pressure across tropical forest areas (Robinson & Bennett, 2000; Bennett, 2002). An increase in human population density increases the demand for wild meat, especially in tropical forests (Milner-Gulland et al., 2003). Higher human populations impact wildlife harvests and decrease the sustainability of hunting (Fa, 2000).

An important pressure on wildlife in 'frontier forests' comes from local communities (including new settlements and increased permanence of indigenous forest dwellers), with usually a high proportion of the population involved very little in the traditional economy (Nasi et al., 2008). Despite the fact that coastal areas are more

densely populated than the vast expenses of land in the interior, people living near the coast have access to fish resources from the sea and rely less than interior people on bushmeat. Therefore, it would appear that hunting pressure and the consumption of bushmeat varies with geographic as well as population densities.

The percentage of hunters decreases with an increase in human population. This is likely because road connections provide more options for households to decrease their reliance on wild meat for consumption and thus reduce the proportion of hunters in the population (detailed information is presented in section 4.4.3). Thus, the impact of roads is not simple; while roads provide access to forest and markets, they also give people opportunities to find alternative forms of protein (Bennett & Rao, 2002). All the factors in this study (road, population density and alternative protein sources) affect hunting independently (Appendix E) to influence hunting activities in the study sites.

According to Smith (2005), edible game preferences are dependent on body mass, ease of preparation, taste and cultural attitudes to different species. Schenk et al. (2006) indicated that other cultural mediating factors also drove the demand for bushmeat such as familiarity, tradition and prestige. There was no species protected by taboo among hunting targets in the villages of this study (Table 3.5), and the preference for introduced species (deer and wild pig) was influenced by their meat content. Although the meat from wild pig is not consumed by muslims, meat from deer has no religious restrictions in the study area. There were no clear or apparent cultural preferences among villages.

Recognising that there may be distinct regional differences in dietary habits, perhaps due to cultural influences, it seems reasonable to assume that variation in ethnic background may also lead to different dietary habits. In this study, although fish consumption was not as high as bushmeat consumption (Figure 3.9), it was comparable with vegetable consumption, and could indicate a cultural influence, as discussed by York and Gossard (2004) to explain cultural/geographic variation in fish consumption.

3.4.4 Consumption patterns

As hunting was mostly conducted to obtain meat for household consumption the percentage of households who had wild meat in their meals was high compared to other meal types (fish, livestock products and vegetables) in villages with high and low

population density. Although hunters from high-density villages reported more hunting for consumption (Figure 3.2) meal survey data showed that wild meat was more common in meals in low-density villages (Figure 3.9).

These findings seem initially to be contradictory; however, although hunters in villages with low population density reported their intent to hunt for trade, they kept some parts of the carcasses including head, bones, legs and intestines for family consumption. Consequently, although hunters sold meat to dealers they still kept some bushmeat for family consumption. Similarly, in Uganda, on average one-third of the meat is consumed in hunter households and the other two-thirds are sold (Olupot et al., 2009).

For people involved in agriculture, such as the coastal communities in this study, crop lands allow the production of significant amounts of carbohydrates, in this case tuber crops and bananas. Those agricultural activities are not fully effective providing animal protein sources for households (Sonbait et al., 2011) despite cultivation of some livestock. The long-term program is to provide livestock assistance to farmers to grow the animals. Some of which should be returned to the livestock aid program manager to be distributed to other farmers who have not received animals from the program. However along the way, farmers sold the animals, so the purpose of the livestock distribution program is not accomplished yet (http://tabloidjubi.com/16/2012/11/19/dinas-perkebunan-dan-peternakan-papua/). Geographical barriers have also restricted the distribution of breeding livestock to some communities, leading to a small number of animals kept by hunters in the studied villages (Figure 3.15). In consequence, people obtained their primary source of meat from hunting rather than livestock (Figure 3.16). This is not unusual; Robinson and Bodmer (1999) note that the main reason for hunting in tropical forests is because wildlife is the most accessible animal protein, especially for those in rural areas.

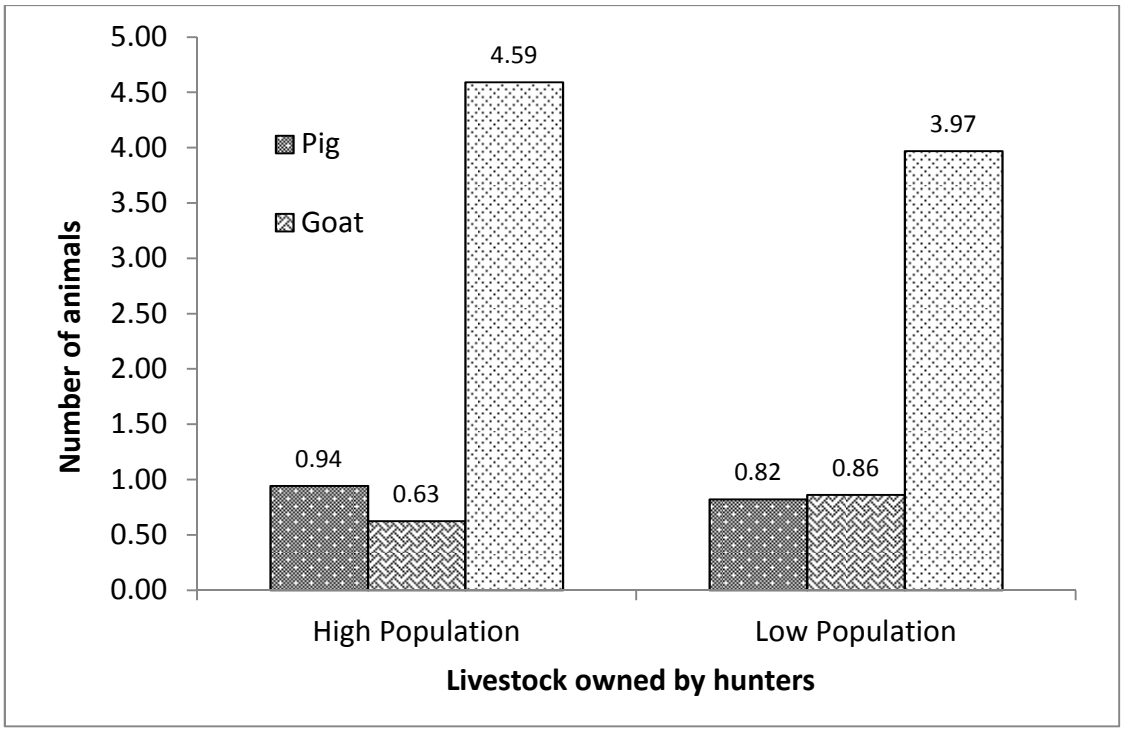


Figure 3.15: Livestock owned by hunters (animals/hunter) in high population density villages (N = 120) and low population density villages (N = 100)

Figure 3.16: A woman in Wefiani village drying venison for later consumption

The consumption of livestock products in villages with both high and low population density was quite similar. Hunters in the study sites were also engaged in rearing pigs, goats and chickens (Figure 3.17). The animals raised within the study sites was numerically dominated by chickens, animals that are easy to breed and transport (Figure 3.18).

Figure 3.17: (a) Domestic pigs in Imbuan village. (b) Goats are commonly kept in the region

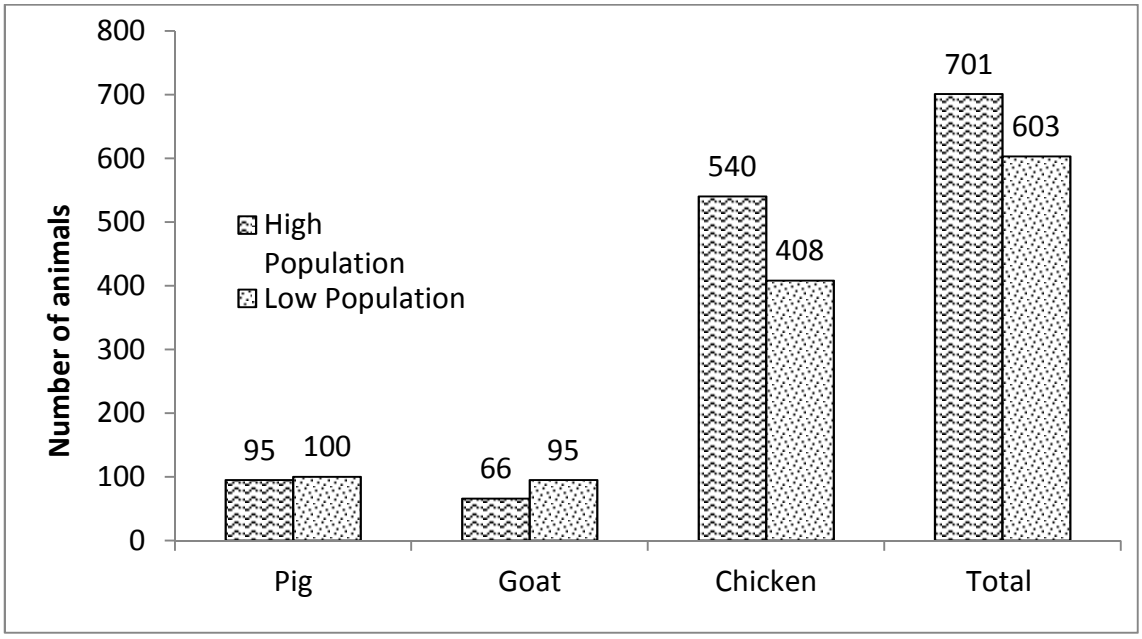


Figure 3.18: Total numbers of different types of domestic animals raised in villages with high or low populations

However, the motivation for keeping livestock was mainly associated with the need for income and savings against future needs. For example, hunters commonly cited

the need for cash to pay education costs. In addition, livestock may be consumed on special occasions such as festivals but are not for daily consumption. This is similar to other tropical forest regions, where livestock such as beef and chicken may be eaten at special occasions like festivals or ceremonies but not for daily consumption, and are mostly kept as "money in the bank" and sold for cash during emergencies or times of hardship (Bennett, 2002; Milner-Gulland et al., 2003).

3.5 Conclusion

In this study, coastal inhabitants derived income and sustained their livelihoods from a variety of sources. Agricultural crops played a significant role but people also engaged in hunting for an alternative income. Hunters shifted intermittently between formal and informal occupations for cash to supplement crop-related incomes, shifting from subsistence-based to market-based hunting. The average income of hunters in high-population villages was greater than in low-population villages and the value of bushmeat trading was substantial as a proportion of total income.

Wild meat was also an important source of protein. Meals containing bushmeat dominated the household diets in villages both with high or low human population density. Although hunters from high-density villages reported more hunting for consumption, wild meat was more common in meals from low-density villages.

Hunting is critically important to inhabitants in villages with both high and low population densities along the coast of Birds's Head Peninsula. Chapter 4 investigates the influence of road connections on hunting practices and access to the urban bushmeat market, leading to further understanding of the likely impact of access on hunting takes that influences the sustainability of hunting.

Chapter 4 Access to forest sites and subsistence hunting

Figure 4.1: The presence of roads connecting villages at Amberbaken District allows bushmeat buyers with motor bikes to purchase meat from hunters. This figure shows a buyer carrying a deer purchased from Arupi, a village in Amberbaken within the study area that is connected by road to the nearest town, Prafi

4.1 Introduction

The spread of roads allows greater access for hunters and traders to undisturbed and remnant forests and is considered a critical factor driving the exploitation of bushmeat (Robinson & Bennett, 2000; Rao & McGowan, 2002; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). Hunting has increased over time and become a regional problem due to the development of markets and associated trade routes to supply regional and international trade networks with most hunted animal species.

Since 2008, roads have been developed along the coast of the Bird's Head Peninsula and have connected some villages in Amberbaken District to Prafi and Manokwari. This chapter assesses the impact of roads on hunting practices as well as offtake from hunting excursions. This chapter also investigates how roads link areas with markets and how they influence wild meat consumption patterns along the coast.

4.1.1 The importance of roads in developing countries

Transportation infrastructure is often mentioned as a key factor in promoting growth and development. Trade economists have written extensively about the link between roads, market access and economic growth, as well as the health of household and national economies in most developing nations (Chohan et al., 2011). The argument relies on the simple logic that one first needs to have access to markets and ideas before one can benefit from them. Road development is increasing worldwide. Roads play important roles where there are strong economic incentives to provide access to large-scale logging, oil and mineral operations as well as agribusiness (Laurance & Balmford, 2013). However, roads can also be a vital link for individuals and communities in remote places, giving farmers, for instance, access to markets for their crops and allowing them access to fertilizers and other technology that makes production more efficient. In brief, an efficient transport system contributes towards economic growth because of the following main factors: reduced production costs, economies of scale, employment opportunities, connectivity, market integration and accessibility (Chohan et al., 2011).

4.1.2 Why road development matters

The International Energy Agency predicts that by 2050 there will be 60% more roads than in 2010. That equates to about 25 million kilometres of new paved roads, enough to circle the Earth more than 600 times (Laurance, 2014). Human development brings with it an increase in the number of roads to fulfil transport needs, but this increase has costly implications for nature (Forman et al., 2003).

There is a growing awareness that road development has major environmental impacts, including damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanisation, and introduction of diseases (Trombulak & Frissel, 2000; Laurance, 2008; Laurance et al., 2009, 2014).

Why are roads particularly bad for rainforests? From a biological perspective, rainforests maintain species that rely on forest-interior and understorey conditions that are susceptible to the environmental changes associated with roads and clearings (Laurance, 2004; Goosem, 2007). Laurance (2007) characterises roads as rainforest killers that directly eradicate a range of species within and around them. The expansion of roads not only leads to increasing loss of forests — at an accelerating rate — but also to the release of billions of tonnes of greenhouse gases into the atmosphere each year (Laurance, 2007).

4.1.3 Impact of roads on hunting

Roads are associated with increased hunting pressure on wildlife populations. Hunting pressure has been shown to be positively correlated with road development as it provides greater access for hunters and traders to undisturbed forests (Robinson & Bennett, 2000; Milner-Gulland et al., 2003; Fa et al., 2005; Refisch & Koné, 2005). This also leads to young people becoming involved in hunting. For example, in the Arunachal Pradesh of India, people began hunting from the age of 10–12 years, although 53% of hunters were between 40 and 60 years old and 43% between 20 and 40 years old (Aiyadurai et al., 2010).

In addition to facilitating access into the forest, road connections decrease the time spent to transport animals to the market, thus facilitating bushmeat trading (Mendelson et al., 2003). Available access also provides significant opportunities for

women to contribute to trading and transporting the meat from rural to urban areas (Adefalu et al., 2012; Olupot et al., 2009).

Established road networks not only bring hunters closer to hunting sources, but also link the resources directly to the market (Robinson et al., 1999). Improvements to the highway connection between North Sulawesi and other provinces of Sulawesi such as Gorontalo and Central Sulawesi have also led to increased importation of wild meat from other parts of Sulawesi for wildlife market demands in Manado and Minahasa (Lee, 2000), and elevated pressure of hunting on wildlife populations (Clayton & Milner-Gulland, 2000). Availability of markets for wild meat increases hunting in the tropical forest areas around the world.

The influence of markets on wildlife hunting is well documented and includes integration of hunting with the market, increasing harvest rates and thereby decreasing sustainability (Robinson & Bennett, 2004). To maximise harvest rate, the involvement of big groups of hunters are acknowledged by working together for stalking, herding and ambushing the animals as an indicator of hunting tactics (Griffin & Griffin, 2000; Fusari & Carpaneto, 2006; Luskin et al., 2014).

4.1.4 Road development in Papua

Large-scale development of infrastructure, including transportation infrastructure, is a government priority in both Papua and West Papua provinces; 21.52% of the total provincial 2000-2001 budget was committed to infrastructure development in (Mertens, 2002). The rationale is to improve the rural economy in order to alleviate poverty within the currently isolated rural areas. It has been estimated that a total of 2,700 km of roads are planned, consisting of 1,500 km of national networks and 1,200 km of provincial network. Currently more than 1,250 km have been developed, around 50% of the planned roads (Mertens, 2002).

The development of the Papua and West Papua provincial road network creates new settlement areas along the road and more entry points closer to forest sites. About 25% of protected areas in Papua are located less than 20 km from the 2,700 km new road development and established road connections (Anggraeni & Watopa, 2004). Part of the road development on the Bird's Head Peninsula connects Manokwari and Sorong

(West Papua's main cities) along the coast (Figure 4.1) by 571 km of the Trans-West Papua road (Pattiselanno & Arobaya, 2013).

4.1.5 How does access to the forest affect hunting?

Evidence from other tropical forests suggests that increases in road connections are likely to transform local communities and the way they use forest resources, including reducing the sustainability of hunting (Clayton & Milner-Gulland, 2000; Lee, 2000; Milner-Gulland et al., 2003).

Ease of access by people to hunted areas generally decreases sustainability of hunting. If areas are easily accessible, outsiders can enter them to hunt, thereby increasing hunting pressure on the wildlife resources (Auzel and Wilkie, 2000; Fimbel et al., 2000; Noss, 2000), and breaking down any traditional controls that might have been placed historically (Bennett et al., 2000; Mena et al., 2000). As proximity of hunted areas to markets and other commercial centres increases, market-driven hunting tends to increase as well (Bennett et al., 2000; Clayton & Milner-Gulland, 2000).

Learning from experiences in other tropical sites, we studied the impact of road development on indigenous hunting along the coastal landscape of West Papua. Determining the relationship between road access and available wildlife markets along the coast allows prediction of the ongoing effect of changes in roads and available markets on subsistence hunting in the Bird's Head Peninsula, where road connections are currently being developed.

Specifically, we aim to evaluate the impact of improved access into the forest on subsistence hunting. Road access should both increase the ability of hunters to access wildlife across a broader area and thire ability to transport their catch to market. The likely consequence of either or both of these is an increase in hunting take.

4.2 Methods

In each village we collected information on hunting strategies from 220 focus respondents (section 2.4.1.1) and 800 community surveys (section 2.4.1.2), hunting effort and harvest rates from 220 respondents (section 2.4.1.1). We confirmed the results by accompanying hunters on 387 hunting excursions (section 2.4.1.3). We also investigated consumption patterns by conducting haphazard visits to 696 households to

observe the types of meals consumed and to ask how often those meals were consumed each week (section 2.4.3).

In this chapter I used log-linear analysis after León and Montiel (2008) in the S^+ package (Jones et al., 2012) to examine the effect of road access on response variables including hunting practices, hunting effort, harvest rates and consumption patterns among respondents in the study sites. Does the road affect the ability of hunters to access wild meat across a broader area and to transport their catch to the market? Do these effects impact hunting strategies, effort, harvest rates and consumption patterns?

4.2.1 Hunting strategies and their interaction with road access

Specific data related to hunting strategies was collected from focused respondents (n = 220) and community survey respondents (n = 800). This data included reasons for hunting, hunting frequency, hunting techniques, tenure of hunted locations, group size when hunting and hunting takes from the three weeks prior to the interviews.

The explanatory variables for the log-linear analysis of hunting strategies were hunting purpose, hunting techniques, hunting tenure, group size involved in hunting and last hunting results. Details of the explanatory variables are presented in Table 4.1.

Table 4.1: Variables for log-linear analysis of hunting strategies

Variable	N	Type	No. of categories	Categories/units
Hunting purpose	1020	Categorical	3	Consumption; sale; other (festive, pest and trophy)
Hunting frequency	1020	Ordinal	3	Very frequent (daily, 2–3 days/week); frequent (weekly, fortnightly, anytime); rare (monthly)
Hunting technique	1020	Categorical	4	Traditional active; traditional passive; dog; gun
Hunting tenure	1020	Categorical	4	Primary forest; secondary forest; river edge; plantation
Hunting group size	1020	Ordinal	3	Individual; 2 people; > 2 people
Last hunting results	1020	Categorical	3	Deer; pig; native species (kangaroo, tree kangaroo, cuscus, bandicoot, bird)

4.2.2 Hunting effort and harvest rates

Information obtained from 220 focus respondents (section 2.4.1.1), were used to gain information on hunting efforts and harvest rates (Table 4.2).

Table 4.2: Variables for log-linear analysis of hunting effort and harvest rates from interviews of focus respondents

ariable	N	Type	Categories/units
Harvest rate	220	Continuous	Number of individuals
Average time spent hunting	220	Continuous	Hours spent hunting
Average distance to hunting site	220	Continuous	Distance travelled from villages to hunting sites (km)

Results from interviews were clarified by accompanying hunters on 387 hunting trips to record the distance hunters travelled from villages and number of offtakes from each trip (Table 4.3).

Table 4.3: Variables for log-linear analysis of hunting effort and harvest rates from 387 hunting trips

Variables	N	Type	Categories/units
Distance to hunting sites	387	Continuous	Distance (km)
Number of individual takes	387	Continuous	Catch results, number of individuals per species

4.2.3 Consumption patterns

In order to study how the presence of roads influenced consumption patterns, in particular wild meat consumption, 696 households were randomly visited to record the types of meals consumed and how often those meals were consumed within a week (Table 4.4).

Table 4.4: Variables for log-linear analysis of household consumption at the study sites

Variable	N	Type	No. of categories	Categories/units
Meal content	696	Categorical	2	Wild meat; non-bushmeat
Meal types	696	Categorical	4	Wild meat; fish; livestock products; vegetables and noodles
Ethnic group	696	Categorical	4	Karon; Mpur; mixed Papuans; non-Papuans
Type of meats	277	Categorical	3	Venison; pork; other

4.3 Results

4.3.1 Impact of road access on hunting strategies

Hunting strategies in this study comprise of motivation for hunting (purpose), hunting frequency, techniques, tenure, group size and last hunting take. Hunting was conducted for a variety of purposes including trade, for family consumption and other purposes such as festive and crop protection. Of the 1020 interviewees, 768 (75%) stated that they hunted with a specific purpose in mind, while 25% hunted opportunistically when working on the farm. In villages without road access hunting was mostly (55%) conducted to obtain meat for family consumption, whereas hunting for trade was more common in villages with road access (Figure 4.2; log-linear $\chi 2 = 27.30$, $df = 1$, $P < 0.001$).

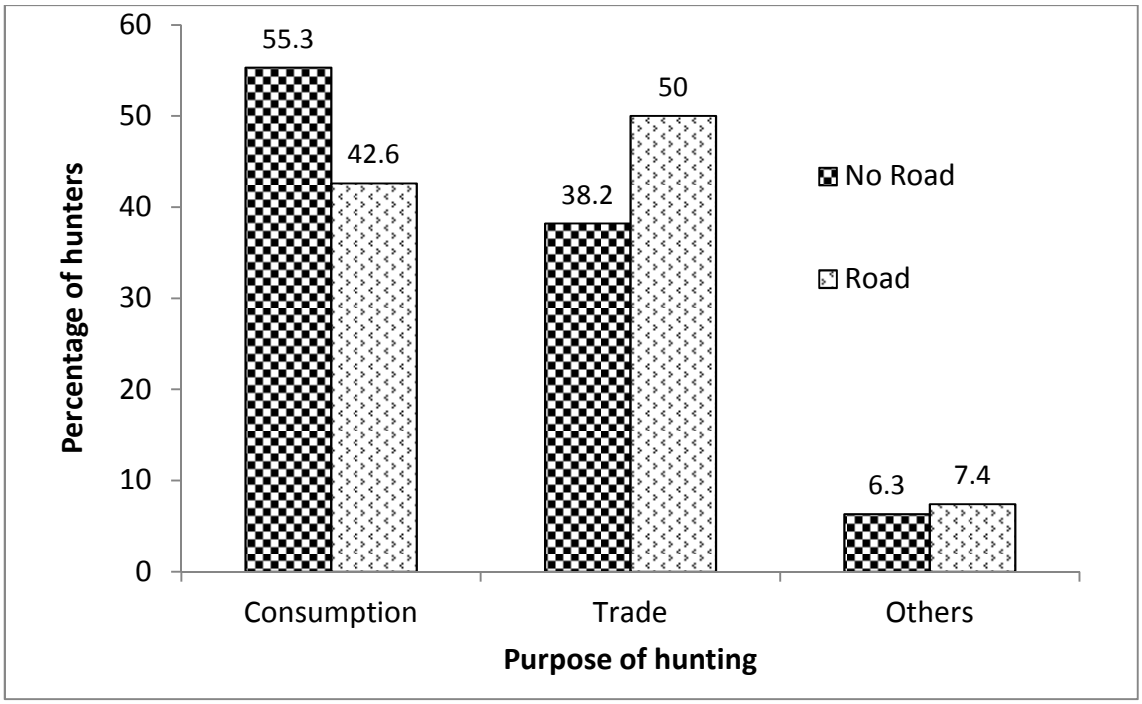


Figure 4.2: Percentage of hunters with different major purposes for hunting in villages with and without road access. Villages with accesible roads N = 420; villages without available roads N = 600; $\chi 2 = 27.30$, df = 1, $p < 0.001$

Providing the household with complete meals including meat was important to respondents and we found that all opportunistic hunting contributed to household consumption. Although we did not record all market transactions, live animals that were still in good condition were generally sold live and complete. However, more commonly, animals were traded dead and hunters removed and used heads, bones, legs and intestines before selling meat. Thus, hunters who hunted for trading were still providing the family with lower-quality meat including bones and other parts that were less valuable items. Hunting for other purposes (festive and crop protection) were the least common practices of hunters in both road-accessible villages (7%) and villages without road access (6.5%). Most crop damage in the study area was attributable to the foraging activities of wild pigs.

4.3.1.1 *Hunting frequency*

Hunting was more frequent in villages with road access (Figure 4.3; log-linear $\chi^2 = 33.53$, df = 1, $p < 0.0001$). Most respondents actively hunted once every 1–2 weeks (92% in the villages with road access and 79.5% in villages without road access; Figure

3.3). A similar result was found using a generalised linear model with binomial error distribution (Appendix E), indicating that hunting frequency increased with road access.

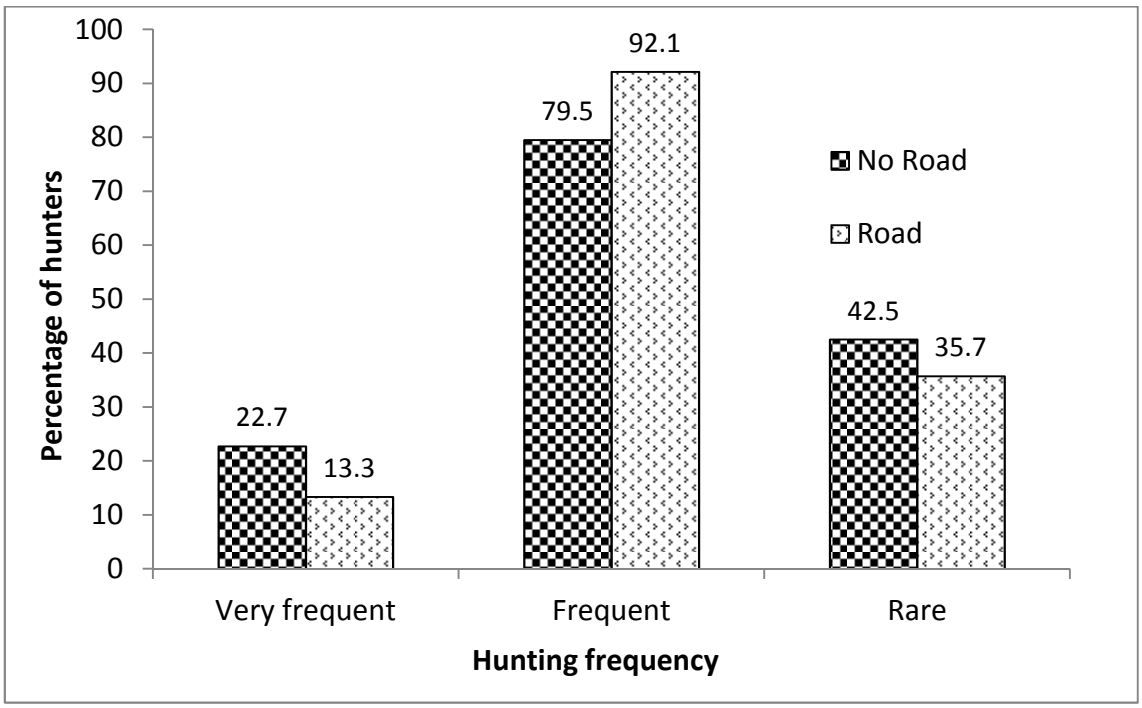


Figure 4.3: The percentage of hunters in different hunting frequency categories (very frequent: daily and 2–3 days a week; frequent: weekly or fortnightly; or rare: monthly) in villages with and without road access. Percentages do not add to 100 because hunting was conducted in more than one category. $\chi^2 = 33.53$, df = 1, $p < 0.0001$

4.3.1.2 *Hunting techniques*

A variety of hunting techniques were documented at the study sites. Hunters used bows and arrows, spears and machetes (active techniques), nylon snare traps (passive technique), and hunted with dogs or using guns. Each hunter typically used more than one technique and the prevalence of different hunting techniques varied with road access (Figure 4.4; log-linear $\chi^2 = 55.53$, df = 1, $p < 0.0001$).

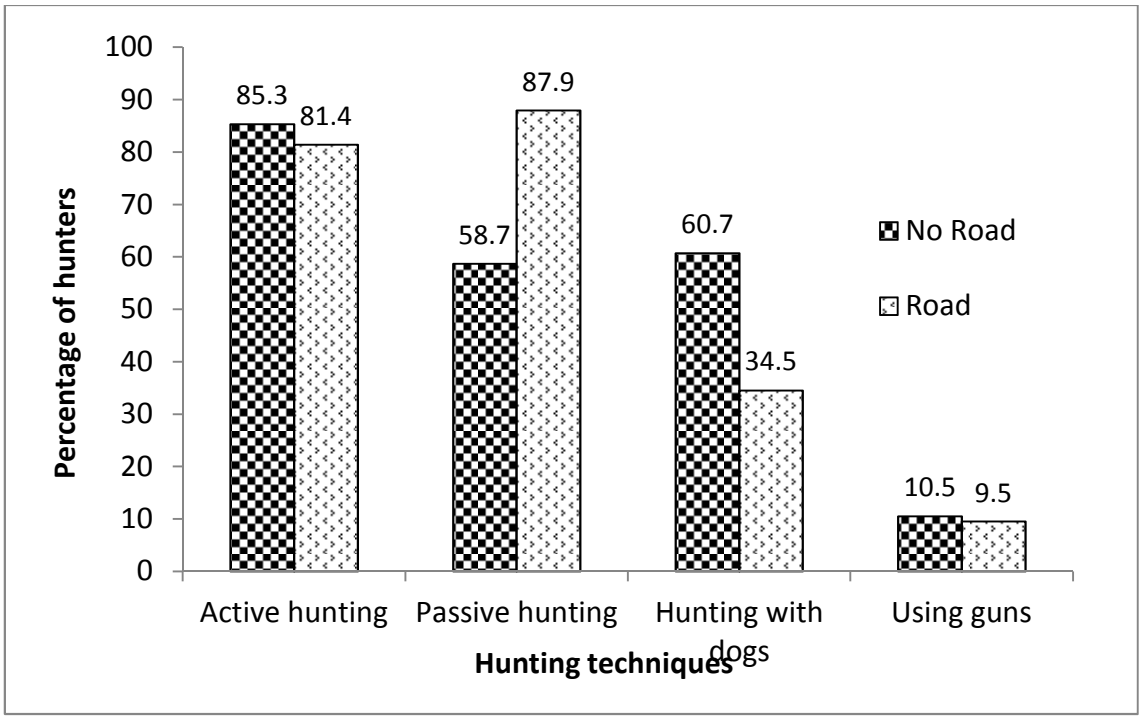


Figure 4.4: Percentage of hunters employing different hunting techniques in villages with and without road access. Percentages do not add to 100 because typically hunters used more than one hunting technique. $\chi 2 = 55.53$, df = 1, $p < 0.0001$

Active techniques (bows and arrows, spears and blades) and dogs were the most popular hunting techniques used by 85.3% of hunters in villages without road access. However, hunters from the road-accessible villages used passive techniques such as nylon snare traps more often (87.9%). The least common hunting technique used was guns, which were only employed by 10% of hunters across both categories of villages.

4.3.1.3 *Hunting tenure*

Road access impacted the hunting locations (Figure 4.5; log-linear $\chi 2 = 34.38$, df = 1, $P < 0.0001$). Hunting was more common on crop land and secondary forest in villages with road access but was more common in primary forests where there was no road access. Crop lands supported 32% of all hunting. This is consistent with relatively frequent opportunistic hunting that occurred 25% of the time and mostly took place while hunters worked on their crops.

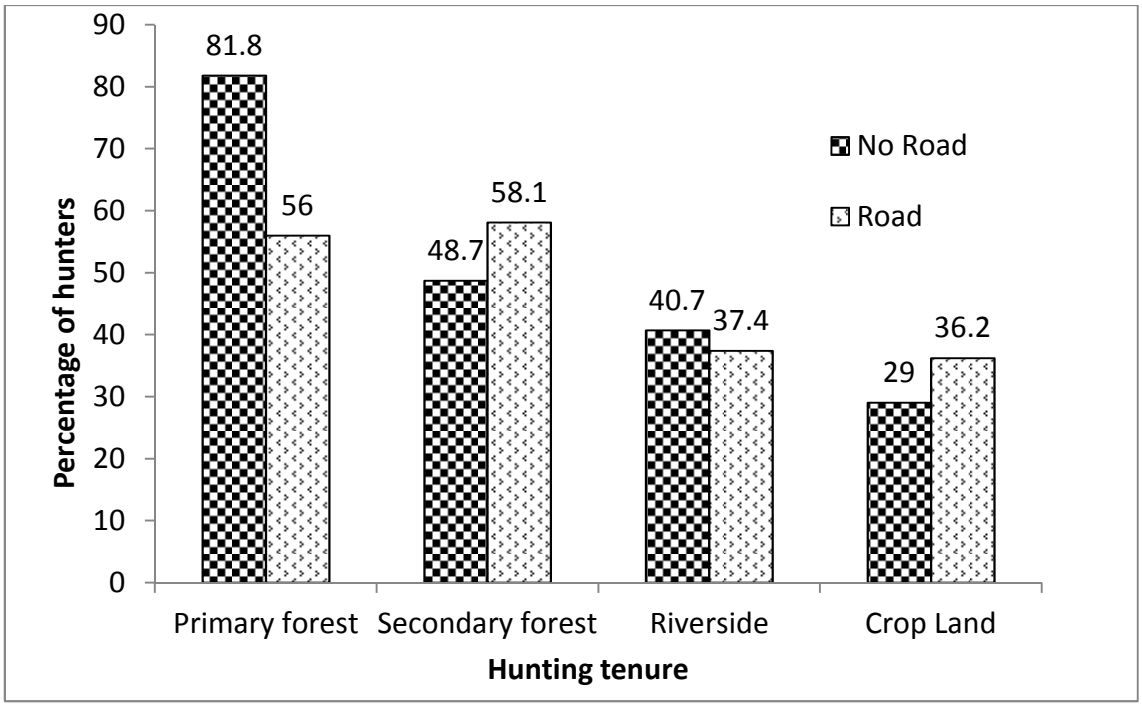


Figure 4.5: Percentage of respondents hunting in each hunting location near villages with and without road access. Percentages do not add to 100 because hunting was conducted in two or more locations. $\chi 2 = 34.38$, df = 1, $p < 0.0001$

4.3.1.4 *Hunting group size*

Motivations for hunting and techniques used corresponded closely to hunting group size. Hunting was mostly performed in large groups of more than two people in both types of village. In villages with road access, 92% of hunters hunted in large groups compared to 89% of hunters in villages with no road access (Figure 4.6). Solitary hunting was rare (2% or below). Distribution among group sizes differed significantly between villages with and without road access (Figure 4.6; log-linear test $\chi^2 = 27.86$, df = 1, $P < 0.0001$). Variation in group size was determined by the composition of the group, including women (N = 198 or 20%) who hunt during work on farms.

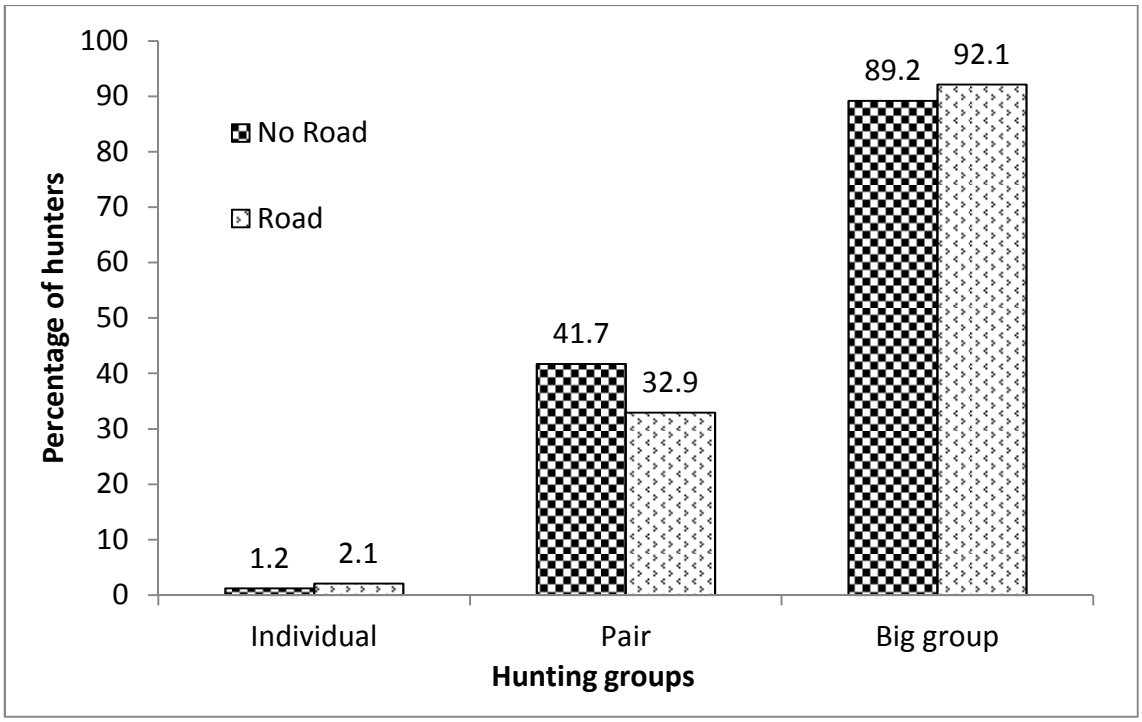


Figure 4.6: Percentage of hunters in differently sized hunting groups from villages with and without road access. Percentages do not add 100 because hunters could be involved in two different groups. $\chi^2 = 27.86$, df = 1, $p < 0.0001$

4.3.1.5 *Last hunting take*

Hunters identified nine prey species that had been hunted in the three weeks prior to the interviews: six mammals and three birds (Table 4.5). Two of the nine species were introduced — rusa deer (*Cervus timorensis*) and wild pig (*Sus scrofa*) — while others were native species. Catch per hunting trip varied between one and five individuals. The average catch per hunting trip was two individuals (2.42 ± 1.93 SD).

Prey species killed by hunters during the previous hunting excursion were similar between villages with and without road access, consisting of deer, pig and native species (Table 4.5). According to hunters, ungulates such as pigs and deer were preferred because they provide a larger mass of meat for both sale and personal consumption (Figure 4.7). More hunters from villages with road access hunted deer than from villages without road access (log-linear $\chi^2 = 22.94$; df = 1; $p < 0.0001$).

Table 4.5: Species hunted in coastal villages along the Bird's Head Peninsula, West Papua (all responses from hunter interviews)

Scientific name	Common name	IUCN status[1]	Status under Indonesian law[2]
Rusa timorensis	Timor deer	Vulnerable	Protected
Sus scrofa	Wild pig	Least concern	
Thylogale brunii	Dusky pademelon	Vulnerable	Protected
Dendrolagus inustus	Grizzled tree kangaroo	Vulnerable	Protected
Spilocuscus maculatus	Common spotted cuscus	Least concern	
Echymipera kalubu	Spiny bandicoots	Least concern	
Casuarius unappendiculatus	Northern cassowary	Vulnerable	Protected
Rhyticeros plicatus	Papuan hornbill	Least concern	
Ducula pinon	Pinon's imperial pigeon	Least concern	

[1]http://www.iucnredlist.org/

[2]Indonesian Law for Natural Resource and Ecosystem (Government Regulation PP No. 7/1999)

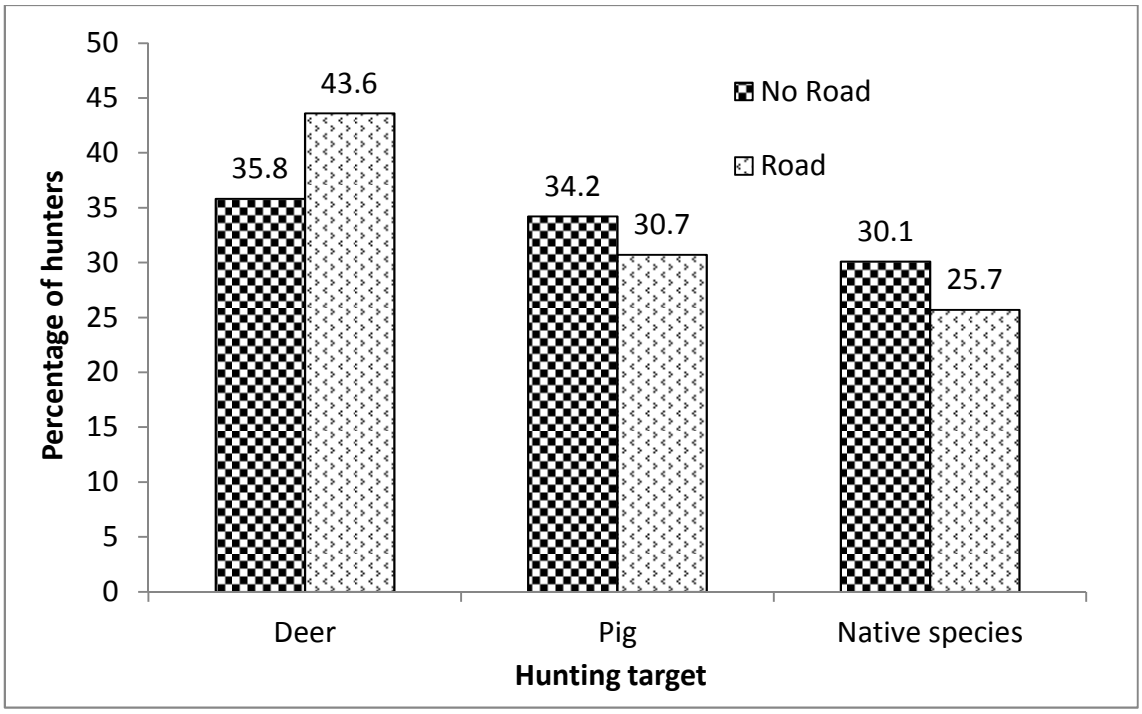


Figure 4.7: Percentage of hunters returning with deer, pig or native species in their last excursions from villages with adn without road access. Log-linear $\chi^2 = 22.94$; df = 1; p < 0.0001

4.3.2 Available road access, hunting effort, harvest rates and their interactions

The distance to hunting sites varied widely from 359 m to 11,310 m (Figure 4.8). In road-accessible villages the average distance hunters travelled to hunting sites was 5,381 ± 1596.14 m (N = 134), greater than that from villages without connecting roads (3,518 ± 1942.91 m, N = 253) (t = -10.11, df = 319.73, P < 0.0001). Time spent hunting varied between 3 and 20 hours per event (Figure 4.9). The mean amount of time spent hunting from villages with road access was greater (13.38 ± 1.76 hours, N = 80) than from villages without road access (9.37 ± 3.26, N = 140) (t = -11.85, df = 217.42, P < 0.0001).

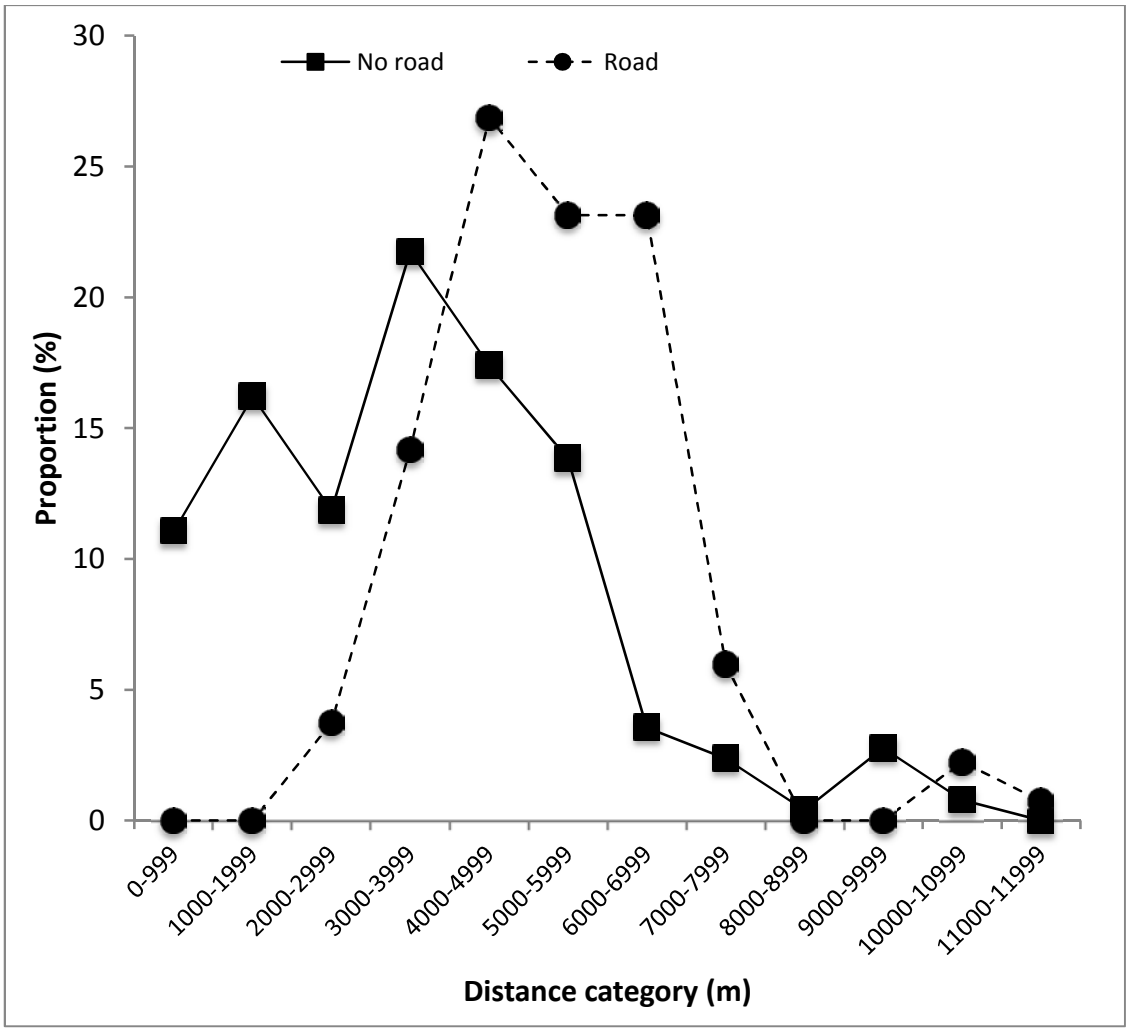


Figure 4.8: Distances travelled to hunting sites from villages with and without road access (N = 134 for road-accessible and N = 253 for road-inaccessible villages)

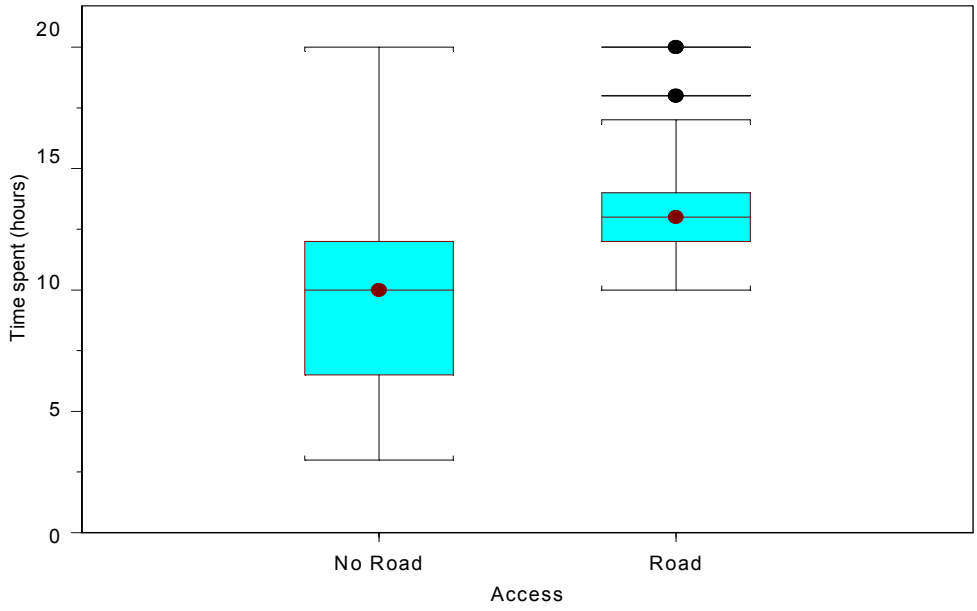


Figure 4.9: The duration of hunting events in villages with and without road access (t = -11.85, df = 217.42, p < 0.0001). Box plot showing minimum, median and maximum time devoted to hunting in the two category of villages, N = 80 for road-accessible and N = 140 for road-inaccessible villages

Harvest rates were calculated from the number of animals captured during the 387 nights we accompanied hunters to the hunting sites. This was also used to confirm prey species captured in the previous hunting trips described by hunters during interviews.

The last hunting takes were dominated by deer and wild pig. In road-accessible villages, an average of 2.27 ± 0.87 animals per trip were taken (N = 134), not significantly greater than 1.99 ± 1.03 animals in road-inaccessible villages (N = 253) (log-linear $\chi^2 = 3.33$, df = 1, P > 0.05). However, the findings revealed that there was a significant relationship between distances to hunting site and catch per capita per hunter ($F_{1, 385} = 136.19$, P < 0; Figure 4.10).

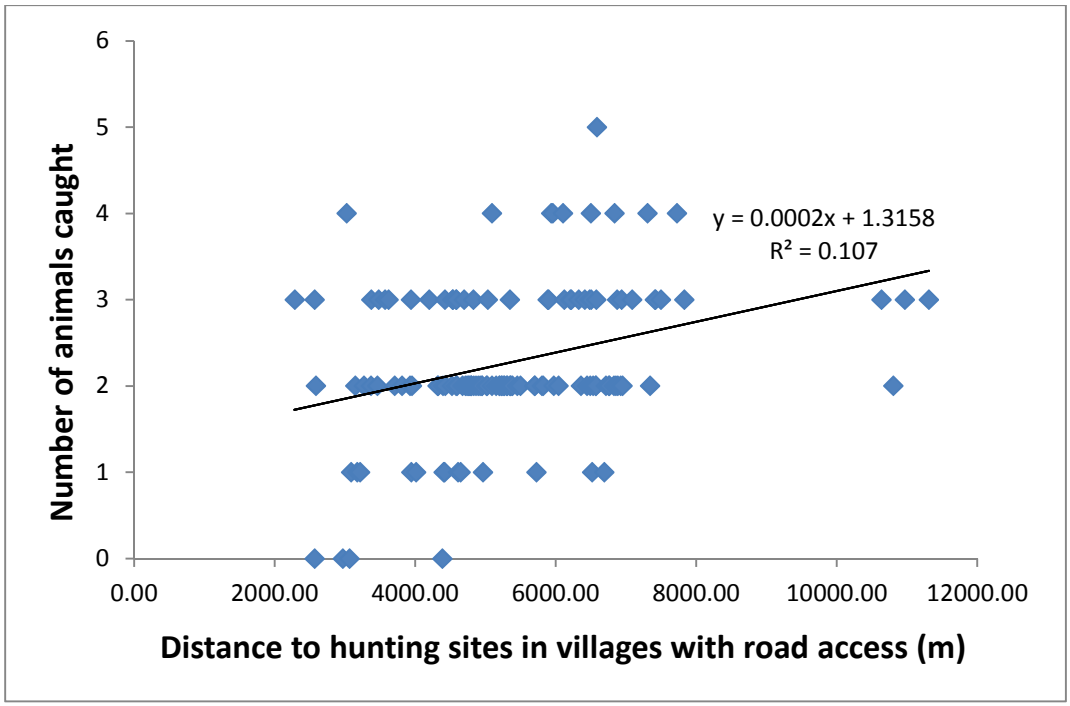
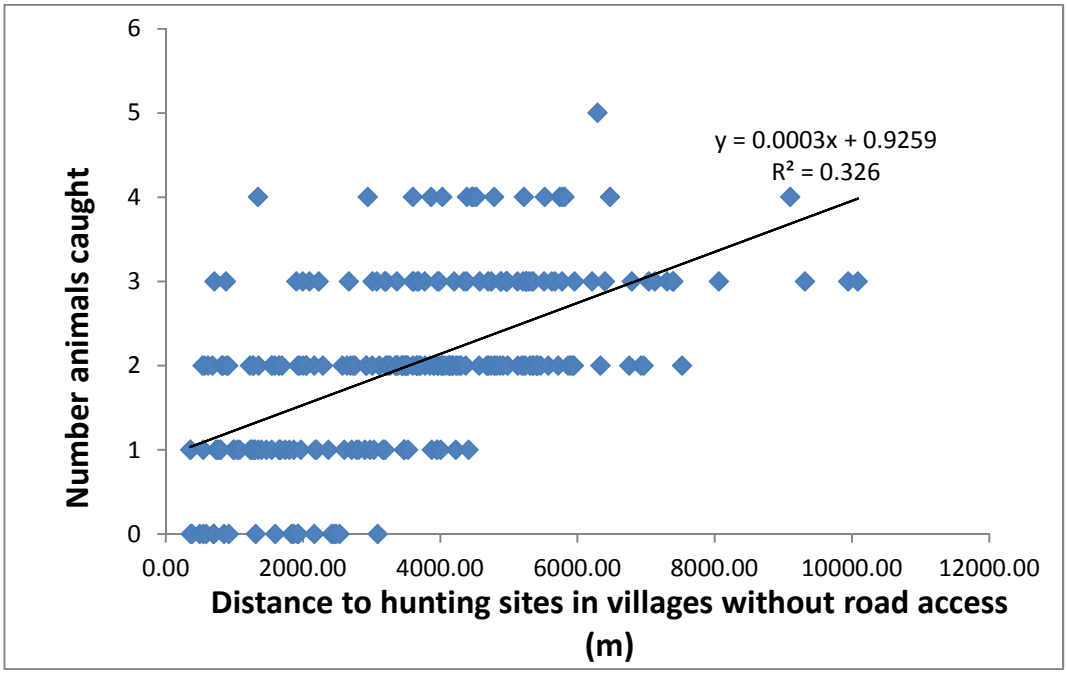


Figure 4.10: (a) Hunting success according to distance from villages with road access. Hunting return was an average of 2.27 ± 0.87 (SD) animals per trip. Scatter plot shows the relationship between distance to hunting sites and catch per hunter. N = 34. (b) Hunting success according to distance from villages without road access. Hunting return was an average of 1.99 ± 1.03 animals per trip. N = 253



4.3.3 Road access, alternative food sources and consumption patterns

Meal content was broadly similar between road access categories, consisting of wild meat, fish, livestock products, vegetables and noodles. The households in road-accessible villages ate more fish and vegetables, whereas in the villages without road access, wild meat consumption was higher (Figure 4.11; log-linear $\chi^2 = 27.89$, df = 1, P < 0.0001).

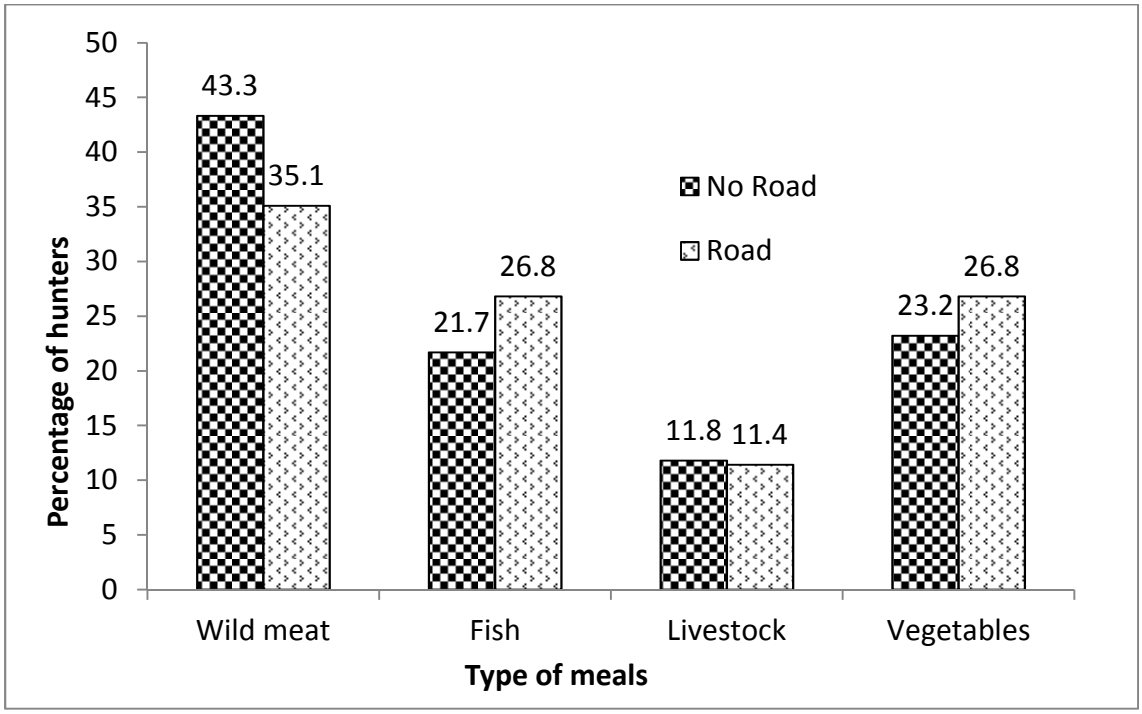


Figure 4.11: Household meal components in villages with (N = 299) and without (N = 397) road access. Log-linear $\chi 2 = 27.89$, df = 1, $p < 0.0001$

4.4 Discussion

4.4.1 The influence of road access on hunting in West Papua

The combination of various hunting practices can be considered together as providing measures of an overall hunting strategy relevant to the local area.

Road access influences the various components of hunting practice separately, but also as an overall strategy. The present study reveals that road development gives more opportunities to gain cash from hunting. Road access also connects hunters with markets and increases the use of traps to boost harvests on crop lands and in secondary

forests. The current road development has also allowed people additional alternatives for food consumption.

4.4.1.1 *Road development and hunters' behaviour*

This study suggests that road development has a substantial impact on hunters' behaviour, shown by the involvement of hunters in the wild meat trade along the coast. In villages with road access, hunters were more likely to hunt for trade and cash income than subsistence. The introduction of a cash market economy, combined with rapid urban and infrastructure development such as road connections along the coast, have brought significant changes to hunting purposes and practices in this region. This finding is consistent with numerous studies from other tropical forests that show the reliance of the local communities on hunting as an important alternative source of family revenue. For example, local households in Palawan, The Philippines, who have an average annual income of less than US $400 per household, hunted to gain extra income from the sale of meat (Shively, 1997).

Hunting also provides an important source of cash for households living in extreme poverty (daily per capita income less than US$1) during lean agricultural seasons in Ghana and India (Mendelson et al., 2003; Hilaluddin et al., 2005). In some countries hunting is also the basis of a substantial business. In Côte d'Ivoire, for instance, in 1996, 120,000 tonnes of bushmeat was harvested and the sale was estimated to represent 1.4% of the gross national product (Williamson, 2002). In that case, hunting had increased rapidly to satisfy fast-growing markets for wild meat in nearby urban centres. In other parts of New Guinea (north-eastern Papua), there has also been a marked shift from local subsistence hunting for meat consumption towards more intensive commercial hunting (Pangau-Adam et al. 2012). Luskin et al. (2014) found both that commercial hunting was more common than subsistence hunting and that hunting within oil palm plantations simultaneously functioned for pest control as well as household economic benefit in Jambi, Sumatra.

The roads that pass through the villages at the Amberbaken District (Figure 4.12) have allowed hunters to leave their semi-nomadic life styles, settle along the road and hunt to supply the demand of the wild meat market in the nearest towns. Commercial traders have also benefited enormously from recent road improvements,

allowing them to travel faster and further to buy meat from the villages. These traders operate either by motorbike or car (Figure 4.13) to buy meat from hunters in the villages. They generally travel during the weekend, as villagers tend to stay in the village to spend time with relatives and friends and to prepare themselves for religious and social activities.

Figure 4.12: a) The settlement located along the road in Arupi village of Amberbaken District. (b) The road running through Arupi village, Amberbaken District

Figure 4.13: (a) Bushmeat traders use motorbikes with cool boxes on the rear seat. (b) Some bushmeat traders drive to villages with road access

Similarly, in the north-east of Ecuador, the Waorani people build their settlements along the established roads to achieve more commercially oriented endeavours in hunting for the demand of the Pompeya market (Suárez et al., 2009). The connecting roads to Gorontalo have created opportunities for bushmeat dealers from Minahasa to complete round trip travel up to 1200 km to purchase meat at the North

Sulawesi, Central Sulawesi and Gorontalo province borders (Milner-Gulland & Clayton, 2002).

4.4.1.2 *The impact of access on hunting strategies*

Hunting frequency

Hunters in villages with road access hunted more frequently than those in road-inaccessible villages. Hunting was also closely related to other livelihood activities; hunters generally had another occupation and went hunting when they were not working. This finding mirrors the indigenous Buglé hunters of Panama who hunt during free time outside their agricultural labouring jobs (Smith, 2005).

In road-accessible villages, we found an informal schedule where traders from the nearest town regularly (weekly) visited the villages to buy meat. Therefore, hunters also operated on a weekly-basis to supply meat for the market demand in town. Those within the villages without road access went hunting more frequently (daily and 2-3 days per week) than hunters in road-accessible villages.

This might possibly be because the major reason for hunting in those villages was to supply family with food. Pangau-Adam et al (2012) reported that in the north-eastern area of Papua hunters went hunting weekly with different amounts of time devoted to hunting because hunting was a part-time activity only. In Arunachal Pradesh, north-east India, there was no fixed hunting schedule for hunters- they hunted when convenient. However, hunting trips occurred more often and might follow a schedule during village festivals and functions (Aiyadurai et al., 2010).

Hunting tenure

Tropical landscapes are heterogeneous, with different wildlife communities and contrasting human pressures. In villages without road access, hunters mostly hunted in primary forest. This may be because villages with less forest disturbance maintained healthier wildlife populations that could then be targeted for hunting. Recent rapid acceleration in losses of tropical forest, largely because of forest conversion to other uses, has also extended access to hunters and traders. As a consequence, hunting is largely unsustainable, creating threats to vertebrate species throughout Asian forests (Bennett & Rao, 2002). Although large-scale forest conversion was not prevalent in the

Tambrau study area, development of roads in Sidey District adjacent to Amberbaken has been accompanied by conversion of 45,000 ha of forests into an oil palm plantation (Figure 4.14). Parallel to biophysical and demographic changes associated with development, wildlife communities (e.g. species composition and relative abundance) are also changing in the new landscapes (Fitzherbert et al., 2008).

Figure 4.14: (a) New oil palm plantation in Sidey District of Manokwari. (b) Road development associated with the plantation

While changing land use to other purposes such as road connections contributes to habitat loss for typical forest species, the mixed agricultural/forest and other disturbed landscapes can provide benefits to other species. Previous studies in tropical forests have found that secondary forests bordering the road, which have expanded as a direct consequence of intensive recurrent agriculture, were exploited frequently and successfully by local hunters for wild game (Wilkie, 1989; Robinson & Bennett, 2004; Wilkie & Lee, 2004; Smith, 2005; Meijaard et al., 2006; Nasi et al., 2008; Clark et al., 2009). Therefore, secondary forests can also support substantial wild meat harvest (Gavin, 2007; Parry et al., 2009). This study found that more hunting was conducted in the secondary forests and crop lands along roadsides and bore evidence that the change in landscape provides secondary forests and crop lands with an abundance of hunting prey.

Our findings show that 69% of the 1020 hunters also farmed. The results confirmed the occurrence of opportunistic hunting as well as the involvement of females in hunting as they worked on crop lands. Smith (2005) explained that Buglé hunters in Western Panama hunting opportunistically while involved in other activities on their

farms. Women in the Wola people from the highlands of Papua New Guinea hunt opportunistically while gardening (Sillitoe, 2002). Dwyer and Minnegal (1991), reported that 44% of the female residents hunted in the Kubo people of the lowland rainforest of Papua New Guinea. This proportion was higher than in our study because they included line fishing in streams.

Hunting techniques

Road development has changed hunters' tactics to catch prey species. Different hunting techniques yield different numbers of target animals and so the most appropriate method can be used for particular species-specific behaviours. In road-accessible villages traps were used to kill prey such as deer and pig. Between 20 and 200 snare traps were set along deer and pig paths. The traps were inspected regularly, often while visiting gardens, to check and remove trapped animals. Trapping (Figure 4.15), which is predominantly used along the roadsides, shows how hunters maximised harvest rates for trading. Trapping can catch a large number of animals (Barnett, 2002) and traps are one of the simplest and most effective devices to kill animals (Fa & Brown, 2009).

Figure 4.15: (a) Hunters demonstrating how to construct a nylon trap. (b) Snare trap commonly used in hunting

Deer is the major hunting target as it provides the largest amount of meat to supply wild meat to consumers in town. Deer and pig are the most important source of income where trade has been documented (Robinson & Bennett, 2000; Fa & Brown, 2009). Elsewhere in Indonesia, such as in Jambi in Sumatra, North Sulawesi, Central

Sulawesi and north-eastern Papua, these species contributed significantly to wild meat trading (Alvard, 2000; Milner-Gulland & Clayton, 2002; Pangau-Adam et al., 2012; Luskin et al., 2014).

Furthermore, passive hunting by trapping is more affordable and less time-consuming than more active techniques. It can also be incorporated into a schedule based on farming activities and operated across wide-ranging areas. Trapping requires little or no money as traps and snares can be built from forest materials and nylon or ropes that can be reused. This allows hunters to produce large numbers of traps cheaply and easily (Fa & Brown, 2009). Importantly, building traps requires effort initially but does not require active pursuit of the animals (Lee, 2000).

Although various hunting techniques were employed by hunters, in the villages without road access active techniques (bows and arrows, spears and machetes), similar to those widely practiced in tropical Asia (Corlett, 2007), were predominant (Figure 4.16). Pattiselanno (2006) showed that native Papuans commonly used traditional hunting weapons such as bows and arrows and spears made from forest materials.

Figure 4.16: Hunter from Napan district hunting by torchlight with bow and arrow

Hunting group size

The size of groups involved in hunts are an indicator of hunting tactics, depending on the organisation of hunters, techniques used and target species. The number of hunters per group in this study was typical of traditional hunting patterns,

although larger groups of three or more hunters were mostly found along the villages with road connections. Larger groups allow division of labour during hunting and may enable effective transport of larger kills. Teams of three to six hunters cooperated in driving, snaring and carrying the animals home from the hunting sites. Larger groups may be used when they need to hunt for community festivals and religious celebrations. In the north-eastern Luzon of the Philippines, teams of hunters comprised of two to about 12 people worked together stalking and ambushing the animals (Griffin & Griffin, 2000). Similarly, in Jambi on Sumatra, hunters participated in big groups (2–6 members) and herded pigs from oil palm plantations into wire net traps (Luskin et al., 2014).

Solitary hunting was rare in this study, in contrast to the Gadio Enga and Rofaifo ethnic groups of Papua New Guinea, whose people normally hunt alone (Dwyer, 1983). Rural Mayan hunters in the Yucatán Peninsula of Mexico, prefer to hunt alone to avoid potential conflicts in relation to unfair distribution of meat from hunting (León & Montiel, 2008**).** In Gile, Mozambique, hunting returns in groups of between 10 and 30 people are shared among group members according to complicated traditional rules (Fusari & Carpaneto, 2006). In this study, there are no rules for the distribution of hunting returns. Meat was shared fairly among group members because those involved in hunting were relatives.

The involvement of women in hunting affects group composition as well as group sizes. Hunting commonly occurred during work on farms, thus stick and blade were the most common weapons used for catching prey. Small animals, including bandicoots, lizards and birds, were caught and significantly contributed to family consumption. The percentage of hunters that experienced fruitless trips is presented in Figure 4.17.

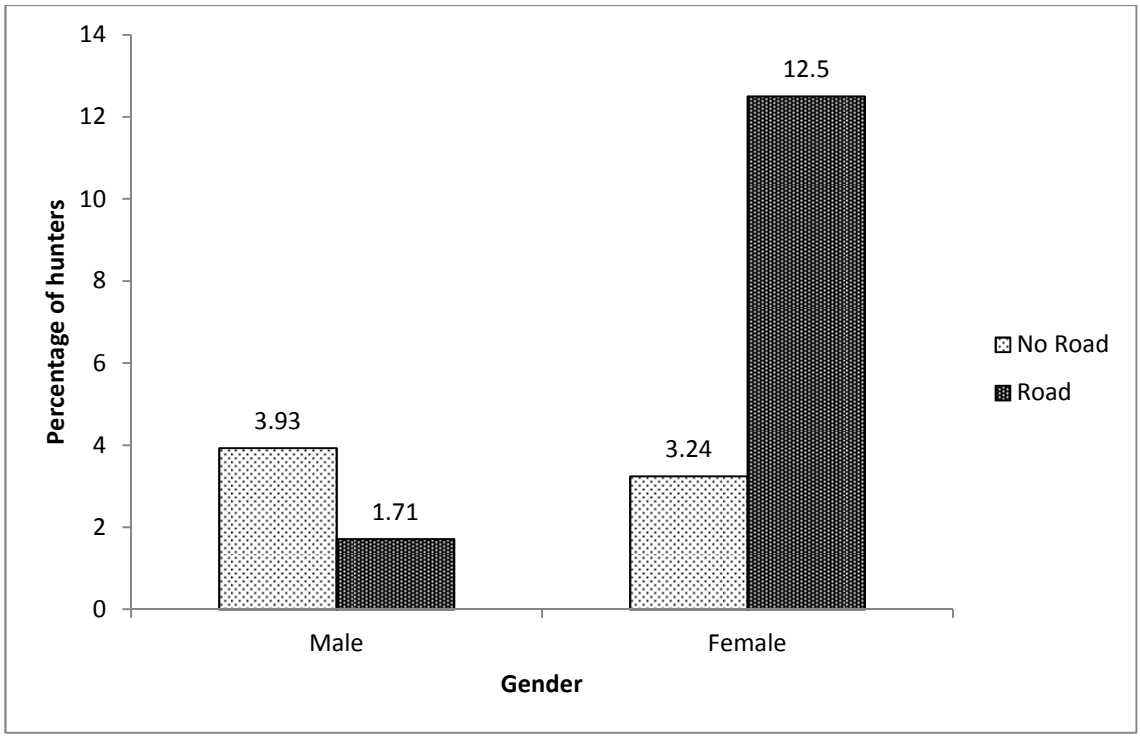


Figure 4.17: Unsuccessful hunting by gender in villages with and without road access

In Nigeria, rural women play a prominent role in the trading of bushmeat and its products at village level and in supplying urban markets (Adefalu et al., 2012). In Uganda, women played important roles in hunting, particularly in transport of the meat. They also helped sell the meat at home in the villages (Olupot et al., 2009).

Last hunting take

The greater numbers of deer brought home in the most recent hunting trips in road-accessible villages not only indicates the abundance of this species at these study sites but also its importance for trade across the villages. This also acknowledges that hunting tenures in this study was ecologically different from studies in Africa and North America, where the largest animals in sampled villages were native ungulates (deer and wild pig). In road-accessible villages (Figure 4.5) hunting was conducted in secondary forest and crop land to protect crops from damage by wild pig. Hunting of both introduced species (deer and pig) may benefit conservation of native species (Griffin and Griffin, 2000).

Species composition of the last hunting returns within the sampled villages was almost the same and they were deer, wild pig and native species (Figure 4.18). While

most hunters in road-inaccessible villages were hunting to obtain meat for food, some also hunted for sale.

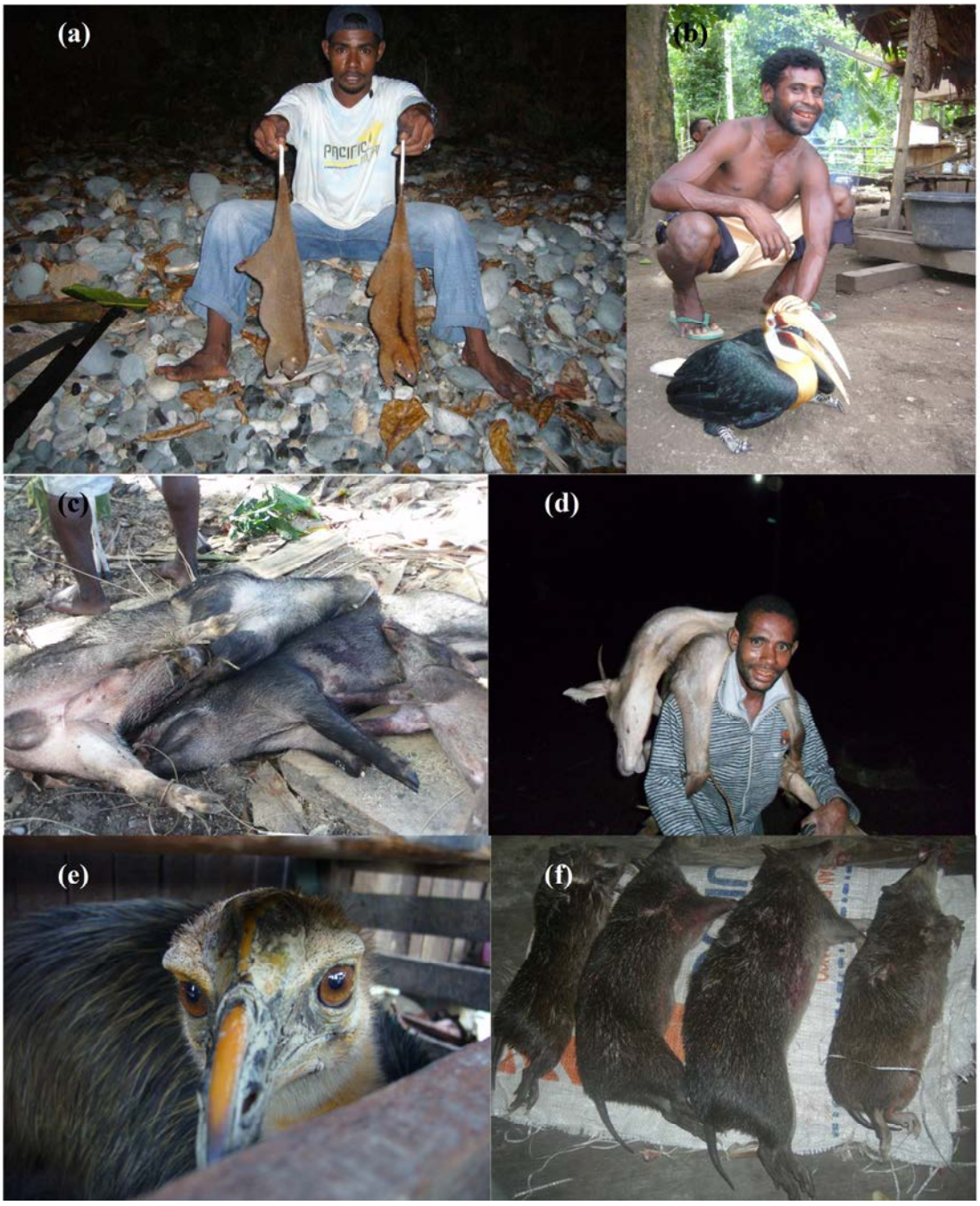


Figure 4.18: Targets of hunters on the Bird's Head Peninsula of West Papua: (a) Ground cuscus; (b) Papuan hornbill; (c) wild pig; (d) rusa deer; (e) cassowary; (f) bandicoot

In Indonesia, these wildlife compositions have led to commercial harvest of wildlife from plantations in addition to the construction of fencing systems to reduce crop damage from wild pigs and elephants (Alfred et al., 2012). In Papua, commercial

hunting for rusa deer and wild pigs not only protects native species from hunting, but is also positive for the environment, reducing crop damage.

In this study, one reason why people hunted and traded was because of the impact to the environment from deer and wild pigs, including crop damage. This differs from previous studies in West Africa, in which over-fishing by foreign and pirate fleets increases the harvest of bushmeat for both trade and household protein (Brashares et al., 2004; Redmond et al., 2006).

Deer and pigs are the most important source of income where trade has been documented (Robinson & Bennett, 2000; Fa & Brown, 2009). For example, in the Langowan market of Minahasa, North Sulawesi wild pigs accounted for 67% of animals sold each week in a 1993–1995 market survey (Milner-Gulland & Clayton, 2002). Pigs also provided 58% of the total large game harvest by weight in traditional hunting by the Wana of upland Central Sulawesi (Alvard, 2000). In Sabah, 54% of the dressed weight of animals hunted consisted of bearded pigs and 42% deer (Bennett et al., 2000). Luskin et al. (2014) found that in 2011 over 7,500 wild boars were sold in Jambi city on Sumatra alone.

Our study parallels different studies across Asia (Alvard, 2000; Bennett et al., 2000; Griffin & Griffin, 2000; Luskin et al., 2014) where subsistence hunting for ungulates is very important because many people depend on wild meat for protein. The overall range of species taken is determined by the hunter's assessment of profitability. Deer and wild pig are targeted because they provide a large amount of meat for both subsistence and sale- body size is the most important determinant of hunting target across a broad range of contexts (Alvard, 2000; Bennett et al., 2000; Milner-Gulland & Clayton, 2002; Luskin et al. 2014).

In West Papua, although the hunting target varies from one site to another, wild pig and deer are the most commonly hunted species in all study sites because they are widely distributed (Pattiselanno, 2006, 2012). Likewise, in the Jayapura region of north-east Papua the main hunting targets were introduced wild pig and rusa deer, apparently because of the large amount of meat each individual provided (Pangau-Adam et al., 2012). Pigs are an extremely important source of hunted meat for traditional groups in Southeast Asia (Caldecott, 1988) and contribute significantly to traditional economies across New Guinea, including Indonesian New Guinea (Dwyer, 1983).

Hunting practices can also interact with each other. Because road access can lead to extra income for hunters (Figure 3.2), hunting is conducted to supply meat for the bushmeat market in nearby towns. Hunting that targets large animals, in this study deer and wild pig, is important for trading. Using traps to maximise harvest rate is also common in road-accessible villages. Similarly, increased hunting group size in road-accessible villages functions to assist in meat transportation.

4.4.2 Differences in road access, hunting effort and hunting success

Infrastructure development, including roads, has affected the landscape around villages in the Amberbaken District that have been connected by roads. Roads often pass the communities' crop lands and gardens (Figure 4.19).

Figure 4.19: (a) A road under construction in the study area. (b) A previous coconut plantation that has been converted into road

Villagers agreed that the road infrastructure could pass by their plantations and gardens because they needed the infrastructure to transport their agricultural products to markets in the towns. As existing gardens were converted into roads, they had to establish new gardens further from the villages. Thus, they have to travel further and spend more time to reach their gardens.

Hunters may also travel further because the most accessible prey near human settlement and gardens are harvested first and as a result, wildlife populations near human habitation tend to be extirpated (Robinson & Bennett, 2000). Change in land use configuration can also have impacts on wildlife populations. The physical configuration of human land uses across the landscape because of infrastructure development and

increase in human population influences wildlife populations (Nasi et al., 2008). Human–wildlife conflicts in tropical landscapes are commonly due to competition for space (Madhusudan & Karanth, 2000; Linkie et al., 2007).

Laurance and Balmford (2013) explained that well-planned roads can increase farmers' access to markets, reducing waste and improving profits. Given the escalating demand for food, fibre and biofuels, researchers and policy-makers have focused on improving agriculture through the use of modern crop varieties, fertilizers, pest control and better transport. The hope is that such technologies will allow farmers to increase yields without using too much extra land (Green et al., 2005).

The greater distance travelled by hunters in villages with connecting roads (1000 m) than by their counterparts in road-inaccessible sites was probably because the presence of roads has replaced their gardens and hunting grounds with road infrastructure while allowing them to expand their hunting territories by travelling farther from the villages to hunting sites. This also indicated hunters' effort – especially those who have been connected to the market in maximising harvest rates and benefiting from the accessible roads for the wild meat market demand.

4.4.2.1 *Does road development benefit hunting effort?*

Distance to hunting grounds

Hunters travelled around 1000 m further to their hunting sites when villages were connected by road. We were not able to collect data on travel distances to hunting sites in the past, but in discussions with elders, they suggested that present hunting sites were located further from their villages than ten or even five years ago. Thus, it seems likely that distances to hunting sites are greater now than in the past and will continue to increase as road development proceeds. Perhaps the most accessible prey near roads and human settlement and gardens are harvested first, and as a result wildlife populations near human habitation tend to be extirpated (Robinson & Bennett, 2000).

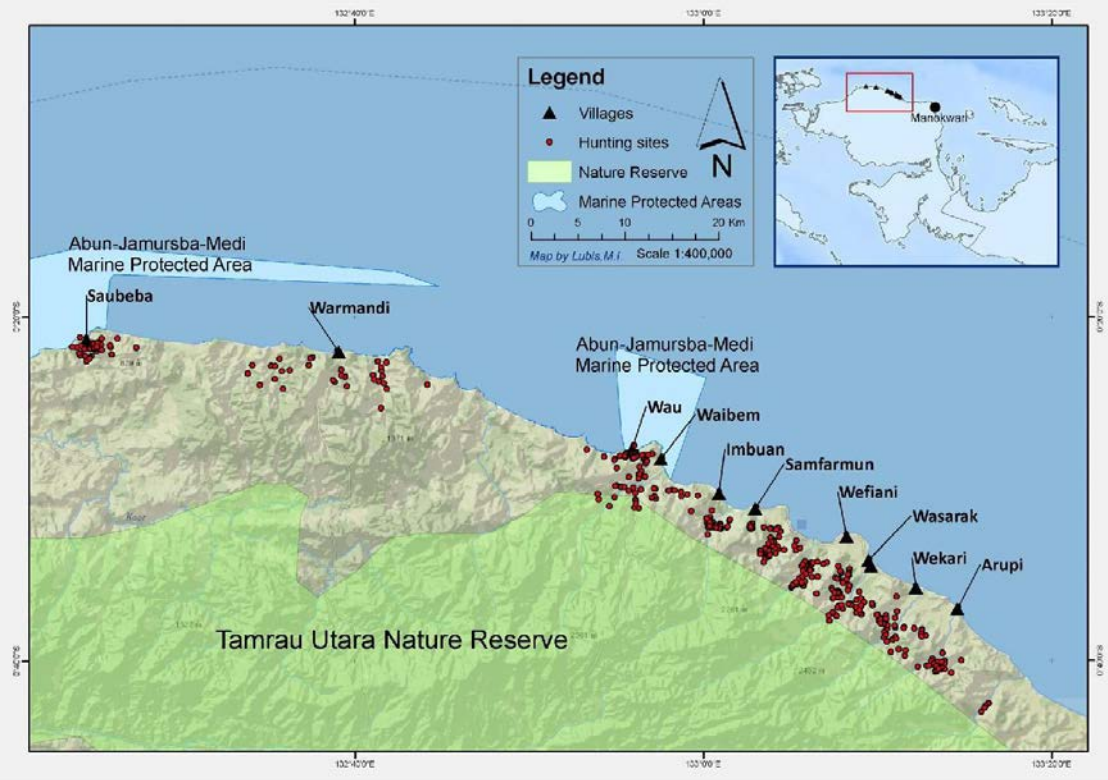


Figure 4.20: The distribution of hunting sites near 11 villages reflected distances hunters travelled from the villages. The villages of Arupi, Wekari, Wasarak and Weifani (non-MPA villages) in the east of the area were accessible by road

In road-inaccessible villages some hunting sites were close to the village (within 1 km). In road-accessible villages no hunting sites were closer than 2 km (Figure 4.20) less distance than hunters travelled in the Kemtukgresi district of Jayapura who walked 7.4 km to their hunting sites (Pangau-Adam et al., 2012). In this study, available roads only helped hunters to reach entry points into the forest. In Kemtukgresi, however, several logging roads provided ready access to more sites within the forest (Pangau-Adam et al., 2012). Similarly, Aiyadurai et al. (2010) documented increased distance of hunting sites from villages in Arunachal Pradesh, India as an effect of road development.

In the northern Congo, the presence of roads allowed hunters to travel between 15 and 30 km further from their villages (Eves & Ruggiero, 2000). Apart from access into the forest, road connections also reduced time to transport animals to the market, facilitating bushmeat trading (Mendelson et al., 2003). Established road networks not only bring hunters closer to the hunting sources, but also link the resources directly to

the market (Robinson & Bodmer, 1999). The positive relationship between distance to hunting sites and catch size indicated that the further the distance from the village to the hunting ground, the better the results obtained from hunting. These results echoed those of a study by Wilkie and Carpenter (1999), who found that seven times less prey was captured close to villages than obtained in forests more than 10 km from settlements in the Congo Basin.

Time devoted to hunting

Prey close to the settlements has been depleted as hunters worked these areas first and so hunters must progressively exploit areas further away. Blake (1994) found that hunters who spent more time travelling on forest concession roads during the night had a higher rate of return (3.7 kg/man-hour) than those who hunted closer to the settlement (2.8 kg/man-hour). This is because animal densities increase with distance from settlement, and there is more pressure near settlement due to easy access. This makes hunting unsustainable, leading to declining yields. Franzen (2006) found the same pattern in Tiimpuca hunters of Huaorani communities in the Amazon Basin of Ecuador. In this study, road access that connected villages in Amberbaken District assisted hunters to travel far from the villages, resulting in more time spent hunting. This contrasts with the report by Pangau-Adam et al (2012), in the Nimboran District of Jayapura, Papua. There, the time hunters devoted to hunting was shorter because the logging roads provided ready access to more sites within 5 km of the villages. Road construction and access to transportation cut the average distance that hunters had to walk from the villages to entry points into any section of the forest where they hunted. This helped hunters by reducing a 3- or 4-day round trip on foot to reach the hunting ground in the forests to a single day (Wilkie et al., 2000).

4.4.2.2 *Road development: a predictor of hunting success?*

Although the harvest rates were not significantly different between villages with and without road access, our data suggests that there was a tendency for hunters with road access to harvest more animals than those with no road access. This indicates that available roads may have influenced hunters to hunt more in order to benefit from trading meat. Nasi et al. (2008) explained that hunting is likely to be more profitable in

the short term than farming in isolated areas of the forest that have only recently been opened up with roads, as wildlife is still abundant.

The influence of markets on wildlife hunting is well documented. Integration of hunting with the market increases harvest rates and decreases sustainability (Robinson & Bennett, 2004). Increased hunting pressure to supply distant markets may drive harvest rates well above sustainable levels. It is clear that high levels of commercialisation are associated with high harvest rates (Bennett et al., 2002). Improvements to the highway connection between North Sulawesi and other provinces such as Gorontalo and Central Sulawesi have also led to increased importation of wild meat from other parts of Sulawesi for the wildlife market demand in Manado and Minahasa (Lee, 2000).

Women hunters also contribute significantly to family consumption. Although they hunt using stick and blade while working on farms, small animals such as bandicoots, lizards and birds were important components of the food supply. The role of women is discussed in section 4.4.1.2.

4.4.3 Road development: alternative access to other food sources

Traditionally, hunting was an extremely important livelihood activity in Papua because it provided the majority of animal protein for families (Pattiselanno, 2006; 2008). In remote areas of Papua, where access to alternative protein sources is limited and food sources from wildlife are available, hunting is conducted for household consumption (Pattiselanno, 2004; 2006). Road development has also created livelihood options and market-based livelihoods are now increasingly common. This study found that both subsistence and commercial hunting were more common at road-connected sites. The common prey species targeted benefit hunters for both consumption and trading purposes (Figure 4.7).

However, this study indicates that road connections provide more options for household consumption and decreases the reliance on wild meat as a protein source for families. More fish and vegetables are available for households in road-accessible villages with lower wild meat consumption than villages without road access (Figure 4.11), showing that access provided more opportunities to find alternative protein sources for consumption. This phenomenon has also been experienced by communities

across Asia where forests have been opened up by roads, allowing people to make a dietary switch from wild to domestic forms of protein (Bennett et al., 1995; Bennett & Rao, 2002).

4.5 Conclusion

Results of this study corroborate and expand on the findings of previous research by providing the following information: (1). Ecologically, road development has created a mosaic habitat where hunting is incorporated with other household activities such as agriculture. That is why, although hunting is not an activity in which women and children are formally engaged, this study acknowledges the involvement of women in opportunistic hunting while tending their gardens, which appears to be under-reported in the literature. In forest areas with fewer disturbances such as road development, hunting was mostly conducted in primary forest. (2) Economically, hunting is not only an important livelihood for those in forest and agricultural landscapes, but also for communities along the coast. The presence of roads has shifted livelihood options from subsistence-based to market-based, in which hunting is conducted to gain more cash income for the households. Though the scale of the trade has not yet been assessed, bushmeat trading along the coast of the Bird's Head Peninsula was important to local livelihoods. (3) Culturally, roads have changed consumption patterns of households by providing more access to alternative meals. The greater availability of alternative meals in road-accessible villages indicates a decrease in reliance on wild meat as a protein source. With the development of roads and the shift to marketing bushmeat, traditional hunting methods using bows and arrows, spears, machetes, are replaced with traps.

Chapter 5 further discusses how the availability of alternative protein sources affect hunting practices and influence wild meat consumption in coastal villages. Specifically, it investigates the role of wild meat as a source of animal protein to households.

Chapter 5 From bush to the table: the availability of alternative protein and subsistence hunting

Figure 5.1: Wild meat processing for family consumption. Meat can be dried to produce jerky, boiled with spices or charred to remove fur before further cooking and serving

5.1 Introduction

In most remote tropical forest areas, indigenous communities have difficulty accessing markets and alternative sources of protein and rely on wild meat from hunting (Bennett, 2002). Consequently, many people in tropical forests are primarily dependent on wild animal meat as a protein source (Bennett & Robinson, 2000; Milner-Gulland et al., 2003), leading to a strong relationship between hunting, the availability of alternative protein sources and wild meat consumption.

This chapter investigates the contribution of wild meat as a source of animal protein to households within and outside a marine protected area (MPA), assuming that people in MPA sites have limited access to marine resources as protein source. This chapter also assesses how the presence of MPAs influences indigenous hunting.

5.1.1 Why people eat wild meat

The significant contribution of wild meat from hunting to household meals (Figure 5.1) in Asia, Africa and Latin America is well understood. The decision to hunt or trade wildlife depends not only on the hunter's nutritional and economic status, but also on the other opportunities available for food and income generation (Milner-Gulland et al., 2003). Using wildlife for food varies between communities. Some people consume it because it is affordable, familiar, and (depending on cultural background) it is acknowledged as a high-quality meal. Others value wild meat for its taste and the fact that it offers variety in the household diet (Wilkie et al., 2005)**.** Rao and McGowan (2002) indicated that wild meat contributes significantly to rural communities in Asia, Africa and Latin America because it is more easily accessible than cultivated meat, and is often the most available dietary protein.

5.1.2 Wild meat: a major dietary protein

Studies show that wild meat contributes significantly to rural communities in Asia, Africa and Latin America because it is more easily accessible than cultivated meat, and is often the most available dietary protein (Rao & McGowan, 2002). In tropical areas world-wide, wild meat has long been part of the staple diet of forest-dwelling peoples (Fa & Yuste, 2001), and is a major source of protein for many people living in or close to tropical forests today (Bennett & Robinson, 2000). Prescot-Allen &

Prescot-Allen (1982) suggested that people in as many as 62 countries are primarily dependent on wild animal meat as a protein source.

5.1.3 Factors affecting wild meat consumption

Economic theory suggests that consumption changes with the price of goods and the price of close substitutes (Wilkie & Godoy, 2001). There are two prices that influence the consumption of wild meat: the price of wild meat itself, and the price of close substitutes such as livestock meats and fish (Wilkie & Godoy, 2001; Apaza et al., 2002). Therefore, providing consumers with access to acceptable and affordable substitutes may help to reduce unsustainable hunting and to promote wildlife conservation (Wilkie et al., 2005).

According to Smith (2005), a preference for particular species as edible game is dependent on body mass, ease of preparation, taste and cultural attitudes towards different species. In addition, Schenk et al. (2006) indicated that other cultural mediating factors also drove the demand for bushmeat, such as familiarity, tradition and prestige. Therefore, many people across Africa and Asia eat wild meat for cultural or taste reasons, though they have easy access to available alternatives (Bennett et al., 2000; Lee 2000; Madhusudan & Karanth 2000).

In some areas people have limited, or no, access to alternative animal protein sources. Consequently, they rely on wild meat and cannot readily make the switch to other sources. This can be due to a lack of specific skills, such as where people, particularly those in isolated areas, lack the skills to raise livestock. Others, based on cultural context, practice swidden agriculture that makes it difficult for them to produce alternative protein sources. This tends to occur in the most remote, traditional forest people (Bennett, 2002). In contrast, Bennett & Rao (2002) asserted that people who lived near coastal sites in Southeast Asia and West Africa were able to find available alternative protein, and decreased their dependence on wild meat.

5.1.4 How does the availability of protein sources affect hunting?

Bennett and Rao (2002) argued that the percentage of people able to find alternative protein is high in Southeast Asia and West Africa because those areas are located near coastal sites where fish are available as a chief dietary protein. Brashares et

al. (2004) showed that wild terrestrial mammals were the second choice after fish as a source of animal protein in Ghana. Traditional subsistence fishing using hand lines from small canoes provides a major source of income and food to coastal people throughout the Bird's Head Seascape (Larsen et al, 2011 cited by Mangubhai et al, 2012).

Four villages in the Abun District where this study was conducted were located within an MPA designed to protect vulnerable marine turtles and coral reefs (see section 2.3.4). This is part of a broader intent to regulate harvesting of marine resources in support of an overall management program for Indonesia's marine resources (Alder et al., 1994). Consequently, people had only limited access to marine resources, with potential to increase the consumption of wild meat (Milner-Gulland et al., 2003; Rowcliffe et al., 2005). Nothing is currently known about the effect of alternative protein source availability on wildlife harvesting in West Papua, and therefore research is crucial to understanding changes in impacts on biodiversity associated with inevitable changes in protein alternatives available to indigenous people in this region.

This study aims to assess the effect of alternative protein source availability on subsistence hunting in West Papua. Use of animal protein derived from the sea should decrease the demand for wildmeat, and conversely, restrictions on harvest of ocean resources will increase dependence on wildmeat. In particular, we aimed to gain more knowledge on the impact of availability of alternative protein on consumption patterns and the reliance of people on wild meat, assuming that one impact of the MPA was to limit access to alternative protein from the sea.

5.2 Methods

The villages in Abun are located in the MPA (Figure 5.2). We assume access to these areas is limited for those people, which potentially has flow-on effects on the consumption of wild meat (Milner-Gulland et al., 2003).

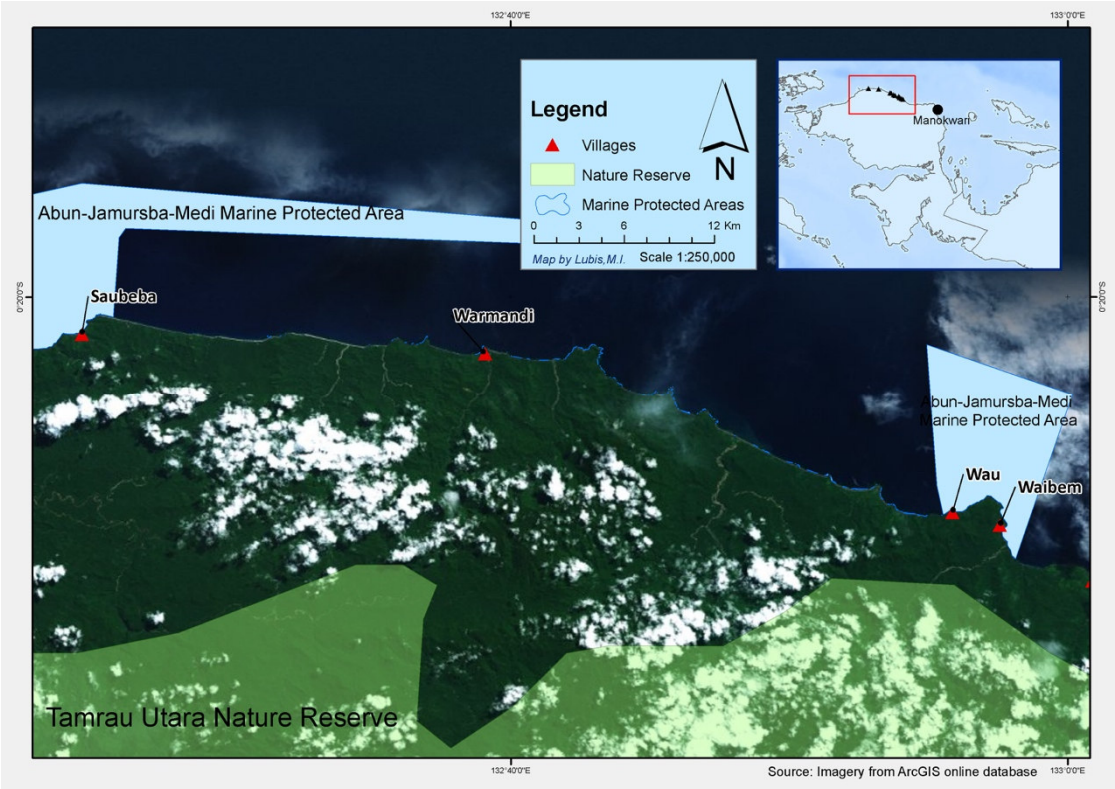


Figure 5.2: Villages in Abun District (red triangles) and MPAs (light blue) on the Bird's Head Peninsula (Modified by Irfansyah Lubis)

5.2.1 Hunting strategies for household consumption

Information on hunting activity to fulfil food requirements for households were obtained through focused respondent surveys (N = 220 respondents) and community hunting surveys (N = 800 respondents). Details of the explanatory variables for the log-linear analysis of hunting strategies (Table 4.1, section 4.2.1) and detailed methods used for data collection are presented in section 2.4.1. In this chapter, we compared hunting strategies between villages in the MPA and non-MPA sites.

5.2.2 Hunting effort and harvest rates

Data about hunting effort and hunting rates (section 2.4.1.3) were used to assess people's reliance on wild meat for consumption. The distance to hunting sites and the number of individual takes during 387 hunting episodes (Table 4.3, section 4.2.2) at MPA and non-MPA villages were compared using log-linear analysis. Hunting sites were visited to confirm information about hunting tenure obtained from interviews and

to measure the distance hunters travelled. Visits were also conducted to record the number of animals hunters captured in each hunting episode.

5.2.3 Consumption patterns

Consumption patterns were also compared between MPA and non-MPA sitesto investigate the effect of availability of alternative sources of protein on consumption. In this chapter, we develop better understanding of wild meat consumption in villages at MPA and non-MPA sites. The methods used were similar to those outlined in section 4.2.3.

5.3 Results

5.3.1 Hunting for household consumption

5.3.1.1 *Variance in hunting strategies*

That road access, population density and alternative protein sources can affect hunting separately is widely acknowledged in the scientific literature. Our findings show that those factors also correlate with each other to affect hunting strategies within our study area.

Reasons for hunting, hunting frequency and hunting tenure

Household consumption was not the only reason for hunting — trade was also a major motivation (Figure 4.2). Our findings show that the motivation for hunting varied between households within and outside the MPA. In the non-MPA households, the purpose of hunting was similar between consumption and trade at 47%, but within MPA villages more hunting was motivated by the need for household consumption and less for trade (Figure 5.3; log-linear test $\chi^2 = 4.30$, df = 1, P = 0.03).

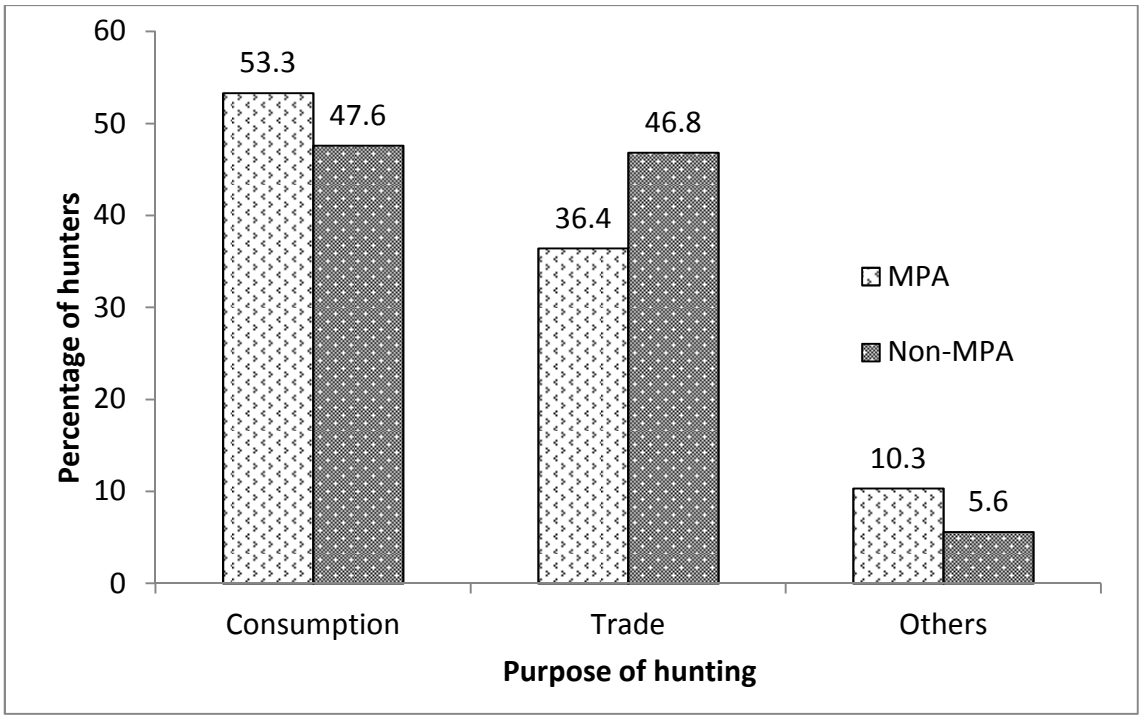


Figure 5.3: Percentage of hunters hunting for consumption, trade or other purposes. N = 318 responses from four MPA villages; N = 702 responses from seven non-MPA villages; $\chi 2 = 4.30$, df = 1, p = 0.03

Hunting frequency was not statistically different between villages inside and outside MPAs (log-linear test $\chi^2 = 2.16$, df = 1, P = 0.14). Primary forest was the dominant tenure of hunting grounds in both MPA and non-MPA villages, although in non-MPA villages hunting was also conducted in other tenures (secondary forests, riversides and crop lands) (log-linear test, $\chi^2 = 0.60$, df = 1, P = 0.43).

Hunting techniques

Hunters used a range of different hunting techniques. Active hunting techniques using machetes, bows and arrows and spears were the most common in both MPA and non-MPA villages, but hunters inside the MPA were more likely to use dogs and those outside more likely to use passive (trapping) techniques (Figure 5.4; log-linear test, $\chi^2 = 7.90$, df = 1, P = 0.004).

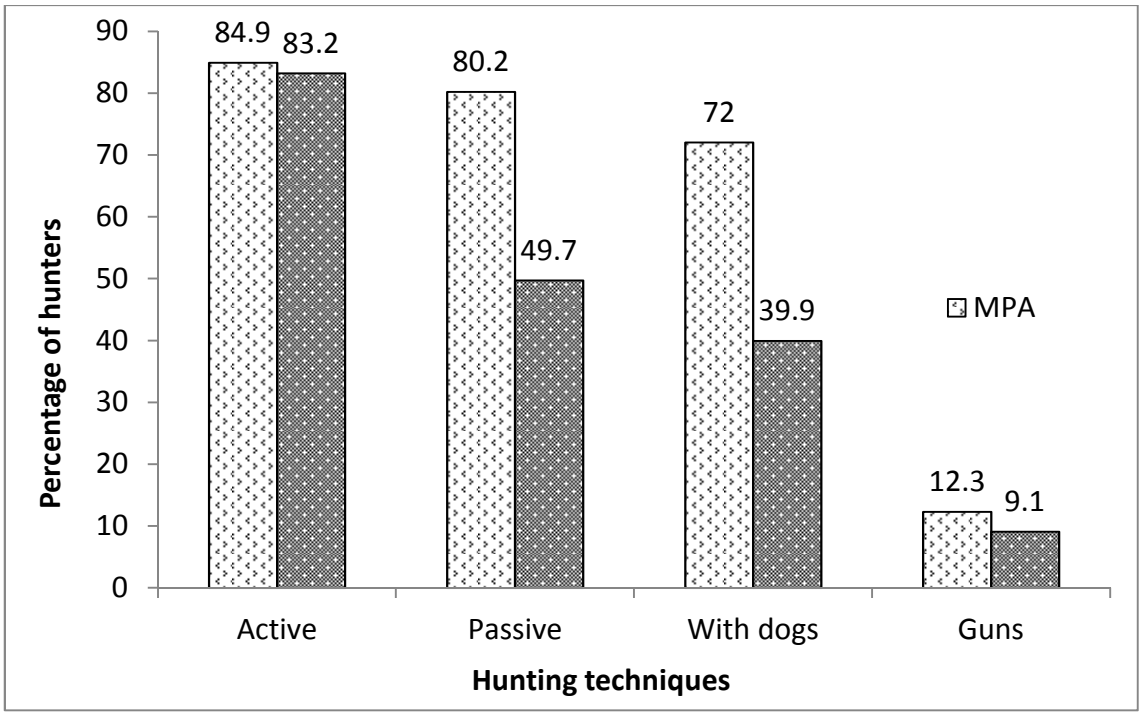


Figure 5.4: Percentage of hunters employing different hunting techniques in MPA and non-MPA villages. Percentages do not add to 100 because two or more techniques were typically used by each hunter on most hunting trips. $\chi 2 = 7.90$, df = 1, p = 0.004. Dogs and guns are active techniques but have been separated for analysis. Active hunting includes with bows and arrows, spears and machetes

Hunters preferred to hunt in big groups (more than two people) across all villages. Hunting in pairs occurred only half as much as group hunting and was more common in the MPA (Figure 5.5; log-linear analysis $\chi 2 = 14.22$, df = 1, $P < 0.0001$). Hunting was rarely conducted by lone individuals.

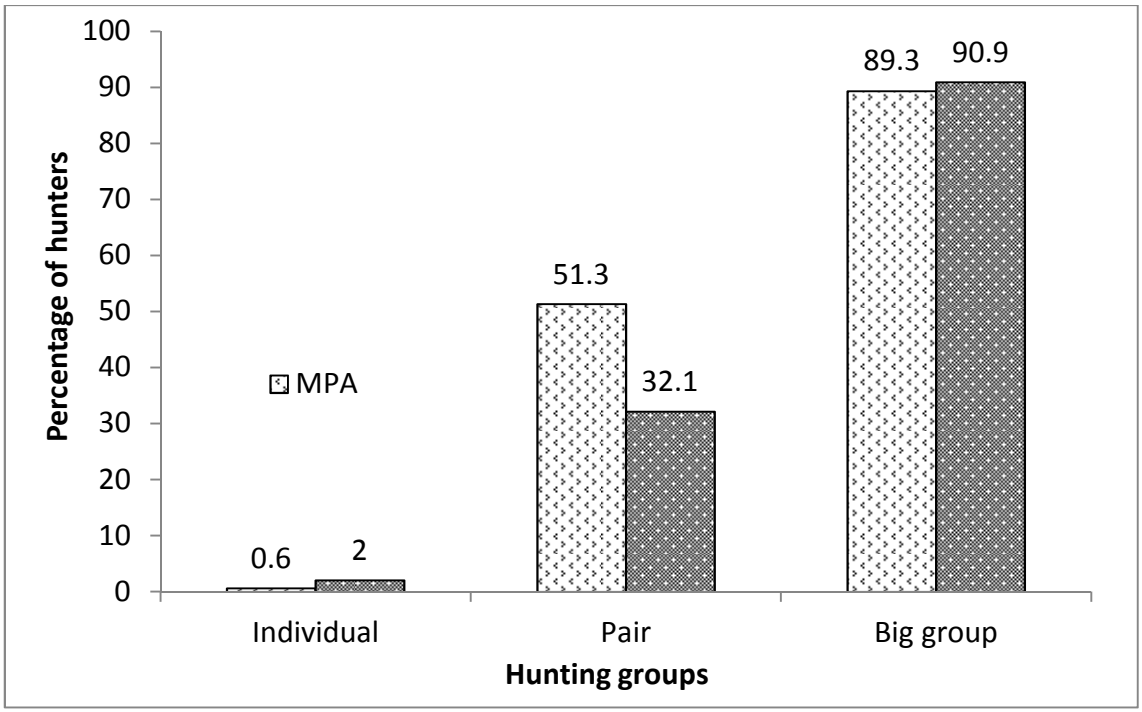


Figure 5.5: Hunting group size in MPA and non-MPA villages. Percentages do not add to 100 because hunters could be assigned to two different groups prior to interview. $\chi 2 = 14.22$, df = 1, $p < 0.0001$

5.3.2 Hunting effort

Hunting effort was assessed by investigating the distance hunters travelled to hunting grounds and the time devoted to hunting. Hunting success was assessed from the harvest rates of each hunting trip on which we accompanied hunters into the hunting grounds.

The distance hunters travelled to hunting grounds varied between sites (Figure 5.6). In the MPA villages the average distance hunters travelled to hunting grounds was (2,994 ± 2,214 m SD, N = 139), a shorter distance than hunters from the non-MPA villages, which averaged (4,818 ± 1,586 m, N = 248) (Figure 5.6; log-linear test $\chi^2 = 28.17$, df = 1, $P < 0.0001$).

The average time devoted to hunting in MPA villages was 7 ± 2 hours (N = 139) while in non-MPA villages it was 13 ± 2 hours (N = 248) (log-linear test $\chi^2 = 90.52$, df = 1, $P < 0.0001$).

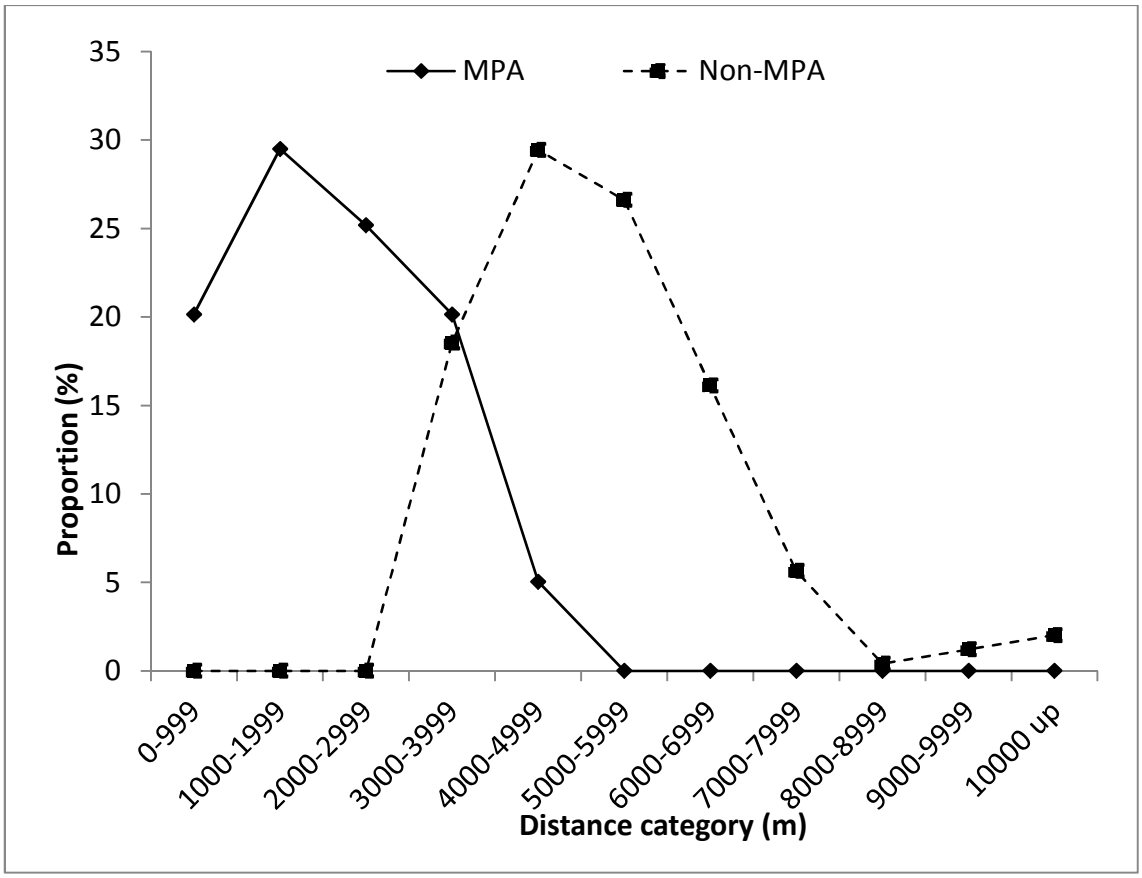


Figure 5.6: Frequency distribution of distances hunters travelled to hunting sites from MPA (N = 139) and non-MPA (N = 248) villages

5.3.3 Harvest rates

The average catch per hunting trip was two animals (section 4.3.1). Catch composition (deer, wild pig or native species) was similar across villages, as was the composition of the last hunting return in MPA and non-MPA villages (log-linear test $\chi^2 = 3.19$, df = 1, $P > 0.05$).

In total 809 animals were captured during the 387 accompanied hunting trips (this was 97% of the hunting take during that period). The average number of animals captured in the MPA villages was 1.74 ± 1.05 individuals, fewer than in non-MPA villages (2.2 ± 0.88 animals) (Figure 5.7; log-linear test $\chi^2 = 9.70$, df = 1, P = 0.001). A generalised linear model with Poisson error distribution also showed that catch was higher in the non-MPA villages than in MPA villages (Appendix E).

Deer was the most common species (39%) captured by hunters, followed by wild pig (31%) and native species (26%). This result was similar to the last hunting take data obtained from hunting interviews.

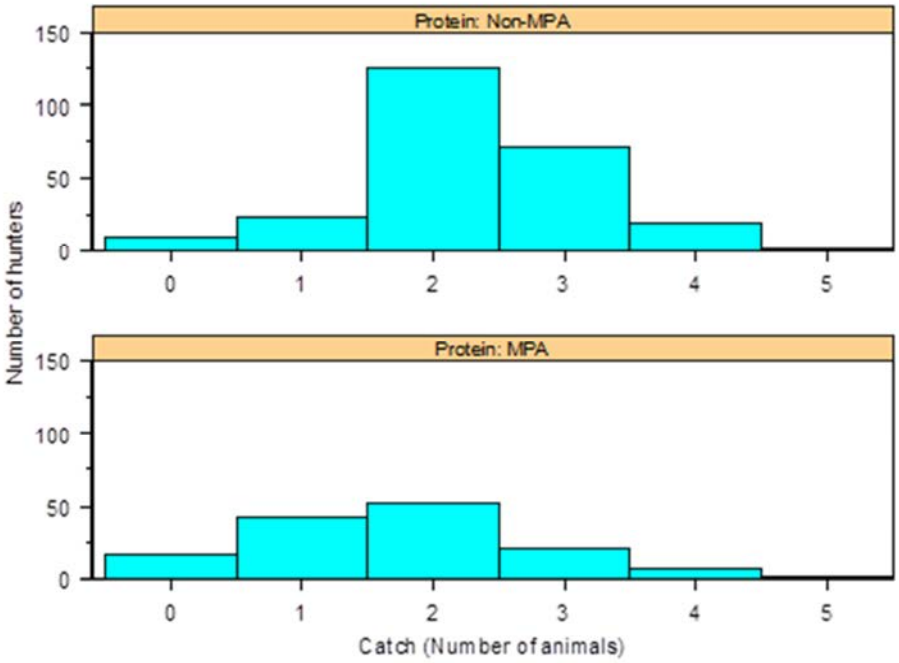


Figure 5.7: Hunting catch from 387 hunting nights in MPA and non-MPA villages

5.3.4 Wild meat in household diets

In MPA villages, 49% of households had wild meat in their meals while in non-MPA villages, only 36% of households consumed wild meat. The households who had wild meat in their diets sold high-value parts of the carcass to wholesalers and consumed the remaining low-value parts. Consumption patterns of households in MPA and non-MPA sites was similar (Figure 5.8; log-linear test $\chi^2 = 0.02$; df = 1; P = 0.88).

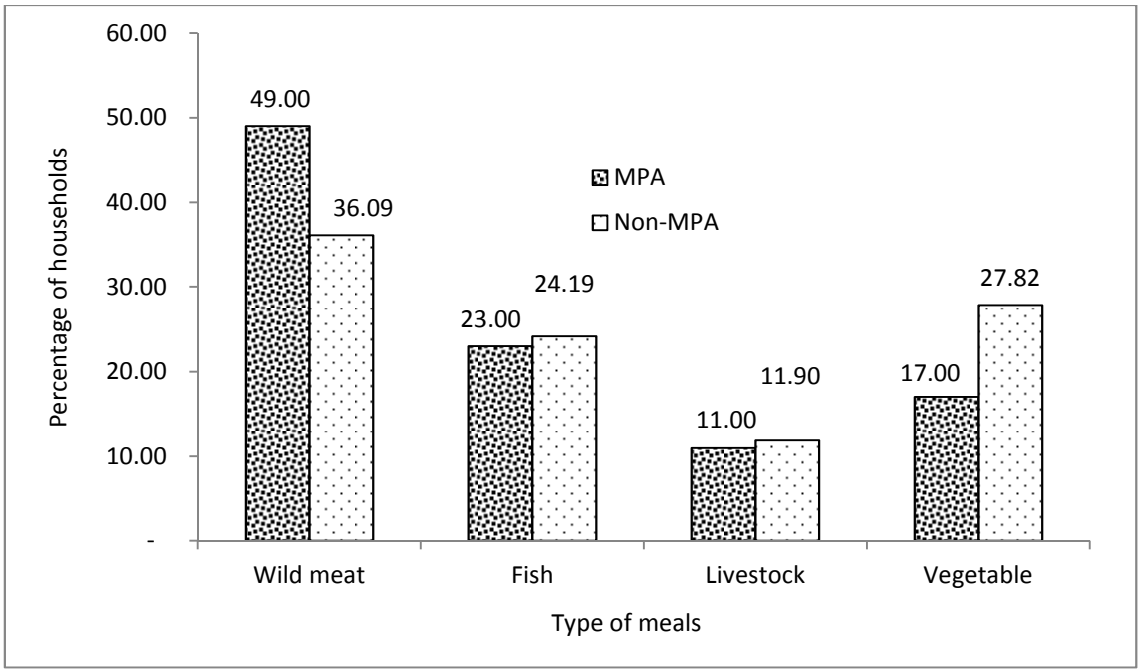


Figure 5.8: Percentage of households consuming different types of meals in MPA (N = 200) and non-MPA villages (N = 496); $\chi 2 = 0.\ 02$, df = 1, $p > 0.5$

5.4 Discussion

5.4.1 Why does hunting wild meat for consumption matter?

The high proportion of wild meat consumption by the respondents indicates that wild meat is an important component of the diet in the villages studied (Figure 5.9).

Figure 5.9: Villagers cutting wild meat into pieces before sun-drying for jerky

Not surprisingly, as most of the respondents are actively involved in agriculture (Table 4.3), the percentage of farmers is 10-fold higher (70%) than those who fish (7%). Consequently, in the sampled villages, poor fish harvest leads to less dietary protein derived from fish and leads households to rely more on wild meat consumption.

The assumption that access to marine resources is regulated by the presence of the MPA and affects the availability of protein source is not really true. This study found that both in MPA and non-MPA sites, low fish consumption was because the majority of respondents in this study were farmers; they spent most of their time farming and relied on hunting in nearby forest or disturbed areas to provide meat for consumption, similar to a previous study by Gjertsen (2011) at the same sites.

Not only did more hunters identify acquiring meat for personal consumption as their primary motivation for hunting in MPA villages than in non-MPA villages, the percentage of wild meat consumers is higher within the MPA than outside (Figure 5.8). It is tempting to conclude that restriction of access to alternative protein sources in the form of seafood has led to greater consumption of wild meat. However, there was no evidence that the consumption of fish was greater in the villages outside the MPA.

There are a number of underlying circumstances in which the situation on the Bird's Head Peninsula varies from the context of studies in Africa. First, in this study data is based on rainforest hunting whereas data on the bushmeat market in West Africa is based primarily on bushmeat hunted in the savannah zone (Rowcliffe et al., 2005). Second, frozen and dried/tinned fish are a potential substitute for bushmeat in Equatorial Guinea, West and Central Africa Africa (Rowcliffe et al., 2005; Kümpel et al., 2010). Third, unlike in West Papua, in West Africa poor fish supply is due to over-fishing by foreign industries and pirate fleets off the coast (Brashares et al., 2004; Redmond et al., 2006; Nasi et al., 2008). Our findings also contrast to those of Bennett & Rao (2002) who suggest that coastal inhabitants in Southeast Asia and West Africa have easier access to alternative protein from fish and this decreases their dependence on wild meat.

Economically, hunting is important for the communities along the coast, where villages are connected by roads and livelihoods have shifted from subsistence-based to market-based, in which hunting is conducted to gain more cash income for the households (Fig.5.7). Road connections also increase options for household consumption, evidenced by more fish and vegetables available for households in road-accessible villages and lower wild meat consumption than villages without road access (Figure 4.11). Thus, different ecosystem zones provide unique hunting prey, and socio-economic background influences consumption and trading patterns of bushmeat across the study sites.

There was potential for the pattern of wild meat consumption in MPA villages and greater trade in non-MPA villages to be confounded with road access. Some villages in the non-MPA area have road connections, allowing more access to the nearest town to look for alternative animal protein sources (section 4.3.3). Bennett and Rao (2002) explain that roads allow people to make a dietary switch from wild to domestic forms of protein. Despite that potential, there were no interactions between the factors in the combined statistical analysis (Appendix E), so neither road access nor population appear to have complicated the effect of the MPA. Furthermore, our findings showed that hunters who hunt for sale removed heads, bones, legs and intestines before selling wild meat carcasses to traders. Similarly, in Uganda, one-third of the meat on

average is consumed in hunter households and the other two-thirds are sold (Olupot et al., 2009).

As the study sites were located along the coast, it was common for the households within the MPA villages (23%) and non-MPA villages (24%) to have fish in their diets (Figure 5.10).

Figure 5.10: Fish caught by fishermen on the coast of the Bird's Head Peninsula, West Papua

Recognising that there may be distinct regional differences in dietary habits, perhaps due to cultural influences, it seems reasonable to assume that a variation in ethnic background may also lead to different dietary habits. Most of the respondents in the study were Mpur and Karon, in Amberbaken and Abun districts respectively (Figure 5.11). They originate from highland areas with free access to river fish but limited access to seafood. They occupied the land along the coast well before the villages were administratively established. Culturally they were farmers, thus farming was the main source of their livelihood along the coast (section 3.3.1.2) and fish was not the major source of protein.

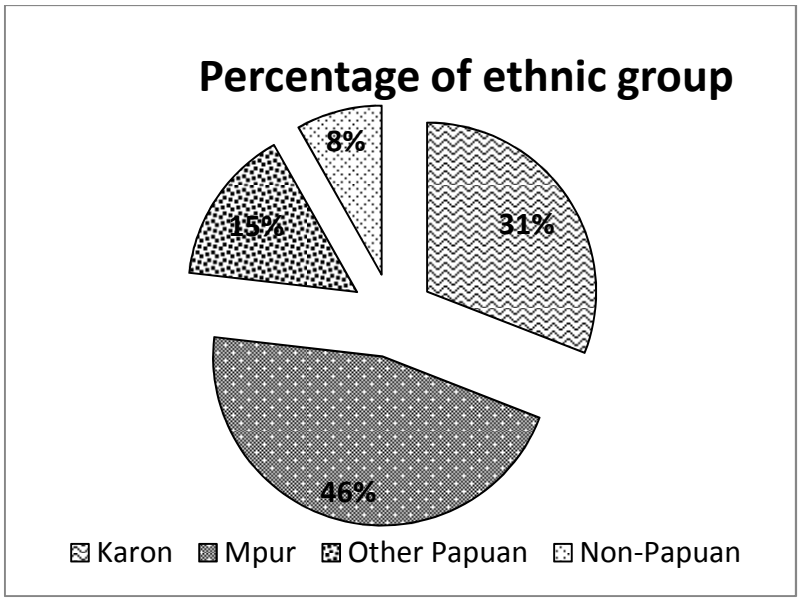


Figure 5.11: Percentage of ethnic groups within the studied villages

York & Gossard (2004) explain that fish consumption is influenced by cultural and geographical regions, so consumption trends cannot be explained by economic or ecological perspectives alone. Evidence from Gabon suggests that bushmeat availability can affect the consumption of fish (Wilkie et al., 2005).

5.4.2 Hunting practices and strategies

Hunting for consumption (Figure 5.12) was conducted by half of the respondents. This indicates that people view introduced mammals and wildlife as a significant source of food. For people involved in agriculture, like the communities in Abun and Amberbaken that took part in our study, crop lands allow the production of carbohydrates from tuber crops and bananas. However, crop lands do not provide animal protein to households and hunting is used to supply animal protein for these people. Consistent with our expectations, the percentage of hunters who hunted for wild meat consumption was slightly higher in MPAs than in non-MPAs.

Figure 5.12 A study village household member preparing wild meat for food. Cuscus meat is cleaned after scorching the fur and then cut into small pieces before further cooking for household consumption

The range of species taken is determined by the hunter's assessment of its profitability. Deer and wild pig are targeted because they provide a large amount of meat for both subsistence and sale purposes (sections 4.3.1, 4.4.1.2). Hunting yield from 33 hunters over seven months (Table 4.5) shows that all species hunted during the study also provide significant animal protein and play an important role in household consumption in the studied villages. Protein availability (Table 5.1) was calculated by multiplying dressed mass for each meat type by protein content per 100 g of meat following Albrechtsen et al. (2006).

Table 5.1: Animal protein availability of different meat types

Species	Annual dressed weight (g)	Protein availability*
Deer	10,028,571	2,757,857
Wild pig	9,642,857	2,651,786
Dusky pademelon	37,029	10,183
Grizzled tree kangaroo	86,400	23,760
Common spoted cuscus	46,286	12,729

*Calculated by multiplying the dressed meat mass for each meat type by protein content per 100 g of bushmeat (27.5 g) following Ntiamoa-Baidu (1997)

In Papua, although the hunting target varies among sites, wild pig and deer are the most commonly hunted species because they are widely distributed (Pattiselanno, 2006, 2012). Likewise, in the Jayapura region of north-east Papua the main hunting targets were introduced wild pig and rusa deer, apparently because of the large amount

of meat each individual provided (Pangau-Adam et al., 2012). Species hunted is also influenced by the abundance of animals in the study sites. The forest landscape along the coast provides suitable habitat for particular prey. Within the MPA villages the topography is very steep and hilly with flowing streams, used by deer and wild pig as habitat. Flatter areas close to the coast are developed for settlements.

Bennett and Rao (2002) argued that the percentage of people able to find alternative protein is high in Southeast Asia and West Africa because those areas are near the coast where fish are available as a chief dietary protein. However, our study found that within villages near MPAs, where access to bushmeat combined with regulation in harvesting of marine resources restricts access to marine sources (Alder et al., 1994), people used bushmeat hunting for both consumption and trading.

The availability of alternative protein from marine sources and increases in livestock and aquaculture production can greatly lessen the consumption of bushmeat (Rowcliffe et al., 2005). Across New Guinea, pig husbandry contributes significantly to animal protein consumption (Hide, 2003). Wild meat is important in providing a significant source of protein and nutrition for many rural people in the highlands without access to marine sources (Mack & West, 2005).

In this study, we found a strong relationship between prey species and methods used in hunting related to road access, population density and availability of alternative protein. Hunters relied on traditional hunting techniques. Technique preference was mostly influenced by the habitat where hunting prey was found and hunters had their own tactics according to the behaviour of the animals (active during day or night time).

Active hunting using spears, blades and bows and arrows was the most popular hunting technique. Hunters mostly relied on traditional methods of hunting based on cultural practices at the study sites. Normally, native Papuans use traditional hunting weapons made from forest materials. Various kinds of timbers, bamboo, lianas, palm leaves and plant fibres are used to build traps, bows and arrows and spears (Pattiselanno, 2006).

As road access is available to some villages in non-MPA areas, interaction between local communities and people from outside the villages influences the way they practice their traditional beliefs. Hunters believe dogs have a strong instinct to

locate and kill prey (Figure 5.13), supporting the results in Figure 5.4. When villages are connected by roads, interaction between local communities and newcomers can lead to erosion of some commonly practiced traditional beliefs.

Figure 5.13: Dogs killing prey that was chased down during a hunting excursion

5.4.3 Hunting effort and harvest rates

No MPA villages in this study have been connected by road yet, and this might have limited the distance hunters travelled to hunting grounds. In non-MPA areas, more villages are connected to roads, which allows hunters to travel further from their villages (section 4.4.2.1). This was confirmed by a generalised linear model with Poisson error distribution analysis that showed that the distance travelled to hunt was significantly greater when there was road access (Appendix E), but did not depend on marine protection, population size or an interaction between population size and either road access or marine protected areas.

5.5 Conclusion

Availability of alternative protein sources did not appear to significantly affect hunting practices along the coast of the Bird's Head Peninsula. However, traditional active and passive hunting techniques that efficiently killed prey were practiced in the sampled villages. In addition to these techniques, hunting with dogs played an important

role in the MPA villages as people believe dogs have a strong instinct to locate and kill the prey and that they also protect hunters and their families from evil spirits.

Household consumption was not the only reason for hunting — trade was also a major motivation. Hunting in both MPA and non-MPA villages was to provide meat for family consumption and trading for extra cash. Food consumption patterns of households in MPA and non-MPA villages were similar, and low fish consumption was because most respondents in this study were farmers; they spent more of their time farming and mostly relied on hunting for protein. The difference in the distances hunters travelled to hunting grounds was influenced by the roads that connected some non-MPA villages.

The high proportion of wild meat consumption by the respondents indicates that wild meat is an important component of diets in the villages studied. Our results are quite different from studies in Africa. Our data was mainly based on hunting practices in the lowland forest near the coast. Fish consumption in this study was not the frozen, dried and tinned fish in other studies in Africa. Our findings also suggest that although the study sites were located along the coast, available alternative protein from fish had not decreased the people's dependence on wild meat.

The general conclusions on the impact of road access, population density and availability of alternative protein and their interactions are discussed in Chapter 6. Chapter 6 also provides priorities for general approaches to address people's needs and aspirations while at the same time conserving wildlife species and the remaining tropical forests in New Guinea.

Chapter 6 Impacts of population, access and availability of alternative protein

Figure 6.1: Papua and West Papua Provinces of Indonesia

Indonesia's Papua and West Papua provinces (Figure 6.1) on the island of New Guinea encompass 404,600 km^2 or about 42 million hectares (Badan Planologi Kehutanan, 2002), of which 80% is tropical forest. It represents one of the highest levels of flora and fauna diversity and endemism in Indonesia; 15,000–20,000 plants, 146 mammals, 329 reptiles and amphibians and 650 birds inhabit the diverse ecosystems of Papua. The 1125 animal species represent more than 50% of Indonesia's terrestrial vertebrate fauna biodiversity (Conservation International, 1999).

West Papua is the least populous province in Indonesia, with only 0.32% of the total national population (Badan Pusat Statistik Papua Barat, 2011). The population of West Papua more than tripled from 221,457 in 1971, when it was part of Papua Province, to 760,422 in 2010 when it had become a separate province. West Papua has the fourth highest population growth in Indonesia (3.98%) behind Papua Province (5.39%), Riau Islands Province (4.95%) and East Kalimantan (3.81%). In the 1990 census the total population had reached 385,509, an average population growth of 2.38% annually (Badan Pusat Statistik Papua Barat, 2011).

Despite this relatively small population, Papua has a much greater diversity of ethnicities and cultures than any other Indonesian province. Mansoben (2007) estimated that about 269 living local languages are spoken in Papua, providing group identity as well as a means of communication. Each ethnic group has its own way of using forest resources, and different species are used to maintain local livelihoods.

West Papua has a resources-dependent economy. Road development (Figure 6.2) is a high priority of government and creates an array of environmental pressures.

Figure 6.2: (a) Gravel road connecting villages in Amberbaken District, (b) Improved road from Manokwari to the nearest town, Prafi in Arfu, the district next to Amberbaken. In villages with no accessible roads, small boats (c) and ships (d) are regularly used as transport to the nearest towns

In many cases extractive initiatives also overlap with vulnerable indigenous territories where the absence or weakness of local governments, and the lack of economic alternatives often result in impacts that go well beyond ecological or environmental modifications to include drastic social changes that affect both the livelihoods of local groups, and the wildlife upon which they depend (Suárez et al., 2009).

Although provincial development brings improvement in education and health care infrastructure and creates alternative jobs in the local community, major landscape changes also have negative impacts on the natural resources on which indigenous people are dependent. This research is crucial to understanding the impact of changes occurring in West Papua — increasing population density, road development and availability of alternative protein sources — on the long-term sustainability of wildlife populations.

6.1 Human population

Overall the reasons for hunting were similar across villages with different population density: for food, sale and other purposes. In villages with high population density hunting was mostly for household consumption. Although hunters from high-density villages reported more hunting for consumption, meal survey data showed that wild meat was more common in meals in low-density villages. These findings seemed initially to be contradictory until we realise that although hunters in low-population villages reported their intent to hunt for trade, they kept some parts of the carcasses including head, bones, legs and intestines, for family consumption. Consequently, although hunters sold meat to dealers they still had parts of bushmeat for family consumption. Similarly, in Uganda, on average one-third of the meat is consumed in hunter households and the other two-thirds are sold (Olupot et al., 2009).

In this study, active hunting using spears, blades and bows and arrows was the most popular hunting technique used. In contrast, hunting with guns was the least used in villages with both high and low human populations. Despite the reliance on traditional hunting techniques, 10% of the prey was killed using guns. Hunting techniques are showing shift from traditional to modern techniques using firearms. As shown in other studies, the use of guns has increased because they are a very powerful and effective way to kill large animals (Carpaneto & Fusari, 2000; Fa & Yuste, 2001; Bennett et al., 2002).

Both subsistence and commercial hunting were more common along the coastal area of Bird's Head Peninsula than cultural hunting or hunting to reduce damage to crops. The composition of catch during the study was similar across the villages and was dominated by deer and wild pig, indicating the importance of both species for trading as well as for consumption.

In this study, the harvest rates of particular species were also more likely to be influenced by market demand and consumer preference for particular bushmeat. Bushmeat was rarely sold to other villagers within a village. Median income ranged between IDR 1,100,000 in low-population villages and IDR 1,300,000 in high-population villages. In this study, per capita monthly income from selling bushmeat alone during the seven-month hunting period reported by 33 focal hunters was IDR

895,238 (US$ 68; N = 18) or 59% of monthly income in high-population villages and IDR 1,122,143 (US$ 85; N= 15) or 89% of monthly income in low-population villages. Such a high income from selling mostly introduced and saleable bushmeat species may urge hunters to increase hunting yield to gain more cash from bushmeat trading.

In contrast to studies from Africa and South America, the bushmeat trade in this study was still a relatively small ecocomic activity. Estimates of the national value of the bushmeat trade range US$42–205 million in countries in West and Central Africa (Davies, 2002). In the Congo Basin the scale of meat trade reached about 5 million tonnes/year or more than 250US$ millions annually (Wilkie & Carpenter, 1999). In the Amazon Basin the value exeeds US$ 175 million per year, and in Côte d'Ivoire it was estimated to be US$ 200 million (Rao & McGowan, 2002). For poor hunters in both high- and low-population villages in this study, increased hunting yields provide important cash income for household livelihoods. Thus, providing alternative sources of income to the household may lessen the reliance of people on hunting.

A number of subsistence activities including shifting cultivation, cultivation of trees and palms, smallholder husbandry (pigs, goats and chickens), fishing and hunting were practiced by households along the coast. In this study, hunting is not a primary source of income. Coastal inhabitants derived income and sustained their livelihoods from a variety of sources; most hunters worked full time on another job (e.g. as farmers, fishermen, government staff, paid labour as mining and conservation workers, and students) and hunted part-time to gain extra income. Agricultural crops played a significant role as the primary source of income, and hunting was performed during leisure time, time off from jobs or after planting and harvest sessions for an alternative income. Villagers identified as farmer-hunters and hunted on a part-time basis. In doing so, they shifted intermittently between major and temporary occupations for cash to supplement crop-related incomes.

Our data showed that the extreme top and bottom age classes only accounted for 5% of hunters with the majority of hunters aged between 20 and 60 years old. Children and women – in this study 20% – were involved in hunting during work on farms. They also transported vegetables, tuber crops and other garden products for their meals back to the villages. While working in the garden, women and children took the opportunity to hunt small prey such as bandicoots or birds. Consequently, although they did not kill

large animals, captures brought home by women and children were a significant contribution to family consumption.

In villages with low human population density the proportion of hunting in non-primary forest tenures (secondary forests, riversides and crop lands) was higher than in those with high human density, indicating both that hunting may be part of traditional farming activities in gardens and fallows and that lower population densities allowed those species to persist in those land uses. With increasing human population, the proportion of hunters decreased. In non-MPA villages with high human populations which have been connected by roads, more options were available for household consumption, decrease the reliance on wild meat for consumption and the proportion of hunters become less. This also suggests the increase in population has created more pressure on hunted species overall, but the impacts are limited in spatial scale. The presence of roads gives people opportunities to find alternative forms of protein (Bennett & Rao, 2002).

6.2 Road development

Road development has an impact on the behaviour of hunters. Roads increase the motivation of villagers for hunting as a source of income. Roads play important roles where there are strong economic incentives to provide access to large-scale logging, oil and mineral operations as well as agribusiness (Laurance & Balmford, 2013). Our studies mirrored results of previous studies that have been conducted in other tropical areas. Many studies have shown that the local communities relied on hunting because it was an important alternative source of family revenue in the Philippines, Ghana, India and Indonesia (Shively, 1997; Mendelson et al., 2003; Hilaluddin et al., 2005; Pangau-Adam et al., 2012; Luskin et al., 2014).

Commercialisation of the wild meat trade increases the number of consumers, the amount of hunting, the incentive to hunt and the entry of non-resident (often commercial) hunters into hunting sites (Bennett & Robinson, 2000). In my study area, commercial traders have benefited from road improvements, allowing them to travel faster and further to buy meat from villages that have been connected by roads along the coast of Amberbaken District. Traders travel either by motorbike or vehicle to buy meat from hunters in the villages, mostly at weekends. My results were similar to a study in

North Sulawesi, a highway connecting Gorontalo and Minahasa created opportunities for bushmeat dealers to complete the round trip of up to 1200 km to purchase meat for urban markets (Milner-Gulland & Clayton, 2002).

Physically, road development increases ease of access by people to hunting areas and may influence hunting pressure. Easy access to hunting sites from villages that are connected by roads increases hunting pressure on wildlife resources (Auzel & Wilkie, 2000; Fa, 2000; Madhusudan & Karanth, 2000). The presence of roads also influences access from hunting areas to markets and other commercial centres. As a result, commercial hunting tends to increase (Bennett et al., 2000; Clayton & Milner-Gulland, 2000) and hunters become more involved in the cash economy so their tendency to sell wild meat to invest in hunting technologies such as weapons and ammunition and batteries for hunting lamps increases (Bennett et al., 2000; Stearman, 2002). Road access can also help hunters travel to hunting sites, but their range is limited to the traditional access regulated by societies and does not depend on recent changes in access.

Despite the fact that land use change driven by road connections contributes to a loss of habitat for typical forest species, mixed agricultural/forest and other disturbed landscapes can provide benefits to some species. Thus, hunters shift their attention to hunting in secondary forests and crop lands. Previous studies throughout the tropical forest biome have found that secondary forests bordering roads, which have expanded as a consequence of shifting agriculture, are exploited frequently and successfully by local hunters for wild game (Wilkie, 1989; Robinson & Bennett, 2004; Wilkie & Lee, 2004; Smith, 2005; Meijaard et al., 2006; Nasi et al., 2008; Clark et al., 2009).

Hunters also use traps to maximise harvest rates for particular prey such as deer and pig for sale. Traps are the simplest and most effective devices to kill animals (Fa & Brown, 2009) and, catch a large number of animals (Barnett, 2002). Previous studies have found that deer and pigs are the most important source of income where trade has been documented (Robinson & Bennett, 2000; Fa & Brown, 2009). In Jambi Province in Sumatra and in North Sulawesi, Central Sulawesi and north-eastern Papua, deer and pigs contribute significantly to the wild meat trade (Alvard, 2000; Milner-Gulland & Clayton, 2002; Pangau-Adam et al., 2012; Luskin et al., 2014).

Although roads increase wild meat commerce, my study also indicates that road connections provide more options to find other sources of protein for household consumption and in some circumstances may decrease the reliance on wild meat as a protein source. This matches the experience of communities across Asia; when forests have been opened up by road people make a dietary switch from wild to domestic forms of protein (Bennett & Rao, 2002).

6.3 Availability of alternative protein

The fact that road access, population density and availability of alternative protein sources can affect hunting separately has been widely acknowledged in the scientific literature. Our findings show that those factors can also interact with each other in affecting hunting strategies at our study sites. In all MPA's villages which have no road connection, hunting is performed to achieve the need for both trading and consumption.

In this case, hunting introduced species not only benefits conservation of native species, but is also ecologically positive to the environment by reducing crop damage. Economically, this also indicates the profitability of hunting introduced species, because of the large amount of meat provided by each animal caught since ungulates are marketable commodities. One of the important outcomes of this study is the illustration that indigenous hunting along the coast of the Bird's Head Peninsula is significantly different from the situation in Africa, North America and Asia.

Household consumption was not the only reason for hunting – trade was also a major motivation. Half of the respondents hunted for consumption, indicating that people view wildlife as a significant source of food. Consistent with our expectations, the percentage of hunters who hunted for wild meat consumption was slightly higher in villages adjacent to MPAs than in non-MPA villages.

Bennett and Rao (2002) argued that the percentage of people able to find alternative protein is high in Southeast Asia and West Africa because those areas are located near coastal sites where fish are available as a chief dietary protein. However, our study found that villages within MPAs, where there was restricted access to marine sources (Alder et al., 1994), used bushmeat hunting for both consumption and trading.

The range of species taken is determined by the hunter's assessment of its profitability. Deer and wild pig are targeted because they provide a large amount of meat for both subsistence and sale. Bennett and Robinson (2000) stated that commercialisation can increase hunting of non-commercial species, in this study native species. When local people are involved in commerce they often turn to non-commercial species for their own subsistence as illlustrated by locals in the Peruvian Amazon (Bodmer & Puertas, 2000). Species hunted is also influenced by the abundance of animals in the study sites. The forest landscape along the coast provides suitable habitat for particular hunting prey. Topographically, area within the MPA villages is very steep and hilly with flowing streams, suitable for deer and wild pig habitat. Flatter areas near to the coast have been developed for settlements.

Active hunting techniques using machetes, bows and arrows and spears were the most common in both MPA and non-MPA villages, but hunters inside the MPA were more likely to use dogs and those outside MPAs, who were more likely to use passive (trapping) techniques. Hunting with dogs is the most common practice across Southeast Asia and New Guinea (Corlett, 2007). The higher percentage of hunters hunting with dogs in the MPA villages was strongly related to the beliefs of the local communities. Restricted road access to villages in MPAs limits the interaction between local communities and people from outside the villages becoming less and influence the way they practice the traditional beliefs.

The assumption that access to marine resources is restricted by the presence of MPA and affects the availability of alternative protein sources is not really true. This study found that both in MPA and non-MPA sites, low fish consumption because the majority of respondents in this study were farmers; they spent more of their time farming and mostly relied on hunting in close-by forest or disturbed areas to provide meat for consumption, similar to results from a previous study by Gjertsen (2011) in the same sites.

The consumption pattern of the households in both sites was similar. It is tempting to conclude that restriction of access to alternative protein sources in the form of seafood has led to greater consumption of wild meat. However, there was no evidence that the consumption of fish was greater in villages outside the MPA.

It seems likely that the pattern of wild meat consumption in MPA villages and greater trade in non-MPA villages is actually more closely associated with road access. Some villages in the non-MPA area have road connections, which allow more access to the nearest town to look for alternative animal protein sources. Bennett and Rao (2002) explained that roads allow people to make a dietary switch from wild to domestic forms of protein. Furthermore, our findings showed that hunters who hunt for sale removed heads, bones, legs and intestines before selling wild meat carcasses to traders. Similarly, in Uganda, one-third of the meat on average is consumed in hunter households and the other two-thirds are sold (Olupot et al., 2009).

As the study sites were located along the coast, it was common for the households within the MPA villages (23%) and non-MPA villages (24%) to have fish in their diets. Recognising that there may be distinct regional differences in dietary habits, perhaps due to cultural influences, it seems reasonable to assume that variation in ethnic background may also lead to different dietary habits. Most of the respondents were Mpur and Karon in Amberbaken and Abun districts respectively. They were originally from the highlands and occupied the land along the coastal far before the villages were administratively established. Culturally they were farmers, thus farming was source of their livelihood along the coast. York & Gossard (2004) explained that fish consumption is influenced by cultural and geographical regions, so consumption trends cannot be explained by economic or ecological perspectives alone. Evidence from Gabon suggests that bushmeat availability can affect the consumption of fish (Wilkie et al., 2005).

6.4 General approaches to reduce reliance on wild meat

The preceding discussions essentially describe factors that have a definable impact on indigenous hunting along the coastal landscape of the Bird's Head Peninsula. In reality, road development, an increase in human population and availability of alternative protein, either by themselves or in concert, affect hunting practices in the study sites. Accordingly, we consider here general approaches to deal with the real situation in the study sites.

For many of the rural households along the coast of the Bird's Head Peninsula wild meat is not a luxury or something that they only turn to in times of hardship.

Introduced species (deer and wild pig) are the largest mammals in Papua, a vital source of animal protein, and commodities that can be sold. The people we studied mainly hunted introduced species in degraded habitats and there was little evidence of hunting of native species or those of conservation concern (Pattiselanno & Koibur, 2008; Pattiselanno & Arobaya, 2013). Large numbers of rusa deer and wild pig brought home in recent hunting trips not only indicates the abundance of the species in these study sites, but also their importance for trade. Hunting of both introduced species may have benefit for conservation of native species.

Our study parallels different studies across Asia (Alvard, 2000; Bennett et al., 2000; Griffin & Griffin, 2000; Luskin et al., 2014) where subsistence hunting for ungulates is very important because many people depend on wild meat for protein. These species, especially wild pig, were hunted in secondary forest and crop lands to protect from crop damage.

In this study only 26 individuals (9%) of the catch over the seven-month observation period were native species (Table 3.5). One possibility is that native species may have already experienced severe population declines because they are more susceptible to hunting. Parallel to biophysical alterations, such as road access and forest conversion, and demographic changes, wildlife communities (e.g. species composition including native species and relative abundance) are also changing within new landscapes (Fitzherbert et al., 2008). However, our survey suggests that hunting is not currently exerting the greatest pressure on native species.

However, this study agrees with Bennett and Robinson (2000) that hunting may change the size structure of the biological community and decrease the representation of large-bodied species. When the large-bodied animals (in this study deer and wild pig) become scarce, hunters will look for the small-bodied animals, most of which are native species. Therefore, in order to concentrate on the twin imperatives of addressing people's needs and aspirations and at the same time conserving the world's last wildlife species and the remaining tropical forests in New Guinea, many scientists suggest that alleviating poverty is key (Robinson and Bennett, 2002; Redmond et al., 2006; Nasi et al., 2008). They advocate an approach that integrates efforts to (1) provide alternative sources of protein and income for the rural people, (2) improve agricultural

infrastructure, (3) provide economic opportunities and employment, (4) educate people especially hunters and consumers.

6.4.1 Providing people with alternative livelihoods

Providing people with alternative livelihoods is important to reduce their dependence on wild meat for food and trading. The villagers in this study originate from highland areas with free access to river fish but limited access to seafood. Looking at the potential of fish and livestock and the available fodders to support their development, the first alternative is to establish programs to provide domestic animals or livestock to meet needs for rural households. Lee (2000) suggested that establishing nutritional programs is the most economically feasible approach to assist in forming village cooperatives for small-scale farming of domesticated animals such as pigs, goats and chickens.

The situation in West Papua different from that in Africa, where landscapes and ecosystems are different, comprising unique wildlife communities with contrasting dynamics and human pressure (Fa & Brown, 2009). Several factors have been identified as drivers of bushmeat hunting in Africa, including war and civil strife, weak governance and institutional deficiency (Redmond et al., 2006). War affects bushmeat hunting in a number of ways (Draulans & Van Krunkelsven, 2002, cited by Redmond et al., 2006), and the increased circulation of weapons and ammunition is also successfully used in hunting for food and selling bushmeat. In Africa, the three taxa mostly used for human consumption are large ungulates, rodents and primates (Redmond et al., 2006).

Even so, native species are also harvested. From a practical standpoint, local government needs to tackle the dilemma of wild meat consumption using several strategies in parallel (Olupot et al., 2009). These could include enhancing awareness of fish as an alternative protein source and increasing livestock production (Bennett & Rao, 2002; Olupot et al., 2009). The importance of these implementation strategies is likely to vary by location.

6.4.2 Improving agricultural infrastructure

The availability of productive agricultural land is not a problem in our study sites, as farming including livestock production makes a significant contribution to the

household income (Gjertsen, 2011). Culturally, people in the study sites were farmers, thus farming was source of their livelihood along the coast (section 3.3.1.2). Most of the hunters also farmed and sold agricultural products outside their villages. However, farmers face a number of barriers to increasing production. They need access to fertilizer, insecticides and modern agricultural equipment to increase crop production. Technical assistance from agricultural extension workers is urgently needed (Gjertsen, 2011).

This study site is populated by small-scale farmers who currently produce food mainly for local consumption. Increasing agricultural production is important for increasing cash income. Although road access is associated with environmental problems, better access to the study sites will also provide access to fertilizers, insecticides, modern farming methods and urban markets for sale of crops. Nasi et al (2008) suggested that farming is likely to be more profitable than hunting in communities that are adjacent to roads and that have been inhabited for a long time. Although agricultural crops have a lower unit value than wildlife, they can be produced in significantly greater quantities than bushmeat and the presence of roads makes transporting them to markets relatively easy. Thus, roads may have both positive and negative consequences for wildlife. The outcome will be determined by the balance between the effects of improving agricultural production and hence income with those of accessibility.

6.4.3 Economic opportunities and employment

For the rural poor with limited access to agricultural markets, the forest provides building materials, fuel, traditional medicines, food and income (Milner-Gulland et al., 2003; Mockrin et al., 2005). Hunters in this study acknowledged that income from hunting is used to pay for medication, children's school fees and other household needs. A national program to subsidize poor households with free health services and school fees for children may help to minimize the reliance on hunting to support health and education costs.

Raising people's incomes by providing alternative sources of revenue is important to lower their reliance on wildlife hunting (Robinson & Bennett, 2002). Bennett (2002) suggested that forest people face problems including remoteness from

markets, lack of cash coming into the community, lack of skills and cultural difficulties. Development efforts should also be focused on creating jobs for remote rural communities to change the behaviour of wild meat purchasers (Robinson & Bennett, 2002).

Collaboration between local governments and the private sector (including logging concessionaires, agro-industrials) should be established to implement good-practice guidelines and benefit sharing (Redmond et al., 2006). The current expansion of palm oil plantations following road development may provide opportunity to recruit local people to work in the plantation and reduce the reliance on hunting for income. In this study, hunters in Abun District also worked as paid labour in mining and logging companies and had good incomes to support their family. Hunters within villages with high population densities had better alternative incomes; they hunted more frequently than their counterparts in low-population villages. The private sector can also be involved in transporting fertilizers, insecticides and other agricultural equipment to local farmers to support agricultural production. At the same time, agricultural products can also be sold to the logging, mining or the agro-industrial companies as a part of the benefit-sharing approach.

6.4.4 Educating hunters and buyers

If the dependence on wild meat is to decrease in order to be sustainable, the people whose behaviour must change are both those who hunt and sell wildlife and those who buy it (Robinson & Bennett, 2002). Current nationwide media and education campaigns in the form of pamphlets, posters, public presentations and discussions are inadequate (Lee, 2000). Information should also be provided to consumers about the negative impacts of consuming wildlife species and to hunters about the legal repercussions of trading in protected species (Lee et al., 2005).

In Papua and West Papua provinces, the Church is the most respected institution and plays an important role in the lives of native Papuans. Therefore, efforts to work with churches and community groups should be enhanced to increase community awareness (Lee, 2000). Education about the impact of intense animal harvesting will be critical to the survival of wildlife populations. Such an approach must include the perspectives of national and local government agencies, international development and

conservation support organisations, commercial logging and mining companies and local NGOs. They must be incorporated into decision-making because each of these groups has a role in exploitation of products from the forests (Eves & Ruggiero, 2000).

This study is the first detailed investigation of how road development, increases in human population and availability of alternative protein separately and jointly impact indigenous hunting along the coastal landscape of West Papua. From a practical standpoint, policy to tackle the dilemma of the reliance on wild meat requires several strategies in tandem such as providing alternative sources of revenue and economic opportunity, improvements to agricultural infrastructure and activities that maximise animal protein production and educating hunters and buyers.

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Appendix A: Individual hunting questionnaire

Data Form 4A: Wawancara perburuan individu saat ini

(Insiden perburuan terkini:)

Kode ☐ **Kode Blok** ☐ **Kode Desa:** ☐ **Pewawancara:** ☐

1. Lokasi: _____ Desa _____ Distrik
2. Posisi: Lat N (dd.ddddd) _____Lon E (dd.ddddd)_____
3. Waktu wawancara (hh/bln/thn) _____
4. Pewawancara: _____
5. Responden: _____
6. Waktu dan jam mulai berburu: _____
7. Waktu dan jam selesai berburu: _____
8. Jumlah waktu berburu (total): _____
9. Jumlah orang yang ikut berburu: _____
10. Identifikasi hasil buruan:

Jika ada pengambilan		
K	F	P

Nama lokal	Nama Ilmiah	Jumlah	Alat buru	Pemanfaatan hasil	Tipe habitat
_____	_____	_____	_____		_____
_____	_____	_____	_____		_____
_____	_____	_____	_____		_____
_____	_____	_____	_____		_____ _

(* Pemanfaatan: Daging (konsumsi), dijual,, hiasan dan obat, pemanfaatan lain)

11. Ada alat buru lain yang digunakan? Ya ( ) Tidak ( )

    Jika ya, jelaskan: (i) jenis: _____ (ii) jumlah: _____

12. Apakah anda menggunakan jerat? Y ( ) Tidak ( )

Jika ya, jelaskan: (i) jenis: _____ (ii) jumlah: _____

13. Lokasi berburu menggunakan jerat:

    Nama lokasi setempat _____

    Perkiraan jarak dari desa (km) _____

    Perkiraan arah: S( ) U( ) T( ) B( ) SE( ) SW( ) NE( ) NW( )

14. Pekerjaan utama:

    (i) Berburu ( ) (ii) Bertani ( ) (iii) Mengumpulkan hasil hutan dan berdagang ( )

    (iii) Lainnya (jelaskan) _____ ( )

15. Silahkan diurut jenis pekerjaan berdasarkan kepentingan ekonomi atau pendapatan (dari yang paling menguntungkan sampai yang kurang menguntungkan):

    (i) Berburu ( ) (ii) Bertani ( ) (iii) Mengumpulkan hasil hutan dan berdagang ( )

    (iv) Lainnya (jelaskan) _____ ( )

16. Silahkan diurut menurut alasan mengapa anda melakukan perburuan (dari yang paling penting sampai yang kurang penting):

    (i) Subsistens ( ) (ii) Perdagangan ( ) (iii) Hama ( ) (iv) Perdagangan tropi ( )

    (v) Lainnya (sebutkan) _____ ( )

17. Komentar:

    _____
    _____
    _____
    _____

Data Form 4B: Wawancara Perburuan Umum

Kode Lokasi: | **Kode Blok Contoh:** | **Kode Desa:** | **Pewawancara:**

Kode Tim:

1. Lokasi: _____ Desa _____ Distrik

   Posisi: Lat N (dd.ddddd) _____Lon E (dd.ddddd)_____

2. Waktu wawancara (tgl/bln/thn) _____

3. Responden: _____

4. Agama responden: _____

5. Seberapa sering melakukan perburuan? (mis. Seminggu sekali, dua minggu sekali, sebulan sekali, dll.)
_____

6. Rata-rata waktu berburu (hari atau jam)_____

7. Waktu (musim) berburu yang laing disukai? _____

8. Jumlah orang yang ikut berburu _____

9. Apakah anda berburu di siang hari, malam hari atau keduanya? Siang hari ( ) Malam hari ( ) Keduanya ( )

10. Alat buru apa yang digunakan?

    Tombak ( ) Anjing ( ) Sumpit ( ) Senjata ( ) Jerat Bambu ( )

    Busur/panah ( ) Perangkap ( ) Lainnya (jelaskan): _____

11. Apa jenis hewan yang paling sering ditangkap? _____

12. Apa jenis hewan yang sebelumnya anda buru? _____

13. Dalam setiap sesi perburuan, berapa banyak rata-rata hasil tangkapan? _____

14. Bagaimana penilaian terhadap kelimpahan satwa di lokasi perburuan dibandingkan lima tahun silam?

    Lebih banyak ( ) Lebih sedikit ( ) Tidak berubah ( )

15. Tolong diurut alasan melakukan perburuan (dari yang paling penting sampai yang kurang penting)

    (i) Subsistens ( ) (ii) Perdagangan ( ) (iii) Hama ( ) (iv) Perdagangan tropi ( )

    (v) Lainnya (jelaskan) _____ ( )

16. Pekerjaan utama:

    (i) Beburu ( ) (ii) Bertani ( ) (iii) Lainnya (jelaskan) _____

17. Silahkan diurut jenis pekerjaan berdasarkan keuntungan secara ekonomi atau pendapatan (dari yang paling menguntungkan sampai yang kurang menguntungkan):

    (i) Berburu ( ) (ii) Perladangan berpindah ( ) (iii) Pengumpulan hasil hutan ( )

    (iv) Lainnya (jelaskan) _____( )

18. Pernahkan anda menjual daging atau bagian lain dari hewan hasil buruan? Tidak ( ) Ya ( )

    Jika ya, silahkan mengisi table berikut:

Jenis satwa yang dijual	Bagian yang dijual	Kegunaan hawan/ bagiannya	Harga (Rp)		Barter/ tukar dengan komoditi lainnya	Jual kepada siapa? (tetangga, pengumpul, lain)	Sasaran/rute perdagangan Asal pembeli
			alam 5 tahun terakhir	aat ini			

Appendix B: Community hunting questionnaire

Unik Survey ID ……

SURVEY PERBURUAN KOMUNITAS

RESPONDEN PERORANGAN (SELEKSI RANDOM)

Nama Pewawancara: …….

1. Informasi Demografi

Desa :

Umur :

Jenis Kelamin :

Agama :

Pekerjaan :

Pendidikan :

Jumlah anggota keluarga :

2. Informasi Perburuan

Pilih dan lengkapi sebanyak pilihan yang sesuai. Tinggalkan kosong jika tidak sesuai dan jelaskan jika diperlukan

- **Seberapa sering anda berburu?**

  ( ) tiap hari, ( ) 2-3 hari/minggu, ( ) tiap minggu, ( ) lebih sering

  Jelaskan

  _____

- **Bagaimana anda menuju lokasi perburuan**

  ( ) jalan kaki, ( ) menggunakan kendaraan, ( ) lainnya

  Jelaskan

  _____

- **Bagaimana keadaan lokasi (habitat) dimana saudara melakukan perburuan?**

  Jelaskan

  _____

- **Teknik perburuan yang sering digunakan**

  ( ) Anjing, ( ) Senjata, ( ) Jerat, ( ) Teknik lainnya

  Jelaskan

  _____

- **Mengapa anda berburu?**

  ( ) Konsumsi, ( ) Kegiatan tertentu (kematian, perkawinan, adat, dll), ( )Dijual, ( ) Lainnya

  Jelaskan

  _____

- **Dimana hasil buruan dijual?**

  ( ) Tidak dijual, ( ) Di desa, ( ) Pasar, ( ) Lainnya

  Jelaskan

  _____

- **Seberapa besar anda tergantung pada perdagangan hasil buruan?**

  ( ) Kurang, ( ) Sedang, ( ) Sangat

  Jelaskan

  _____

- **Berapa jumlah anggota berburu dalam aktivitas berburu terakhir?**

  ( ) Pria, ( ) Wanita, ( ) Anak

  Jelaskan

  _____

- **Apa jenis hewan buruan yang diperoleh pada aktivitas berburu terakhir?**

  Jelaskan

  _____

- **Tipe habitat pada saat melakukan perburuan terakhir?**

  Jelaskan

  _____

3. Komentar

Appendix C: Village socio-economic questionnaire

INFORMASI KEPENDUDUKAN

Nama Pewawancara: ……

1. Keterangan Perorangan

Nama Kepala Keluarga :
Umur:
Pendidikan terakhir:
Agama:
Anggota Keluarga

No	Nama	L/P	Umur (Thn)	Pendidikan	Tanggungan (Ya/Tidak)*

**Menjadi tanggungan dalam keluarga*

2. Keterangan domisili

- Kepemilikan rumah: ( ) Milik sendiri, ( ) Milik orang tua, ( ) Sewa
- Konstruksi rumah: ( ) Permanen beton, ( ) Setengah beton/kayu, ( ) Sederhana
- Sambungan listrik terpasang: ( ) Ada, ( ) Tidak
- Jika tidak, dari mana mendapatkan sumber penerangan, sebutkan…….

3. Status keluarga

- Status perkawinan: ( ) Nikah, ( ) Belum, ( ) Cerai

- Tahun perkawinan (jika sudah nikah)
- Tempat lahir kepala keluarga, jika di luar kampung, sebutkan …….
- Kelompok etnik kepala keluarga: …….

4. Kondisi ekonomi keluarga

- Mata pencaharian utama
  ( ) Tani, ( ) Pengumpul hasil hutan, ( ) Nelayan, ( ) Lainnya, sebutkan
- Rata-rata penerimaan tunai per bulan: Rp ……
- Pendapatan tambahan jika ada (sebutkan dengan jumlah) ……
- Memiliki simpanan di bank ( ) Ya, ( ) Tidak
- Jika ada simpanan dalam bentuk lain, sebutkan……
- Bentuk pengeluaran per bulan menurut kebutuhan (sebutkan)
  ……
  ……
  ……
  ……
  ……

5. Kepemilikan keluarga

- <u>Lahan</u>
  ( ) Milik pribadi, ( ) Hibah/pemberian, ( ) Milik kelompok, suku, klen
- Jenis lahan (sebutkan): Pertanian, Perkebunan, dll:
  ……
  …..
- Perkiraan luas lahan:
  ……

- <u>Ternak peliharaan</u> (sebutkan menurut jenis ternak dan jumlah)
  ( ) Ayam: …… ekor
  ( ) Babi: …….. ekor
  ( ) Kambing: ……... ekor
  ( ) Sapi …… ekor
  ( ) …… ekor

- Kepemilikan lainnya (jika ada)

  ( ) Generator, ( ) TV, ( ) Radio, ( ) CD Player, ( ) Perahu, ( ) Jaring, ( ) Motor tempel, ( ) Alat pertanian: cangkul, sekop, parang, gerobak, dll, ( ) Alat buru, ( ) Furniture

  Lainnya dapat disebutkan sesuai dengan kepemilikan yang ada……..

- Keterangan lain yang perlu:

  .....

  .....

  .....

  .....

Catatan: *Statistik kampung terkini jika ada dapat dicatat sebagai penunjang*

Appendix D: Household questionnaire

Unik Survey ID ……

SURVEY KONSUMSI DAGING SATWA RUMAH TANGGA

RESPONDEN RUMAH TANGGA (SELEKSI RANDOM)

Nama Pewawancara: …….

1. Informasi komposisi makanan

Pilih dan lengkapi sebanyak pilihan yang sesuai. Tinggalkan kosong jika tidak sesuai dan jelaskan jika diperlukan

- **Apa saja komposisi makanan malam ini?**

  ( ) Daging satwa, ( ) Ikan, ( ) Produk ternak (telur dan daging kaleng), ( ) Sayuran

  Jelaskan

  _____

- **Sudah berapa hari bahan makanan ini tersedia bagi keluarga**

  ( ) hari ini, ( ) dua hari, ( ) lebih dari dua hari

  Jelaskan

  _____

- **Bagaimana cara mendapatkan bahan makanan ini?**

  Jelaskan

  _____

2. Komentar

_____

_____

_____

_____

Appendix E: Combined statistical treatment of access, population and available protein sources

Hunting frequency:

Analysis: Generalised linear model with binomial error distribution (fraction out of maximum hunting frequency). Parameters: Access + MPA + Population category + Access * Pop.cat + MPA * Pop.cat

Call:

glm(formula = cbind((Hunt.freq - 1), not.hunt) ~ Access.cat + MPA + Pop.cat + Access.cat * Pop.cat + MPA * Pop.cat, family = binomial, data = freddy.data)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.5758	-1.1945	0.3966	0.4725	2.0492

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-0.67446	0.23644	-2.853	0.00434	**
Access.catRoad	0.69702	0.33137	2.103	0.03543	*
MPANon.MPA	-0.17284	0.33975	-0.509	0.61094	
Pop.catLow	0.05542	0.33294	0.166	0.86781	
Access.catRoad:Pop.catLow	17.64085	1220.18588	0.014	0.98846	
MPANon.MPA:Pop.catLow	-18.11051	1220.18588	-0.015	0.98816	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 183.49 on 219 degrees of freedom

Residual deviance: 144.56 on 214 degrees of freedom

AIC: 343.71

Number of Fisher Scoring iterations: 17

Distance:

Analysis: Generalised linear model with Poisson error distribution. Parameters: Access + MPA + Population category + Access * Pop.cat + MPA * Pop.cat

Call:

glm(formula = Distance ~ Access.cat + MPA + Pop.cat + Access.cat * Pop.cat + MPA * Pop.cat, family = poisson, data = freddy.data)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.2294	-0.6174	-0.2214	0.3414	1.6461

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.231101	0.085436	14.410	<2e-16	***

Access.catRoad 0.229009 0.114895 1.993 0.0462
*

MPANon.MPA -0.007326 0.121046 -0.061 0.9517

Pop.catLow 0.028779 0.119964 0.240 0.8104

Access.catRoad:Pop.catLow -0.115680 0.180240 -0.642 0.5210

MPANon.MPA:Pop.catLow 0.069201 0.187290 0.369 0.7118

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

Null deviance: 98.307 on 219 degrees of freedom

Residual deviance: 90.366 on 214 degrees of freedom

AIC: 795.98

Number of Fisher Scoring iterations: 4

***Total catch*:**

Coefficients:

Estimate Std. Error z value
Pr(>|z|)

(Intercept) 0.51083 0.09129 5.596
2.2e-08 ***

AccessRoad -0.04280 0.11131 -0.385
0.7006

MPANon-MPA 0.33275 0.11798 2.820
0.0048 **

Population_categoricalLow 0.08850 0.12857 0.688
0.4912

AccessRoad:Population_categoricalLow 0.07797 0.17540 0.445
0.6567

MPANon-MPA:Population_categoricalLow -0.12416 0.18484 -0.672
0.5018

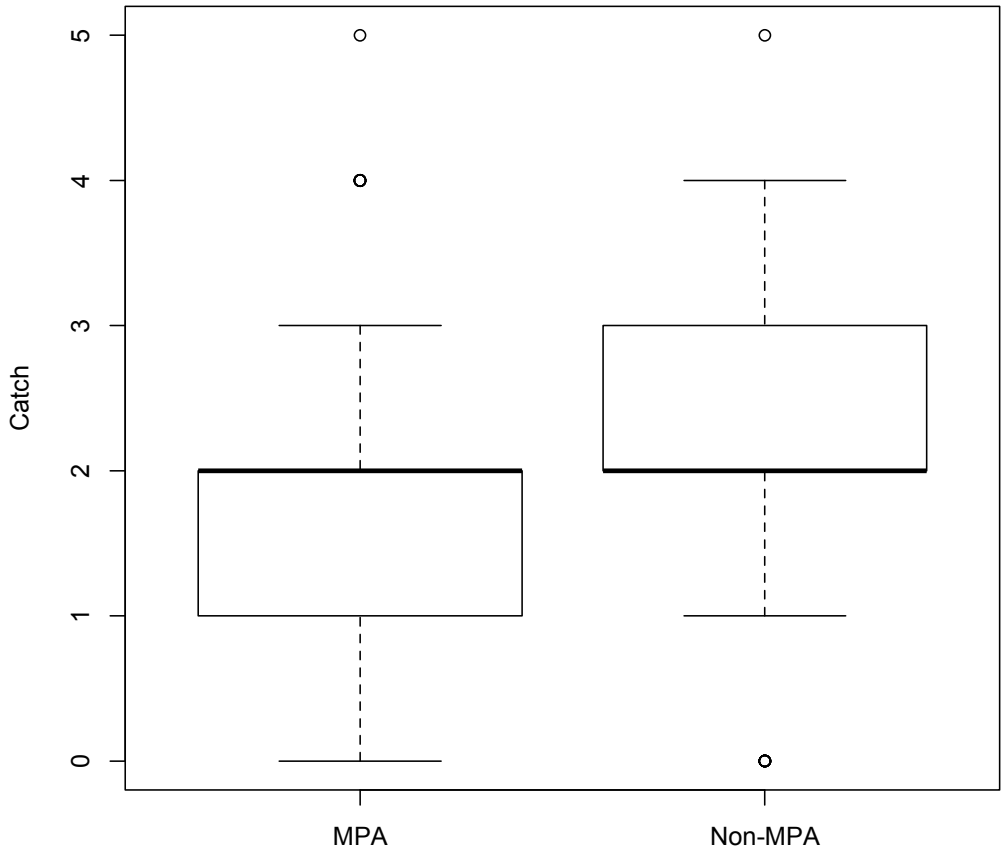
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

Null deviance : 224.65 on 386 degrees of freedom

Residual deviance: 210.92 on 381 degrees of freedom

AIC: 1182.7


Catch
0
1
2
3
4
5
MPA
Non-MPA