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Target, tool, tenure and timing: the four T's limiting the impact of traditional hunting in Indonesian Papua

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Subsistence hunting has sustained human populations in New Guinea for millennia, without seriously affecting the highest levels of biodiversity on Earth. Recent changes to hunting practices, demographic, social and economic context and the introduction of large exotic species has significantly altered the dynamic of hunting and its potential effects in north-west New Guinea. In this paper we examine contemporary hunting practices of six ethnic groups from highland to coastal sites throughout Papua and West Papua provinces of Indonesia. Semi-structured interviews were used to examine hunting practices as well as customary rules and attitudes associated with hunting in the region and how they have changed in living memory. Each group indicated traditional restrictions on at least one of target, tool, timing or tenure, albeit in varied ways. Six different hunting tools were used and each hunter typically combined several tools while hunting. Religious and cultural factors deeply influenced hunting practices among the communities. We discuss the implications of these findings and conclude with recommendations to integrate local, village level governance and customary practices with regional and national law for more effective conservation and management of wildlife in the region while simultaneously respecting cultural heritage and local ecological knowledge.

KEYWORDS

customary law, indigenous hunting, taboos, Papua, Indonesia

1 Introduction

Because of its species-rich forest environment for Australopapuan fauna, including many endemic species, New Guinea is considered a global priority for biodiversity conservation (Robbins 1971 as cited by McPhee, 1988; Conservation International, 1999). The western half of the island, comprising the Indonesian provinces of Papua and West Papua (hereafter referred to as 'Papua'), hosts approximately 15,000–20,000 plants, 146 mammals, 329 reptiles and amphibians and 650 birds (Marshall and Beehler, 2007), although scientists believe many more species remain undiscovered (Hance, 2011; Watson, 2011). More than half of Indonesia's terrestrial vertebrate fauna is represented by the 1125 known animal species (Conservation International, 1999). That diversity is also reflected in human society and culture. Alongside its extraordinary biological richness, collectively, the Papuan provinces have a much greater diversity of ethnicities and cultures than any other Indonesian province, with about 269 living local languages (Mansoben, 2007). In this paper, the word 'Papua' refers to both the provinces of Papua and West Papua.

Many Papuans rely on plant and animal resources found in tropical forests. Gathering, hunting and any other subsistence activities for food, as well as collecting ceremonial, architectural, and medicinal materials, continue to play essential parts in many people's cultural lives. While they mostly rely on natural resources, native Papuans established and practiced systems of customary management that controls Indigenous Communities' rights and responsibilities with relation to their natural resources (Mangubhai et al., 2012; Pattiselanno et al., 2020). Traditional systems of tenure for land and sea are highly complex and highly variable across Papua is not written into formal law, but passed on verbally from one generation to another with resource rights vested in individuals, families, clans or entire communities. Indigenous Groups give different knowledge and perspectives based on their own locally formed resource use and land management techniques, which can provide useful insights into modern natural resource management and biological conservation practices (Ziembicki et al., 2013).

In the past, in Papua, hunting was mostly associated with a variety of ritual events: subsistence, marriages, mortuary feasts, etc. (Pattiselanno, 2006; Pattiselanno and Arobaya, 2013). While trade of some protected species, such as the sugar glider (*Petaurus breviceps*), has been recorded (Lyons and Natusch, 2012), few studies have looked at hunting practices and possible changes within local communities (Pangau-Adam et al., 2012). Traditionally, hunting was strongly influenced by a number of resource and habitat taboos (cf. Colding and Folke, 2001).

Although low human population densities, together with customary resource management, such as taboos by locals, may once have provided long-term, security of resources, there is a range of changes that challenge this security. Globally, the principal threat to wildlife is habitat loss due to forest conversion for commercial agriculture, logging and mining (Margono et al., 2014). Habitat loss is growing in importance in Papua, and Abood et al. (2015) found that 12.5 million ha, or about 30% of Papua, is designated for various extractive activities. Further to the direct effect of extractive industry, more subtle effects of industry on hunting also have a significant impact. Pangau-Adam et al. (2012) reports an increase in hunting pressure as a result of the transition from subsistence to commercial hunting to supply the demand for the bushmeat market in the north-east of Papua. Pattiselanno et al. (2020), also found also found that the wild meat trade chain as a part of commercial hunting on the Bird's Head Peninsula's cost. This shift is often linked to extractive industries and associated population increase.

In brief, market integration of hunting enhances harvest rates while decreasing hunting sustainability (Robinson and Bennett 2004). Market access not only promotes hunting on commonly targeted target species but also threatens other species (Bennett et al., 2000, Bodmer and Puertas 2000, Fa et al., 2000). Thus, the commercial wildlife trade is large throughout most of Asia, but it is now primarily providing a luxury, urban market, both for meat and body parts for traditional remedies (Bennett et al., 2002; Corlett, 2007). Many species of mammals and birds (Mack and West 2005) are hunted in Papua New Guinea by a number of ethnic groups, and all of these creatures are considered acha (edible fauna) (Dwyer 1983; Sillitoe 2001). These included a handful of genera such as Sus, Phalanger, Spilocuscus, Dendrolagus, Zaglossus and Casuarius (Johnson et al., 2004).

Hunting technological advancements and modifications such as weapons, portable lights, and vehicles have made wildlife hunting more efficient and hence dramatically raised harvest rates. The hunting mode has a significant impact on the overall take. Traditional or western hunting weaponry, snares, spotlights, and others have a significant impact on hunting success and wildlife populations (Robinson and Bennett, 2000; Fa et al., 2002; Fa et al., 2005, Milner-Gulland et al., 2003, Refisch and Koné, 2005 , Corlett, 2007).

The interaction between Indigenous Peoples and animals is complicated by habitat modification caused by extractive industries such as mining, logging, and plantation forestry. Forest clearing not only affects habitat for numerous species, but it also offers hunters with access to forest areas and markets (Laporte et al., 2007). In many cases, extractive projects overlap with vulnerable indigenous territories where the absence or weakness of local governments and a lack of economic alternatives often result in impacts that go well beyond ecological or environmental changes to include drastic social changes that affect both the livelihoods of local groups and the wildlife on which they rely (Laurance et al., 2006; Poulsen et al., 2009; Suárez et al., 2009).

Timing in hunting might possibly influenced by the major reason for hunting was to supply family with food. Pangau-Adam et al. (2012) stated that hunters went hunting weekly in the north-eastern area of Papua, with varying amounts of time dedicated to hunting because hunting was a part-time occupation only. Previous research has revealed that hunting is frequently an "alternative" activity. Most hunters have full-time occupations other than hunting (Ntiamoa-Baidu, 1997; Mendelson et al., 2003; Naranjo et al., 2004). Part-time hunting is essential for supplementing cash crop earnings (Mendelson et al., 2003). Similarly, hunters in Latin America mix their formal and informal employment to augment their income because they are extremely poor (Stearman 2002, Naranjo et al., 2004). Hunters in Arunachal Pradesh, north-east

India, had no set hunting schedule; they hunted whenever it was convenient. Hunting trips, on the other hand, were more frequent and may have followed a timetable during village festivals and activities (Aiyadurai et al., 2010).

As previously explained that target, tool, tenure and timing – 4Ts, influence hunting practices worldwide, the current study examines how widespread traditional practices and beliefs, which are currently widely practiced among many Indigenous Populations, may limit the impacts of hunting and how changes in current hunting practices might alter that impact. We describe traditional or customary limitations on hunting across a range of ethnic groups.

2 Materials and methods

2.1 Study area and its peoples

Six ethnic groups (Table 1) from highland to coastal sites (Figure 1) at the Bird's Head Peninsula, West Papua, were selected for this study. Selected study sites represented highland, lowland and coastal areas at the Bird's Head Peninsula where the main local livelihoods were gardening, growing vegetables and hunting (Taime 2000), that strongly connected to the practice of the customary laws as parts of their social livelihood. All the study sites were currently being connected with the Trans Papuan Road Connections (Pattiselanno and Krockenberger, 2021), that increase the interactions between migrants and local people, lead to the influence of the customary law practices. These sites also considered as Industrial/Special Economic Zone and Development of the Indigenous Territory of Doberai (FWI, 2020) that possibly impact the traditional lifestyles because of introduction of economic zones.

Arfak - The area where the Arfak tribes live in the Arfak Mountains 134°05'E, 1°40" S. The regency bisected the Arfak Mountains Nature height up to 2,950 meters above sea level (asl). The Arfak Mountains has diverse ecosystem types from lowland rainforests (<300m), foothill forests 300-1000m and the lower mountain forest 1000-2800m asl. Arfak people are considered good hunters in the highland areas, and. They are also specialists in preparing herbal medicine (Antono, 2018). They used to hunt wild pig while working in their plantation sites. Shifting cultivation is the main livelihood of the Arfak community, where cultivation areas are abandoned after two or three harvests to become forests again (Apomfires and Sapulete, 1994).

Abun - The Karon are the most populous ethnic group in the Abun District. (132°44'47" E 0°27'48" S). Abun is located on the Bird's Head Peninsula and is designated as a Marine Protected Area (MPA) due to the importance of nesting beaches for leatherback, olive ridley, green, and hawksbill turtles. Because it is located between Manokwari and Sorong, Abun is a transit location for hunters who carry out hunting activities along the coast. The Karon have mingled with other Papuan ethnic groups along the coast, such as the Biak, Serui, Ayamaru, Arfak and non-Papuan peoples such as Makassar, Bugis, Butonese, Javanese and Moluccas. Livelihoods are based on the cultivation of bananas, beans, yams, and vegetables (Pattiselanno and Lubis, 2014).

Kebar – Kebar is located at 133°03'44.1" E 00°50'57.3" S in the north central region of the Bird's Head Peninsula. The Kebar valley floor is leveled and moderately sloped to three degrees, with the Kasi River serving as the valley's primary drainage. Throughout the valley there are many natural pastures as the major habitat of the Rusa Deer (*Cervus timorensis*) – a main hunting target across the valley (Pattiselanno 2004). The natives of Kebar rely on natural resources, cultivated from the forest or collected from the bush, such as fire wood, building materials, food and wild meats. Most village families grow domestic livestock, particularly pigs that are rarely confined in confinement and instead roam freely throughout the settlements. To round out the menu, hunters' catch (pork and venison) is frequently served. (Pattiselanno, 2012). Smoked meat, or dried meat (jerky or "dendeng" in Bahasa Indonesia) is often eaten.

Maybrat – Geographically, Maybrat is located between in 132° 18'44.27" E and 1° 16' 51.59" S. The topography of Maybrat is quite varied, consisting of highlands which are areas of mountains and slopes, (inland ± 65%), lowlands, brackish water and beaches (35%). The main livelihood of the Maybrat people is shifting cultivation. Hunting activity is a side activity carried out which aims to meet the need for protein and meat in the family (Pattiselanno and Mentasan 2010). Maybrat people also often hold cultural practices such as the exchange of eastern cloth or initiation, namely as an embodiment of the spirit of solidarity, in order to maintain social relations between groups (Boelaars, 1992). The Maybrat region covers a diverse range of habitats including fertile land of agricultural potential that

TABLE 1 Distribution of ethnic groups, locations and zones of respondent hunters.

Ethnic groups	District	Number[1] and Name of sample village	Population[2]		Survey duration
			♀	♂	
Arfak	Taige/Highland	N (11), Taige	214	239	12 days
Karon	Abun/Coastal	N (4), Waibem	98	102	10 days
Kebar	Eastern Kebar/Highland	N (13), Jandurau	58	55	10 days
Maybrat	Central Aitinyo/Lowland	N (14), Yaksoro	77	75	12 days
Napan	Napan/Coastal	N (3), Napan	120	101	14 days
Sebyar/Aranday	Aranday/Coastal Swamp	N (4), Aranday	112	124	14 days

[1]Number of villages was gathered from the latest information at Statistic Bureau Office of Papua Barat website.
[2]Data from the surveyed villages recorded in village offices during the survey.

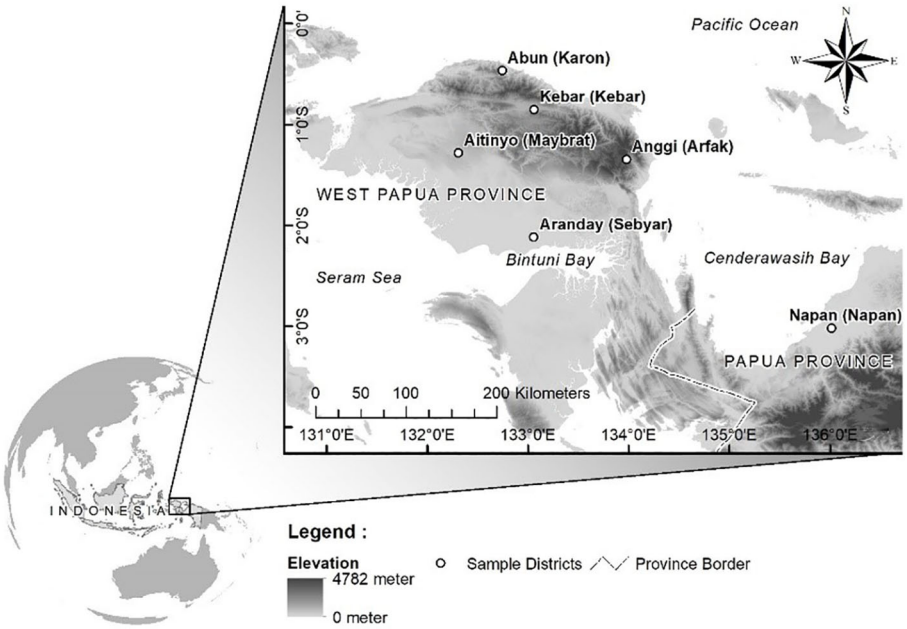

FIGURE 1
Distribution of study areas across Papua; Dots represent communities involved in this study. Brackets represent sites of the study (by Dave Manuhua).

supported local generated-revenue (Badan Pusat Statistik Kabupaten Maybrat, 2017).

Napan – Geographically is located at 136° 01' 00.44" S and 3° 01'00.44" E at the Cenderawasih Bay. Main livelihood of Napan people is fishermen, while subsistence farming, hunting and gathering are their side activities (Pattiselanno 2007). The cultivated products are commonly used for daily consumption, and are sold to traditional markets on the island of Moor and the city of Nabire, including sea products (fish and sea cucumbers), agricultural products (vegetables and crops), and processed products such as coconut oil and wild meat such as pork (Pattiselanno 2007). Sago is a staple food and considered as an important thing in traditional ceremony of the Napan.

Sebyar – the area in Bintuni Bay, found at 133°03'32.55" E and 2° 06'56.44" S along the Sebyar River. The Sebyar tribe inhabit the area in the Arandai sub-district, and originated from the sacred mountain called Prophet's Mount (in Indonesian known as Gunung Nabi). The traditional beliefs of the Sebyar people affect the patterns of daily life of the people. This allows them to maintain their cultural norms and customs as a standard in their daily lives. Cultural norms continue to both regulate relations between humans and regulate the interaction between people and nature is still practiced today as parts of the interaction between human and nature (Handoyo et al., 2014). Most people rely on taking daily consumption needs directly from forests, such as extracting sago from palms and catching fish with simple equipment.

2.2 Sampling

We worked intensively with Karon, when the first author collected data for his postgraduate study, while other ethnic groups were purposively selected during his involvement on biodiversity survey for the Biodiversity Research Center of Universitas Papua. We also worked in close collaboration with village leaders in each group to ensure that villagers understood the rationale and aims of the study on traditional hunting practices and taboos related to hunting practices by Indigenous Native Papuans. In each study site, we ensured that Papuan hunters were involved by seeking the consent of village leaders to identify 10 active male hunters, without any consideration on their ages, to participate in the interviews. In Papua, the villagers have a very close kinship, so that the village leader knows exactly the occupation of villagers. We did not have any Muslim hunters in this study. Most of the study sites were dominated by Christians, except in Sebyar the percentage of Christian and Muslim population was almost similar. Those who were actively hunting in Sebyar were Christians. In further interviews, Muslim respondents acknowledged that although, hunting is not prohibited, in the implementation, there are several binding rules related to prey targets (for example the rules set out in Surah Almaidah). They also need to ensure the survival of fellow living creatures and be aware of consuming halal meat according to religious rules. Therefore, Muslim respondents are not as active as the Christian Fellows in hunting.

2.3 The Survey

We used semi-structured interviews with modified questions from Spradley (1997) and Lee (2000), to gather information from all ethnic groups on common traditional practices - taboos and beliefs related to hunting (Table 2). The questions used in interviews are summarized in Table 3. Literatures have evidenced how the 4Ts

TABLE 2 Aspects of customary limits related to hunting (Target, Tool, Tenure and Timing) and its contribution toward the utilization of the natural resources.

Aspects of customary law in hunting	Application	Contribution (Berkes et al., 2000)
Target	Limitation in selecting target species	Rare species, sustainable use of resources
Tool	Limitation in using hunting tool	Sustainable use of resources, ecological processes
Tenure	Limitation in utilizing hunting tenure	Protected areas, ecological resources, sustainable use of resources
Timing	Limitation in determine timing for hunting	Ecological processes, sustainable use of resources

influenced hunting practices (Bennett et al., 2002; Milner-Gulland et al., 2003; Corlett, 2007, Refisch and Koné, 2005, Ntiamoa-Baidu, 1997; Mendelson et al., 2003; Naranjo et al., 2004; Laurance et al., 2006; Corlett, 2007; Poulsen et al., 2009) were used as references. We applied the 4Ts approaches during the interviews and observations based on the previous studies (Pattiselanno, 2008; Pattiselanno et al., 2015; Pattiselanno et al., 2015) in both Papua and West Papua provinces to have better understanding of the concept of conservation ethics in Papua related to the wildlife conservation based on traditional wisdom.

Methods used in this study are based on survey/questionnaire information. A literature-based approach to support the method on the 4 Ts practices, was used to assess answers from interviews. This is one of the weaknesses of the method used, because the participant respondents do not fully understand the western concept of sustainability. We used the approach to have better understand on the cultural practices by the respondents across the study sites.

Interviews were conducted individually by visiting hunters at their homes to determine current hunting practices. Questions (Table 3), are used as variables for further data analysis. Target (prey and non-prey animals); Tool (used and not permitted in hunting); Tenure (used and prohibited in hunting); Timing (anytime and seasonal). Number of respondents respond to the particular aspect of each variable are considered for further analysis. For all surveys, we used photographs to aid in the proper identification of hunted species (De Roij 1917, Menzies, 1976; Flannery, 1995; Pratt and Beehler, 2015).

TABLE 3 List of questions asked in interview.

No	Questions
1.	Why do you hunt?
2.	What animals are hunted, and what for?
3.	What animals are not allowed to hunt? Why?
4.	What tools are used in hunting?
5.	Any particular tools are not permitted in hunting? Why?
6.	Where is your hunting tenure?
7.	Any particular locations are prohibited in hunting? Why?
8.	Can hunting be performed at any time? If not, why?

We attempted to cross-validate the information acquired in order to decrease any errors, biases, and failing memories, and we also interviewed elders, tribe leaders, village heads, and religious leaders. Of 10 hunters in each ethnic group, if five or more acknowledged similar answers on the 4 Ts customary laws implemented, then these were considered as answers represented of the ethnic groups. Aspects of the research carried out involving human subjects was completed in accordance with the ethical guidelines detailed by the Association of Social Anthropologists of the Commonwealth. Prior to fieldwork commencing to Karon communities, the study received human research ethics approval from the James Cook University (JCU) Human Research Ethics Committee (approval number: H4203). While observation on other sites were approved by the Research Permit No 08/UN42.15.2/KP/VIII/2018 from Biodiversity Research Centre of Universitas Papua. All of the results in this study were analyzed using descriptive statistics. The descriptive statistics were used to examine all of the findings in this study. The collected data was processed and presented in graphs, figures, and tables. In order to provide a thorough description of the study sites, a contextual approach was adopted to explain the situation in the field.

3 Result

3.1 Customary laws in hunting

Although each ethnic group included in this study implemented customary limitations in slightly different ways, they implemented some type of customary that created limitation on hunting. We observed that using traditional weapons, prohibiting hunts in the sacred forests, applying tenurial rights and seasons in hunting were among the customary laws applied by all ethnic groups (Table 4). Driving prey to water applied only to Karon as they alone occupied coastal sites along the Birds Head Peninsula. Half of the ethnic groups restricted hunting snakes, because they are poisonous, and half restricted the use of guns in hunting.

The details of limitations on target taxa were diverse. In some cases, particular species (target limitation) were protected by a religious "taboo", such as birds of paradise, which were protected in 4 out of 6 of the groups surveyed. People believe that their ancestors descended from birds of paradise; as a result, hunting these species as pets or adornment materials is outlawed. Birds of paradise were regarded sacred, and people revered and valued them for cultural and religious reasons. Three groups (Maybrat, Karon and Napan, N=17) named lesser birds of paradise (*Paradisea minor*), while Arfak (N=10), mentioned long-tailed paradigalla (*Paradigalla carunculata*) as a species protected by religious taboo. In the other 2 groups, although birds of paradise were hunted, hunting was limited by other restrictions. In general, the limitation involved tool, allowing them to be hunted only in specific, limited ways or by a limited subset of the community

TABLE 4 Customary hunting restrictions implemented by each ethnic group.

Ethnic group	Customary laws implemented by each group											
	Target			Tool					Tenure			Timing
	Birds of Paradise as a symbol	Snake - toxic	Frog -toxic	Using tra-ditional weapons	Using fire	Eating meat killed by dogs	Guns -restricted	Driving preys to water	Sacred forests	Tenurial rights	Tenurial permits	Seasons
Maybrat	✓			✓			✓		✓	✓		✓
Kebar				✓	✓	✓			✓	✓	✓	✓
Karon	✓		✓	✓		✓		✓✓	✓	✓	✓	✓
Arfak	✓	✓		✓					✓	✓	✓	✓
Sebyar		✓		✓			✓		✓	✓	✓	✓
Napan	✓	✓	✓	✓	✓		✓		✓	✓		✓
%	66.6	50	33.3	100	33.3	33.3	50	16.6	100	100	66.6	100

who are considered eligible to wear birds of paradise plumes due to high social status. This is mirroring a study of Dwyer (1983) in the highlands of Papua New Guinea.

In all parts of Indonesian New Guinea (Papua and West Papua provinces), the implementation to ban the use of head band using the feather of birds of paradise is currently implemented in the local government regulations. This leads to restrict hunting particular endemic species including birds of paradise. The law granted by the government is widely applied to all areas by all ethnic groups.

Two of ten respondents of Maybrat also acknowledged the religious protection of Victoria Crowned-pigeon (*Goura victoria*). This bird species was considered as a cultural guard that protected the communities from the calamities. Victoria bird is used as the logo of the city of Manokwari, *Goura victoria* is preferred because of unique crown and colorful plumages. In the Vogelkop peninsula this species is widely distributed and we observed that hunting of this species still put into practice. In addition, three respondents from Arfak ethnic group mentioned the prohibition of hunting the brown tree snake (*Boiga irregularis*) as their local ancestors belonged to this species. If this species was found during hunting excursions, it had to be driven out of the hunting grounds. Otherwise, they have to find any other locations to hunt. Our observation in the field proofed, how locals of Arfak respect this protection by cultural approach.

Other limits on target species were based on their suitability as food—across half of the ethnic groups' consumption of snakes and/or frogs were considered dangerously toxic to human life. Particular snake species that were acknowledged by the respondents were Death adder (*Acanthophis antarcticus*), Ikaheka (*Micropechis ikaheka*) Inland taipan (*Oxyuranus microlepidotus*) and the green tree python (*Python viridis*). Snakes are considered poisonous because of their venom. The frogs recognized by the respondents in the study sites were the common frogs found in Papua such as Papua Wrinkled ground frog (*Platymantis papuensis*) and White-lipped tree frog (*Nyctimystes infrafrenatus*). The skin of frogs produces mucus, so it is believed, frogs are not feasible and are dangerous for consumption, because they have poisonous skin.

Direct observation showed that people are avoiding interactions with snakes. People scraed of snakes venom, and cosidered snakes as dangerous wild species that can killed them. People also keeps away from frogs on the other hand, because they feel disgust with the mucus from the frog's skin.

The relationship between species and cultural values was heavily addressed when selecting a hunting target, and all ethnic groups used the limitation when selecting a hunting target. More specifically, limiting prey species selection helps to safeguard uncommon species for the long-term usage of resources. Every group acknowledges that, there was some limitation on the tools that were acceptable to at least some members of the community, such as restricting hunting largely to traditional weapons. Six different hunting tools (Figure 2), were used across the groups: bow and arrow, spear, machete, dog, gun, and trapping. Hunters typically combined more than one tool depending on the species being hunted. In addition, Karon, who occupies coastal sites, also have a traditional tool that involves driving game toward water, where they are captured. Despite the reliance on traditional hunting tools, we also encountered the use of guns in hunting. In three of the groups, firearms were not considered lawful.

We presume hunting practices are showing shift from traditional to modern tools by employing firearms. All tools are the most common hunting tools used across the Indonesian New Guinea. We observed that selected hunting tools are mainly used for particular species-specific behavior and tactics to succumb certain species.

Four of the 6 groups restricted use of fire in hunting, because they believe fire could destroy large areas of forests. Sites in Kebar, and some spots in Napan are grassland. These areas were used as deer hunting sites. During a long dry season especially between July and October, the most common hunting practice using fire is applied. Regarding tools used in hunting, two ethnic groups acknowledged that animals captured using dogs were considered to be unsuitable and dangerous for consumption by pregnant or lactating women, not being allowed to consume the meat of the captured animals. People believe that dog's saliva can affect the health of pregnant or lactating women. Traditional

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FIGURE 2
Images clockwise are personal documentation, the last one dog caught the prey species – (Picture by Arthur Duwiri).

weapons are recognized as a method for hunters to acquire a limited number of preys since they kill fewer animals than improved hunting strategies using guns. Limitations on hunting tools provide additional options for sustainable resource use and the preservation of ecological processes.

All groups had jurisdiction over the areas where hunting was permitted. The size of all specified taboo or sacred forests varied according to the land possessed by each community. Information gathered during interviews indicated that on average, the sacred forests were more than 10 hectares in size. One of the Maybrat's tribe leaders reported that their sacred forest areas varied between 10 and 30 ha among clans within the group, with clearly understood boundaries denoted by features of the natural landscape. Hunting was prohibited in these locations because they housed the departed spirits of ancestors. The called of "hutan adat" is still put into practice that prohibit access into the forest, Thus, this is very important in terms protection on particular wild animals that inhabited the forests.

All parties also agreed that hunting could only be done within the territory of the hunter's clan or tribe. However, in 4 of the 6 groups, there was a system of tenurial permit allowing access to hunters outside the clan in certain circumstances, with explicit permission. In these cases, there were often acknowledged blood relationship with permitted hunters and, generally, a requirement to share the catch with the landowner clan. For example, if they caught deer, or wild boar, half of the back thigh should be shared with landowners. Sometimes they provided cigarettes, sugar, salt and cooking oil as compensation to the landowners. Tenurial-based of land ownership is common across the Indonesian New Guinea and requesting permit to access the other clans or ethnic groups' land or forests is compulsory.

These practices, which have been passed down and were still in use, limited hunters' access and safeguarded specific species in their natural habitats. Hunting tenure restrictions play a significant part in developing protected areas that support ecological processes for sustainable resource use.

The timing of hunting was controlled by all ethnic groups surveyed. In Napan, there was a season "closed" to hunting and, in 5 other groups, there were seasonal or occasional restrictions based around specific species. The period of closed seasons varies among species. Sebyar for example, prohibited hunting on marsupials between June and September, as these species were commonly found with offspring in their pouch. The Kebar people restrict deer hunting to particular cultural celebrations, the Karon hunt cassowaries for wedding celebrations and pigs during a "fruiting" season. Although ficus is bearing fruit throughout the year, in this case, the closed season takes place from April to June. Hunters usually used ficus as indicator, as this species is the most common fruit consumed by different wildlife species. Ficus is also forest plants that used to construct traditional hunting tools.

The practice of "sasi" still cotinues today, and gives advantages to limit harvest on particular seasons or periods, and creates chances to wild animals increase their population naturally. Seasonal hunting provides greater opportunity for wildlife species to reproduce. Limiting the timing of hunting is vital for maintaining ecological processes while also allowing for the sustainable use of resources.

Taboos were most commonly inherited from old generations to young generations. Within the families, parents passed down taboos to the children. These generational and bilateral taboos were observed and honored by all young people and would not be

ignored. Violators of the customary management received sanctions, taboo or "pamali" in Indonesian language. This is a big concern for the community because they are often socially isolated or gossiped, or other forms of social pressure as a sanction for the violation of taboos. Violators are very affected by the sanctions given. Social relations in social life play an important role, therefore society is greatly affected.

3.2 Hunting practices relevant to the 4Ts

Hunters cited four main reasons for hunting (Table 5) with consumption being the most common, followed in order by sale, cultural ceremonies and pest species control. Crop lands enable the production of considerable amounts of carbohydrates, in this case tuber crops and bananas, for those who interested in agriculture, such as the respondents in this study. These agricultural activities are insufficient in terms of providing animal protein sources for households; thus, hunting is carried out to supply animal protein for the families.

People were mostly reliant on agriculture for their livelihoods, thus to protect loses suffered from crop raiding, hunting is performed to drive away the animals. Deer and wild boar make up more than half of hunter's preferences. Hunters acknowledged that introduced species, such as deer and wild pig were preferred for over native species that were mainly consumed within their households. Both species were also considered for consumption and sale, as they provide large amount of meat. At this stage, hunting wild pig and deer plays important role in supporting trade. Trading of native species were not found during the study.

Six different hunting tools were used (Table 6), and each hunter typically combined more than one tool. Spears and traps were largely used together with the spear being used by hunters to kill live animals caught in traps.

All hunters were familiar with use of trap, because hunters can leave the traps and check them periodically while tending gardens. Trapping involves little or no money because traps and snares can be made from forest resources and reusable nylon or ropes. This enables hunters to construct a huge number of traps quickly and cheaply. More crucially, creating traps demands initial work but does not require active pursuit of the animals. Construction of traps is financially more cost effective, because materials used from previous traps can be re-used. It's just that designing and constructing traps requires time and effort, especially since the very large number of traps usually more than twenty traps are usually installed. It is very profitable because the installation of traps is carried out at the same time as activities on plantation land.

Bow and arrow were also commonly used. Arrows and bows do not use materials that are used once. Making arrows and bows is done once every few years, so it doesn't cost money. Bows and arrows will be repaired if their flexibility becomes reduced or the material is damaged. The knowledge of designing and installing traps and arrows and bows is passed on to the next generation since children become involved in hunting activities. They were made from materials available from the forests.

TABLE 5 Major motivation for hunting and species targeted by hunters.

Purpose of hunting	Ethnic Groups, Prey species, Number of hunters (N)					
	Maybrat	Kebar	Karon	Arfak	Sebyar	Napan
Sale		Rusa timor N = 2	Rusa timor, Wild boar N = 4			
Consumption	Common echymipera (*E. kalubu*), Common spotted cuscus (*Spilocuscus maculatus*), Orange-footed scrubfowl (*Megapodius reinwardt*), Rusa timor (*Cervus timorensis*), Victoria crowned pigeon (*Goura victoria*), Wild boar (*Sus scrofa*) N = 10	Common spotted cuscus (*Spilocuscus maculatus*), Long-nosed echymipera (*E. refescens*), Mangrove monitor (*Varanus indicus*), Northern common cuscus (*Phalanger orientalis*) N = 10	Common spotted cuscus (*Spilocuscus maculatus*), Dusky pademelon (*Thylogale brunii*), Northern cassowary (*Casuarius unappendiculatus*), Papuan hornbill (*Rhyticeros plicatus*), Northern common cuscus (*Phalanger orientalis*), Rusa timor (*Cervus timorensis*), Wild boar (*Sus scrofa*) N = 10	Common echymipera (*E. kalubu*), Emerald tree monitor (*Varanus prasinus*), Grizzled tree kangaroo (*Dendrolagus inustus*), Salvator lizard (*Varanus salvator*), Victoria crowned pigeon (*Goura victoria*), Wattled brushturkey (*Aepypodius arfakianus*) N = 10	Cattle egret (*Bubulcus ibis*), Orange-footed scrubfowl (*Megapodius reinwardt*), Dwarf cassowary (*Casuarius bennetti*), Greater Flying fox (*Pteropus papuanus*), Mangrove monitor (*Varanus indicus*), Western crowned-pigeon (*Goura cristata*), Rusa timor (*Cervus timorensis*) N = 10	Northern cassowary (*Casuarius unappendiculatus*), Northern common cuscus (*Phalanger orientalis*), Orange-footed scrubfowl (*Megapodius reinwardt*), Rusa timor (*Cervus timorensis*), Wild boar (*Sus scrofa*) N = 10
Cultural ceremonies	Common spotted cuscus (*Spilocuscus maculatus*) N = 2	Northern common cuscus (*Spilocuscus maculatus*) N = 1	Dusky pademelon (*Thylogale brunii*), Northern cassowary (*Casuarius unappendiculatus*) N = 4			
Pest eradication	Wild boar (*Sus scrofa*) N = 2		Wild boar (*Sus scrofa*) N = 3		Rusa timor (*Cervus timorensis*) N = 1	

TABLE 6 Hunting tools used by hunters across the study sites (N = 60).

Ethnic groups	Spear	Dog	Bow & Arrow	Gun	Machete	Trap
Maybrat	1	4	3	1	0	5
Kebar	0	4	2	2	2	4
Karon	2	2	3	0	3	5
Arfak	1	3	2	2	2	1
Sebyar	1	1	5	0	1	3
Napan	2	1	4	1	2	2
Total	7	15	19	6	10	20
%*	11.66	25.00	31.66	10.00	16.66	33.33

*Percentages do not add to 100 because typically hunters used more than one tool.

Hunters acknowledged the importance of using dogs for improving hunting success and also as protection from evil spirits during the hunt. Active hunting requires the hunter to actively pursue the animal, which is time demanding and labor intensive, whereas passive approaches involve extensive work at initially, such as creating a trap or setting a snare. This was introduced and widely adopted by other Papuan peoples (e.g., Biak and Serui), because it is much more effective than spears and arrows. Currently trapping was the most widely used practice within the study sites. There is also a recent practice of using guns by hunters, indicating a shift from traditional to modern hunting tools. This is possible, because sales of air rifle are most common found in Manokwari, Sorong and other big cities in Papua.

4 Discussion

4.1 The importance of customary laws

Religious and culturally-based customary laws strongly influence hunting practices among the communities. According to the respondents, customary laws were well known, understood and extensively practiced across the study areas, with every group recognizing spatially-based tenure limitations and limits on tool. Furthermore, the Karon communities in the Abun district have long implemented an unwritten rule "*bur, nden, sem mikindewa membow*", in Karon language translated as "land, forest and coasts protected for the future", which plays an important role in natural resource management. Only one group (Kebar) did not report a target-based limitation, and all limited the timing of hunting (Table 4).

Together, the functions of these traditional laws in Papua refer to the traditional ecological knowledge that channeled into fauna and flora protection, in this study, regulates the hunting practices across the studied ethnic groups. This approach leads to lesser the impact of hunting pressure on forest fauna and improve the potential for sustainability of that hunting pressure, that has been described by Coad et al. (2019).

Spatially-based limitations of hunting were the most consistent across every ethnic group surveyed. Prohibition of hunting in sacred or "taboo" forest areas was the most common cultural limitation on hunting and was reported by almost all hunters interviewed (present across all groups surveyed). Sacred forests were common throughout the sites and believed to be inhabited by non-human spirits. The importance of sacred forests to the local communities is an expression of respect to their ancestors, acknowledging that the spirit of their ancestors lived in and occupied the forests, so the areas are protected from hunting.

Apart from the wholesale traditional protection of "taboo" areas, the restriction of hunting access to members of the landowner clan was consistent, and effectively functions to limit potential take (Colding and Folke, 2001; Negi, 2010). Land and sea tenure in Papua are not formalized into formal legislation, but are passed down orally from generation to generation, with resource-use entitlements vested in individuals, families, clans, or entire communities. (McLeod et al., 2009). Territory for hunting is regulated by traditional right, and usually belongs to the clans and hunting access to forest, of which kin-composed group members are jointly custodians and rightful users (Wanggai and Kilmaskosssu, 1995, Sillitoe, 2002). In a slight shift from that strict clan-based limitation, some ethnic groups recognized a system of permits, where hunters from other clans or tribes could be permitted to hunt on their land, but must first seek such permission. Traditionally when seeking it, outsiders must either give something to the land owner (as a symbol that they agree to the community's regulation), or share the catch with the land owner. This form of customary limitation still functions to regulate access and use of resources in time and space as indicated by Berkes et al. (2000) and Colding and Folke (2001), and has an equivalent in formal law in Papua, where communities have the right to lease their land to others or to provide outsiders permission to use their natural resources (Mangubhai et al., 2012).

A number of taxa were regarded as "taboo" and could not be hunted, or only hunted in limited ways, including birds of paradise, snakes and frogs. Birds of paradise were typically considered to be precious and protected, because people believe the birds originate from local ancestors. Their songs were described as worship songs. Even where they were not entirely protected, all species of Birds of Paradise enjoyed a prestige that afford them some protection via

limitations on who was able to hunt them or which birds could be taken. Birds of Paradise plumes were highly respected as a "crown of greatness" for leaders and worn upon women's heads for a decoration during traditional ceremonies or dancing. Where they hunted, only particularly respected and recognized men in the tribe were able to take the most beautiful bird with developed and magnificent plumage.

Certain snakes and frogs that were perceived to be toxic were therefore unsuitable as a hunting target. We also found specific target taboos relevant to segments of communities. For example, hunters from two ethnic groups reported that pregnant women or breast-feeding mothers are prohibited from consuming game killed by dogs, because of the belief that their health could be adversely affected due to toxins from the dogs' saliva. Despite this taboo, however, hunting with dogs was still being practiced, due to their hunting abilities and the belief that they protect hunters and their families from evil spirits.

Although birds of paradise have been hunted for a long time, a combination of hunting limitations and their mating behavior and reproductive biology protect them from overharvest. Beehler, as cited by Jemison (2015) explains that, in Papua New Guinea, only dominant fully adult males above the age of seven are hunted for their feathers, limiting the harvest and allowing those individuals to reproduce earlier.Much more variations are found across Papua New Guinea (Dwyer, 1983).

The influence of culture and traditional limits on target taxa is widespread in New Guinea, often based on belief systems where those animals had a strong connection with their ancestors, so they were respected as totems for the tribe (Goswami, 2018). Outside of New Guinea, ethnic identity is also an important factor influencing selection of hunting target (Santos-Fita et al., 2012). This also proved by Ramenzoni (2023), explaining that dietary taboos are more often restrict the use of natural resource, that support the biodiversity conservation.

Traditional hunting tools are still important to the ethnic groups in this study. Powell (1976) found that materials used in making hunting weapons in New Guinea were usually taken from the forest plants such as *Hibiscus* sp., *Trema* sp., *Ficus* spp, *Syzigium* sp., *Aglaia sapindina* and *Dodonea viscosa*. The traditional tools used by surveyed hunters are similar to those reported elsewhere in New Guinea (see Bulmer, 1968; Bulmer, 1972; Dwyer and Minnegal, 1991; Sillitoe, 2002).

Hunters acknowledged that traditional hunting tools were cheaper than the modern ones. They require little or no money, because they can be made largely from forest materials, although sometimes they may include some modern materials such as nylon or rope. Combinations of traditional and modern hunting tools are widespread in bushmeat hunting across West Papua (Pattiselanno and Lubis, 2014). Traditional hunting methods play an important role in the conservation of wildlife species. They limit hunting returns compared with modern hunting tools using guns that strongly improve hunting success and, consequently increase pressure on wildlife populations (Ripple et al., 2016; Wilkie et al., 2016; Benitez-López et al., 2017).

Many ethnic groups reported time-based hunting restrictions, with a variety of variances in the nature of the customary regulation. We presume that because hunting is often an "alternative" activity, and interviewees derive their major income from full-time activities, they shift intermittently between formal and informal occupations to gain extra income from hunting. The study of Knoop et al. (2020) support our assumption indicated that the hunting frequency of Maraquá influenced by their extractive activities.

In this study, hunters from the Napan people acknowledged open and closed hunting seasons implemented as part of the natural resource management systems known as 'sasi'. When Moluccas missionaries carried the gospel to the Cenderawasih Bay areas in the 1850s, they integrated the practice into the marine harvest methods. This was based around a system of fallows and rotations that was adopted from a practice of seasonal marine harvest in Moluccas (Nikijuluw, 1995; Thorburn, 2000). Since then, it was applied in customary hunting practices among ethnic groups surrounding Cenderawasih Bay and other coastal Papuan communities in eastern Indonesia. Sasi in the sea is most commonly associated with the temporary closure of specific fisheries resources (e.g., sea cucumbers, Trochus sp.) or fisheries areas for periods ranging from 6 months to 5 years (McLeod et al., 2009). The degree to which sasi and other conservation-oriented customary practices are honoured by villages throughout the Bird's Head Seascape varies (Mangubhai et al., 2012). Earlier study of Johannes (1978) from the Pacific, indicated that the right to fish in a specific area was held by a clan, chief, or family, who regulated the exploitation of their own marine resources. Similarly, Ntiamoa-Baidu (1997) revealed that similar traditional practices were widespread across Africa, even to the point of regulating use of taxa generally falling outside formal laws, such as invertebrates, insects and snails.

4.2 Formal law Vs. customary law

Under Indonesian law (Government Decree – Peraturan Pemerintah (PP) RI No. 7/1999. Pengawetan Jenis Tumbuhan dan Satwa about the preservation of plants and animal species; Peraturan Pemerintah (PP) RI No. 8/1999. Pemanfaatan Jenis Tumbuhan dan Satwa Liar about the utilization of plants and animal species), although the commercial sale of wild meat is prohibited, our research found that hunting of introduced species such as deer and pig was popular. The capture of wild animals is allowed for study purposes but researchers must obtain legal permit from Balai Besar Konservasi Sumber Daya Alam (Nature Conservation Agency). In an interesting contrast, under Indonesian law (Government Decree – Peraturan Pemerintah (PP) RI No. 7/1999. Pengawetan Jenis Tumbuhan dan Satwa), four species (Dusky pademelon, Grizzled tree kangaroo, Northern cassowary and Victoria crowned pigeon), among the preferred targets were legally protected (Table 5). Most hunters (82%) responded they were unaware of any regulation controlling wild animal protection. In this study, traditional hunting restrictions were apparently more effective than formal law, because species protected under customary law were not hunted, while those legally protected by the government regulations were preferred targets. The implementation of this formal law is not well enforced, as we found some activities fail to meet the law requirements. Although in some schools and government offices, a

leaflet showing particular protected fauna is commonly displayed on the wall as part of education and regulation warning. Our respondents acknowledged the presence of formal law, but found it difficult to respect as no penalties were given. By contrast, customary law still has a strong influence in regulating social order and relations with forest and natural resources. The degrees to which taboos or customary laws are honoured are high, although they are not enforced by the government. The reason is because customary societies, which believe in spiritual enforcement of sanctions and religious beliefs, have a strong kinship relationship (Colding and Folke, 2001).

Industrial activities in villages such as logging and mining for example, must obtain permission from villagers. These customary rights over land and sea have been recognized under the Papua Special Autonomy arrangements in 2001. Belief in supernatural phenomena for certain places and objects or events plays a large part in local lives. In Indonesian, adat refers to a customary rule that, while not put into official legislation, is passed down verbally from generation to generation, with resource rights vested in individuals, families, clans, or entire communities. "*Igya ser hanjop*"– stands guard at the border – is the customary law protecting the forest that is implemented by Arfak people at the Arfak Mountain Strict Nature Reserve (Laksono et al., 2001). Local people acknowledge the management of forests through four areas of Meyakh language, "*bahamti, nimahamti and susti*" (primary forests, buffer zone and areas for agriculture and settlements, where the communitiescarry out their daily activities). Another example is "*bur, nden, sem mikindewa membow*" which in the Karon language means land, forest and coasts protected for the future and still continue to play an important role in natural resource management of the Karon communities in the Abun district.

4.3 Challenges for sustainability in hunting

The customary limitations described in this study imitates previous studies that make significant contributions to the conservation of biodiversity and management of protected areas (Arjjumend and Beaulieu-Boon, 2018), play an important role in protecting rare species (Virtanen, 2002); and to sustainable climate change adaptation (Mekonnen et al, 2021). Change or breakdown of those limits likely to increase pressure or threatens on biodiversity.

Hunting was and continues to be an enormously significant livelihood activity in Papua because it provides households with the majority of their animal protein needs, in addition to fishing in coastal areas (Pattiselanno and Arobaya, 2013, Pattiselanno and Koibur, 2018; Pattiselanno et al., 2019). This may indicate that the Indonesian Government's household assistance program to increase livestock production in the villages (Sonbait et al., 2011) is not fully effective, possibly because farmers have sold the animals outside the long-term program's plan for the distribution of the animals to other households (Tabloid Jubi, 2012). Geographical barriers have also restricted the distribution of breeding livestock to some communities, leading to a high price of farmed and wild meat.

Deer and wild pig were the preferred game, over and above any of the native species, even though deer are protected under the Government Regulation PP No. 7/1999. These species provided the largest amount of hunted meat, and the most important source of income from hunting, enabling hunters to meet both the market and household consumption demands. In the Abun District, agricultural goods produced in the gardens of the Karon villages are commonly consumed within the household, but part of that harvest, together with bushmeat, are sold to dealers who access the villages via a boat that visits the villages approximately once a month. Those dealers transport their purchases to markets in the larger regional cities such as Manokwari, Sorong and Sausapor.

The people we studied were mostly hunting introduced species in degraded environments, with no indication of hunting native or conservation-sensitive species (Pattiselanno and Koibur, 2018; Pattiselanno & Arobaya, 2013). The species composition of hunting returns within the sampled villages was nearly identical, consisting of deer, wild pigs, and native animals (Table 7). In the study sites, commercial hunting for rusa deer and wild pigs not only protect native species as target species, but also benefits the agriculture land by decreasing crop damage. Because ungulates are marketable commodities, this also illustrates the economic viability of hunting introduced species due to the enormous amount of meat supplied by each animal caught.

Our findings reveal a big gap between traditional beliefs, taboos and practices, and government regulations in Indonesia. To the Papuan ethnic groups in this study, hunting is a traditional way of life dating from the time of their distant ancestors (Pattiselanno, 2008; Pattiselanno et al., 2015). We found that people not only knew the traditional hunting limitations, but also implemented them in their hunting practices. In addition, each village has its traditional own customary board, members of which are responsible for controlling the practices of customary law. Sanctions for violations of customary management, pamali (Indonesian term for taboo) are acknowledged through social alienation or exclusion, gossiping or other forms of social pressures as sanctions on the violation of taboos. These forms of sanctions really affect their interaction with others within communities. To a certain extent, they would feel sick because of the consequence they would receive. Customary board are the chosen people from among those who are respected and have extensive knowledge about customary – Adat, law. They have been assigned as caretakers or traditional authorities to run the enforcement of customary law.

Indigenous Hunting in Indonesian New Guinea is very similar to hunting in Papua New Guinea. Land and sea tenure are verbally passed down from generation to generation, with resource rights vested in individuals, families, clans, or entire communities. However, this study shows that practices in Papua have begun to show similar changes to those recorded from other parts of Indonesia and other tropical forests, where it is shifting from subsistence to market-based hunting where wild pig and deer are the major prey (Milner-Gulland and Clayton, 2002; Luskin et al., 2014).

Future challenges to the sustainability of hunting along the coastal landscape of the Birds' Head Peninsula will be difficult to accomplish, due to the boost in demand for wild meat associated with commercialization and human population growth, as well as increased access to forest sites by continued development of road connections as well as the increasing use of advanced hunting techniques (Robinson and Bennett, 2000; Milner-Gulland et al.,

TABLE 7 Species hunted in coastal villages along the Bird's Head Peninsula, West Papua.

Scientific name	Common name	Utilization	IUCN status[1]	Status under Indonesian law[2]
Aepypodius arfakianus	Wattled brush-turkey	Egg collected; meat consumed	Least concern	
Bubulcus ibis	Cattle Egret	Meat consumed	Least concern	
Casuarius bennetti	Dwarf cassowary	Meat consumed	Least concern	Protected
Casuarius unappendiculatus	Northern cassowary	Meat consumed	Least concern	Protected
Dendrolagus inustus	Grizzled tree kangaroo	Meat consumed, decoration material	Vulnerable	Protected
Echymipera rufescens	Long-nosed echymipera	Meat consumed	Least concern	
Echymipera kalubu	Common echymipera	Meat consumed	Least concern	
Goura cristata	Western crowned pigeon	Meat consumed, pet	Vulnerable	
Goura victoria	Victoria crowned pigeon	Meat consumed, pet	Near threatened	
Megapodius reinwardt	Orange-footed Scrubfowl	Egg collected, meat consumed	Least concern	Protected
Phalanger orientalis	Northern common cuscus	Meat consumed, decoration material	Least concern	
Pteropus papuanus	Greater Flying Fox	Meat consumed	Least concern	
Rhyticeros plicatus	Papuan hornbill	Meat consumed, pet	Least concern	
Rusa timorensis[3]	Timor deer	Meat consumed, trophy	Vulnerable	Protected
Spilocuscus maculatus	Common spotted cuscus	Meat consumed, decoration material	Least concern	
Sus scrofa[3]	Wild pig	Meat consumed, tusks for decoration	Least concern	
Thylogale brunii	Dusky pademelon	Meat consumed, decoration material	Vulnerable	Protected
Varanus indicus	Mangrove monitor	Meat consumed, offset animal	Least concern	
Varanus prasinus	Emerald Monitor	Meat consumed, offset animal	Least concern	Protected
Varanus salvator	Common Water Monitor	Meat consumed, offset animal	Least concern	

[1]http://www.iucnredlist.org/
[2]Indonesian Law for Natural Resource and Ecosystem (Government Regulation PP No. 7/1999).
[3]Introduced species.

2003). The loss of traditional lifestyle typically implies that traditional territories and hunting methods are opened up by road access and human population development, resulting in a loss of sense of land and game ownership (Nasi et al., 2008). This will easily erode the practice of particular taboos and make it difficult to sustain the customary laws in practice (Robinson and Bennett, 2000). Recent empirical study has shown that modernization and economic growth are variables that contribute to the loss of traditional ecological knowledge (Gómez-Baggethun et al., 2010; Reyes-García et al., 2013). Our findings suggest that the experience of unsustainable hunting across the tropical forests in Africa, Latin America, Asia and Papua New Guinea will, sooner or later, be experienced by hunters in Indonesian New Guinea. Thus, it is important to consider the implementation of customary law in hunting as those practices can help to conserve biodiversity, protect rare species, manage the protected areas, maintain ecological process and sustainable resources use in general (Berkes et al., 2000). We also optimism that Majelis Rakyat Papua (MRP), the Papuan People's Assembly's program of promoting socio-cultural empowerment policy via initiatives to deepen indigenous wisdom and values, would have the potential to significantly aid in the long-term sustainability of customary co-management for wildlife conservation in Papua.

Conclusions

Many people in Papua rely on resources from tropical forest flora and fauna, collecting and hunting activities for food and ceremonial materials play key roles in traditional cultural life. This study examines how widespread cultural customs and beliefs are still widely practiced across various Indigenous Populations limit the impacts of hunting and suggests ways in which changes in current hunting practices might alter that impact. Our results arrive to five main conclusions. Firstly, although each ethnic group included in this study implemented customary limitations in slightly different ways, all groups implemented some type of customary limitation on hunting. The details of limitations on target taxa were diverse. Other limits on the target were based on their understood suitability as food that were considered as dangerously toxic to human life. While the consideration of sacred species is also high because a value for cultural and religious concerns.

Secondly, different hunting tools were used, and each hunter typically combined more than one tool. Traps, bows and arrows were largely used by hunters to kill live animals, and limit the harvest rate of hunting. We also noted a shift from traditional to modern hunting tools, because an easy access to buy air rifles that most common in some big cities in Papua.

Afterwards, a practice of traditional forest tenure is acknowledged by certain ethnic groups, and still in practice, benefiting biodiversity sources in the areas. Some ethnic groups recognized a system of permits, and such permission must be granted before hunters from other clans or tribes could hunt on their land. These practices are indirectly strict access to particular sites and the wildlife within and surrounding are protected.

Moreover, time-based restrictions on hunting are adopted from "sasi", a practice of seasonal marine harvest in Moluccas, especially to those occupy the coastal sites. While perform hunting at certain time of period based on the extractive activities is also considered as time-based restrictions that has an implication on wildlife conservation.

Lastly, the Papuan People's Assembly's present program of promoting socio-cultural empowerment policy via efforts to deepen Indigenous wisdom and values has the potential to considerably aid sustainable customary co-management for wildlife conservation in Papua. The implementation of this program throughout Papua and West Papua provinces is possibly making significant impact on biodiversity conservation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by James Cook University (JCU) Human Research Ethics Committee (approval number: H4203) for the Karon communities, and Research Permit No 08/UN42.15.2/KP/VIII/2018 from the Biodiversity Research Centre of Universitas Papua for the other sites. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

FP: Conceptualization, Data curation, Validation, Writing – original draft. MZ: Data curation, Writing – review & editing. RN: Data curation, Writing – review & editing. AK: Conceptualization, Data Curation, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Abood, S. A., Lee, J. S. H., Burivalova, Z., Garcia-Ulloa, J., and Koh, L. P. (2015). Relative contributions of the logging, fiber, oil palm, and mining industries to forest loss in Indonesia. *Conserv. Lett.* 8, 58–67. doi: 10.1111/conl.12103

Aiyadurai, A., Singh, N. J., and Milner-Gulland, E. J. (2010). Wildlife hunting by indigenous tribes: a case study from Arunachal Pradesh, north-east India. *Oryx* 44 (4), 564–572. doi: 10.1017/S0030605309990937

Antono, A. (2018) *Empat kebudayaan suku Arfak yang fenomenal.* Available at: https://ilmuseni.com/seni-budaya/kebudayaan-suku-arfak (Accessed Agustus 2019).

Apomfires, F., and Sapulete, d. K. (1994). "Masyarakat Arfak di Anggi, Manokwari, Irian Jaya," in Koentjaraningrat,, P. Suparlan, B. Rudito, N. Effendi, A.M. Kartawinata and Yudhisti (Eds.) *Masyarakat Terasing di Indonesia* (Gramedia, Jakarta).

Arjjumend, H., and Beaulieu-Boon, H. (20182018). Customary Institutions and Rules underlying Conservation Functions of Sacred Sites or Indigenous and Community Conserved AreasGrassroots. *J. Natural Resour.* 12.

Badan Pusat Statistik Kabupaten Maybrat (2017). *Kabupaten Maybrat Dalam Angka 2017* (Badan Pusat Statistik Kabupaten Maybrat).

Benitez-López, A., Alkemade, R. R., Schipper, A. M., Ingram, D. J., Verweij, P. A., Eikelboom, J. A. J., et al. (2017). The impact of hunting on tropical mammal and bird populations. *Science* 356 (6334), 180–183. doi: 10.1126/science.aaj1891

Bennett, E. L., Nyaoi, A. J., and Sompud, J. (2000). Saving Borneo's bacon: the sustainability of hunting in Sarawak and Sabah. *Hunting sustainability Trop. forests* (New York), 305–324.

Bennett, E. L., Milner-Gulland, E. J., Bakarr, M., Eves, H. E., Robinson, J. G., and Wilkie, D. S. (2002). Hunting the world's wildlife to extinction. *Oryx* 36, 328–329. doi: 10.1017/S0030605302000637

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* 10, 1251–1262. doi: 10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Bodmer, R. E., and Puertas, P. (2000). Community-based comanagement of wildlife in the Peruvian Amazon. *Hunting sustainability Trop. forests* (New York), 395–412.

Boelaars, J. (1992). *Manusia Irian: Dahulu, Sekarang, dan Masa Depan* (Jakarta: PT Gramedia Pustaka).

Bulmer, R. (1968). Strategies of hunting in new Guinea. *Oceania* 38 (4), 302–318. doi: 10.1002/j.1834-4461.1968.tb00975.x

Bulmer, R. N. H. (1972). "Hunting," in *Encyclopaedia of Papua and New Guinea*. Ed. P. Ryan (Melbourne: Melbourne University Press in association with the University of Papua and New Guinea), 543–546.

Coad, L., Fa, J. E., Abernethy, K., Van Vliet, N., Santamaria, C., Wilkie, D., et al. (2019) *Toward a Sustainable, Participatory and Inclusive Wild Meat Sector. Bogor, Indonesia : CIFOR*.

Colding, J., and Folke, C. (2001). Social taboos: "Invisible" systems of local resource management and biological conservation. *Ecol. Appl.* 11, 584–600.

Conservation International (1999). *Irian Jaya Biodiversity Conservation Priority-Setting Workshop.* (Biak: Conservation International).

Corlett, R. T. (2007). The impact of hunting on the mammalian fauna of Tropical Asian Forests. *Biotropica* 39, 292–303. doi: 10.1111/j.1744-7429.2007.00271.x

Dwyer, P. D. (1983). Etolo hunting performances and energetics. *Hum. Ecol.* 11, 145–174.

Dwyer, P. D., and Minnegal, M. (1991). Hunting in lowland, tropical rain forest: towards a model of non-agricultural subsistence. *Hum. Ecol.* 19 (2), 187–212. doi: 10.1007/BF00888745

Fa, J. E., Peres, C. A., and Meeuwig, J. (2002). Bushmeat exploitation in tropical forests: an intercontinental comparison. *Conserv. Biol.* 16, 232–237. doi: 10.1046/j.1523-1739.2002.00275.x

Fa, J. E., Ryan, S. F., and Bell, D. J. (2005). Hunting vulnerability, ecological characteristics and harvest rates of bushmeat species in Afrotropical forests. *Biol. Conserv.* 121, 167–176.

Fa, J. E., Yuste, J. E. G., and Castelo, R. (2000). Bushmeat markets on Bioko Island as a measure of hunting pressure. *Conserv. Biol.* 14 (6), 1602–1613.

Flannery, T. F. (1995). *Mammals of New Guinea* (Australia: Reed Books).

Forest Watch Indonesia – FWI (2020). *Infrastruktur di Papua untuk siapa?* (Lembar Fakta FWI). Available at: https://fwi.or.id/infrastruktur-di-papua-untuk-siapa/.

Gómez-Baggethun, E., Mingorría, S., Reyes-García, V., Calvet, L., and Montes, C. (2010). Traditional ecological knowledge trends in the transition to a market economy: empirical study in the Doñana Natural Areas. *Conserv. Biol.* 24 (3), 721–729. doi: 10.1111/j.1523-1739.2009.01401.x

Goswami, M. P. (2018). *Totenism and Tribes: A study of a concept and practoce* (Amarkantak: Indira Gandhi National Tribal University).

Hance, J. (2011) *3,000 amphibians, 160 land mammals remain undiscovered—that is if they don't go extinct first*. Available at: https://news.mongabay.com/2011/05/3000-amphibians-160-land-mammals-remain-undiscovered-that-is-if-they-dont-go-extinct-first/ (Accessed 29 May 2015).

Handoyo, A., Kastanya, I., Bone, ,. L. R., Wibowo, ,. P. J., Pelupessy, ,. I., De Rozari, ,. A., et al. (2014). *Panduan Pelibatan Masyarakat Lokal dalam Implementasi REDD⁺ di Indonesia Timur* (Jakarta: Pusat Penelitian dan Pengembangan Perubahan Iklim).

Jemison, M. (2015) *Feathers of seduction – the connection between birds and people of New Guinea*. Available at: http://smithsonianscience.org/2015/01/feathers-seduction-connection-birds-people-new-guinea/ (Accessed 24 April 2015).

Johannes, R. E. (1978). Traditional Marine conservation methods in oceania and their demise. *Annu. Rev. Ecol. Systematics* 9, 349–364. doi: 10.1146/annurev.es.09.110178.002025

Johnson, A., Bino, R., and Igag, P. (2004). A preliminary evaluation of the sustainability of cassowary (Aves: Casuariidae) capture and trade in Papua New Guinea. *Anim. Conserv.* 7, 129–137.

Knoop, S. B., Morcatty, T. Q., El Bizri, H. R., and Cheyne, S. M. (2020). Age, religion, and taboos influence subsistence hunting by indigenous people of the lower madeira river, Brazilian amazon. *J. @ Ethnobiology* 40 (2), 131–148. doi: 10.2993/0278-0771-40.2.131

Laksono, P. M., Rianti, A., Hendrijani, A., Gunawan, B., Mandacan, A., and dan M. Mansoara., A. (2001). *Igya ser hanjop masyarakat Arfak dan konsep konservasi* (Yogjakarta, Indonesia: Kehati, PSAP-UGM, YBLBC).

Laporte, N. T., Stabach, J. A., Grosch, R., Lin, T. S., and Goetz, S. J. (2007). Expansion of industrial logging in Central Africa. *Science* 316, 1451.

Laurance, W. F., Alonso, A., Lee M, M., and Campbell, P. (2006). Challenges for forest conservation in Gabon. *Futures* 38 (4), 454–470. doi: 10.1016/j.futures.2005.07.012

Lee, R. J. (2000). "Impact of Subsistence Hunting in North Sulawesi, INDONESIA and Conservation Options," in *Hunting for Sustainability in Tropical Forests*. Eds. R. G. Robinson and E. L. Bennett (New York, USA: Columbia University Press), 455–472.

Luskin, M. S., Christina, E. D., Kelley, L. C., and Potts, M. D. (2014). Modern hunting practices and wild meat trade in the oil plantation-dominated landscape of Sumatra. *Hum. Ecol.* 42, 35–45. doi: 10.1007/s10745-013-9606-8

Lyons, J. A., and Natusch, D. J. D. (2012). Over-stepping the quota? The trade in sugar gliders in west papua, Indonesia. *Traffic Bull. Vol* 24 (1), 5–6.

Mack, A. L., and West, P. (2005). Ten thousand tonnes of small animals: wildlife consumption in Papua New Guinea, a vital resource in need of management. *Resource Manage. Asia-Pacific Working Paper No. 61 Resource Manage. Asia-Pacific Program.* (Canberra). http://rspas.anu.edu.au/papers/rmap/Wpapers/rmap_wp61.pdf.

Mangubhai, S., Eerdmann, M. V., Wilson, J. R., Huffard, C. L., Ballamu, F., Hidayat, N. I., et al. (2012). Papuan Bird's Head Seascape: Emerging threats and challenges in the global center of marine biodiversity. *Mar. pollut. Bull.* 64, 2279–2295. doi: 10.1016/j.marpolbul.2012.07.024

Mansoben, J. R. (2007). "The socio-cultural plurality of Papuan society," in *The ecology of Papua Part 1*. Eds. A. J. Marshall and B. M. Beehler (Singapore: Periplus), 108–120.

Margono, B. A., Potapov, P. V., Turubanove, S., Stolle, F., and Hansen, M. C. (2014). Primary forest cover loss in Indonesia over 2000-2012. *Nat. Climate Change* 4, 730–735. doi: 10.1038/nclimate2277

Marshall, A. J., and Beehler, B. M. (2007). *Ecology of Papua Part 1* (Periplus Edition (HK) Limited).

McLeod, E., Szuster, B., and Salm., R. (2009). Sasi and marine conservation in Raja Ampat, Indonesia. *Coast. Manage.* 37, 656–676. doi: 10.1080/08920750903244143

McPhee, E. C. (1988). Ecology and Diet of some rodents from the lower montane region of Papua New Guinea. *Aust. Wildlife Res.* 15, 91–102. doi: 10.1071/WR9880091

Mekonnen, Z., Kidemu, M., Abebe, H., Semere, M., Gebreyesus, M., Worku, A., et al. (2021). *Traditional knowledge and Institutions for Sustainable Climate Change Adaptation in Ethiopia* Vol. 3 (Current Research in Environmental Sustainability).

Mendelson, S., Cowlishaw, G., and Rowcliffe, J. M. (2003). Anatomy of a bushmeat commodity chain in Takoradi, Ghana. *J. Peasant Stud.* 31 (1), 73–100. doi: 10.1080/03066150310001693 4

Menzies, J. I. (1976). *Handbook of Common New Guinea Frogs* (Papua New Guinea: Wau Ecology Institute).

Milner-Gulland, E. J., Bennett, E. L., Abenerthy, K., Bakarr, M., Bodmer, R., Brashares, J., et al. (2003). Wild meat: the bigger picture. *Trends Ecol. Evol.* 18, 351–357. doi: 10.1016/S0169-5347(03)00123-X

Milner-Gulland, E. J., and Clayton, L. (2002). The trade in babirusas and wild pigs in North Sulawesi, Indonesia. *Ecol. Economics* 42, 165–183. doi: 10.1016/S0921-8009(02)00047-2

Naranjo, E. J., Guerra, M. M., Bodmer, R. E., and Bolaños, J. E. (2004). Subsitence hunting by three ethnic groups of the Lacandon Forest, Mexico. *J. Ethnobiology* 24 (2), 233–253.

Nasi, R., Brown, D., Wilkie, D., Bennett, E., Tutin, C., van Tol, G., et al. (2008). Conservation and use of wildlife-based resources: the bushmeat crisis. *CBD Tech. Ser. No. 33* (Montreal, CanadaIndonesia).

Negi, C. S. (2010). The institution of taboo and the local resource management and conservation surrounding sacred natural sites in Uttarakhand, Central Himalaya. *Int. J. Biodiversity Conserv.* 2, 186–195.

Nikijuluw, V. P. H. (1995). Community-based fishery management (Sasi) in Maluku. *Indonesian Agric. Res. Dev. J.* 17, 33–39.

Ntiamoa-Baidu, Y. (1997). *Wildlife and food security in Africa. FAO Conservation Guide 33* (Rome: Food and Agriculture Organization of the United Nations).

Pangau-Adam, M., Noske, R., and Muehlenberg, M. (2012). Wildmeat or bushmeat? Subsistence hunting and commercial harvesting in Papua (West New Guinea), Indonesia. *Hum. Ecol.* 40, 611–621. doi: 10.1007/s10745-012-9492-5

Pattiselanno, F. (2004). Wildlife utilization and food security in West Papua, Indonesia. *Southeast Asian Regional Center Graduate Study Res. Agric. (SEARCA) Agric. Dev. Seminar Ser.* (Los Baños).

Pattiselanno, F. (2006). Wildlife hunting in papua. *Biota XI*, 59–61.

Pattiselanno, F. (2007). Possibility threatens on the wildlife potency along the Sebyar River. *Aranday Papua Warta Konservasi Lahan Basah* 15 (1), 22–23.

Pattiselanno, F. (2008). Man-wildlife interaction: Understanding the concept of conservation ethics in Papua. *Tigerpaper* 35, 10–12.

Pattiselanno, F., and Mentansan, G. (2010). The practice of traditional wisdom in wildlife hunting by Maybrat ethnic group to support wildlife sustainable in Sorong Selatan Regency. *Makara Sosial Humaniora* 14 (2), 75–82.

Pattiselanno, F. (2012). *Deer (Cervus timorensis) at the Highland Kebar, West Papua, Indonesia – Deer Utilization in Papua* (Germany: LAP – Lambert Academic Publishing).

Pattiselanno, F., Apituley, J. R. M., Arobaya, A. Y. S., and Koibur, J. F. (2019). Using wildlife for local livelihood – Experiences from the Bird's Head Peninsula. *Biodiversitas* 20 (7), 1839–1845. doi: 10.13057/biodiv/d200708

Pattiselanno, F., and Arobaya, A. Y. S. (2013). Sustenance hunting by Napan ethnic group in Nabire, Papua, Indonesia. *Tigerpaper* 40, 23–29.

Pattiselanno, F., and Koibur, J. F. (2018). Returns from Indigenous Hunting in the Lowland Coastal Forest of West Papua, Benefits threatened wildlife species. *Jurnal Manajemen Hutan Tropika* 24 (1), 46–50. doi: 10.7226/jtfm.4.1.246

Pattiselanno, F., Koibur, J. F., and Yohanes, C. H. (2015). "Traditional ecological knowledge (TEK) in hunting: from culture to nature," in *ICSBP Conference Proceedings International Conference on Social Science and Biodiversity of Papua and Papua New Guinea* (Dubai, United Arab Emirates: KnE Publishing), Vol. 2016.

Pattiselanno, F., and Krockenberger, A. (2021). Road development and Indigenous hunting in Tanah Papua: Connecting the facts for future wildlife conservation agendas. *For. Soc.* 5 (1), 181-189. doi: 10.24259/fs.v5i1.12528

Pattiselanno, F., Lloyd, J. K. F., Sayer, J., Boedhihartono, A. K., and Arobaya., A. Y. S. (2020). Wild meat trade chain on the bird's head peninsula of west papua province, Indonesia. *J. Ethnobiology* 40 (2), 202–217. doi: 10.2993/0278-0771-40.2.202

Pattiselanno, F., and Lubis, M. I. (2014). Hunting at the Abun Regional Marine Protected Areas: A link between wildmeat and food security. *Hayati J. Bioscience* 21, 180–186. doi: 10.4308/hjb.21.4.180

Peraturan Pemerintah (PP) RI No. 7/1999. *Pengawetan Jenis Tumbuhan dan Satwa* (1999).

Peraturan Pemerintah (PP) RI No. 8/1999. *Pemanfaatan Jenis Tumbuhan dan Satwa Liar* (1999).

Poulsen, J. J., Clark, C. J., Mavah, G., and Elkan, P. W. (2009). Bushmeat supply and consumption in a tropical logging concession in Northern Congo. *Conserv. Biol.* 23 (6), 1597–1608. doi: 10.1111/j.1523-1739.2009.01251.x

Powell, J. M. (1976). "Ethnobotany," in *New Guinea vegetation*. Ed. K. Paijmans (Canberra: Australian National University Press), 106–183.

Pratt, T. K., and Beehler, B. M. (2015). *Birds of New Guinea. 2nd edition* (Princeton University Press).

Ramenzoni, V. C. (2023). Taboos, food avoidance and diseases: Local epistomologies of health among Coastal Endenese in Eastern Indonesia. *Front. Sustain. Food Syst.* 7. doi: 10.3389/fsufs.2023.977694

Refisch, J., and Koné, I. (2005). Impact of commercial hunting on monkey populations in the Taï region, Côte d'Ivoire. *Biotropica* 37 (1), 136–144. doi: 10.1111/j.1744-7429.2005.03174.x

Reyes-García, V., Guèze, M., Luz, A. C., Paneque-Gálvez, J., Macía, M. J., Orta-Martínez, M., et al. (2013). Evidence of traditional knowledge loss among a contemporary. *Evol. Hum. Behav.* 34 (4), 249–257. doi: 10.1016/j.evolhumbehav.2013.03.002

Ripple, W. J., Abernethy, K., Betts, M. G., Chapron, G., Dirzo, R., Galetti, M., et al. (2016). Bushmeat hunting and extinction risk to the world's mammals. *R. Soc. Open Sci.* 3 (10). doi: 10.1098/rsos.160498

Robinson, J. G., and Bennett, E. L. (2000). *Hunting for sustainability in tropical forests* (New York, USA: Columbia University Press), 582.

Robinson, J. G., and Bennett, E. L. (2004). Having your wildlife and eating it too: an analysis of hunting sustainability across tropical ecosystems. *Anim. Conserv.* 7, 397–408.

Santos-Fita, D., Naranjo, E. J., and Rangel-Salazar, J. L. (2012). Wildlife uses and hunting patterns in rural communities of the Yucatan Peninsula, Mexico. *J. Ethnobiology Ethnomedicine* 8 (38). doi: 10.1186/1746-4269-8-38

Sillitoe, P. (2002). Always been farmer-foragers? Hunting and gathering in the Papua New Guinea Highlands. *Anthropological Forum* 12, 45–76. doi: 10.1080/00664670220128808

Sillitoe, P. (2001). Hunting for conservation in the Papua New Guinea Highlands. *Ethnos* 66 (3), 365–393.

Sonbait, L. Y., Santosa, K. A., and Panjono, (2011). Evaluation of cattle sharing system in the development of cattle farming for the farmer groups under Lembaga Mandiri Yang Mengakar di Masyarakat in Manokwari Regency, West Papua. *Bull. Peternakan* 35, 208–217.

Spradley, J. P. (1997). *Metode etnografi (The Ethnographic Interview)* (Yogjakarta: Terjemahan Misbah Zulfa Elizabeth; Penyunting Amirudin. Tiara Wacana Yoga).

Suárez, E., Morales, M., Cueva, R., Bucheli, V. U., Zapata-Rios, G., Toral, E., et al. (2009). Oil industry, wild meat trade and roads: indirect effects of oil extraction activities in a protected area in north eastern Ecuador. *Anim. Conserv.* 12, 364–373. doi: 10.1111/j.1469-1795.2009.00262.x

Tabloid Jubi (2012). *Dinas Perkebunan dan Peternakan Papua Distribusi 800 Sapi ke Tiga Kabupaten* (Tabloid Jubi).

Taime, T. (2002). Sistem Mata Pencaharian Masyarakat Papua. Dinas Kesehatan Provinsi Papua. *Makalah untuk Kegiatan RACE di Papua* (Jayapura).

Thorburn, C. C. (2000). Changing customary marine resource management practice and institutions: the case of sasi lola in the kei islands, Indonesia. *World Dev.* 28, 1461–1479. doi: 10.1016/S0305-750X(00)00039-5

Virtanen, P. (2002). The role of customary institutions in the conservation of biodiversity: Sacred forests in Mozambique. *Environ. Values* 11 (2), 227–241. doi: 10.1177/096327190201100208

Wanggai, F., and Kilmaskosssu, M. (1995). *Partisipasi masyarakat dalam kegiatan konservasi Taman Nasional Laut Teluk Cenderawasih.* (Manokwari: Makalah Rapat Koordinasi Pembangunan Taman Nasional Laut Teluk Cenderawasih).

Watson, T. (2011)86 Percent of Earth's Species Still Unknown? Millions of organisms unnamed as extinction accelerates, study says. Available at: http://news.nationalgeographic.com/news/2011/08/110824-earths-species-8-7-million-biology-planet-animals-science/ (Accessed 06 June 2015).

Wilkie, D. S., Wieland, M., Boulet, H., Le Bel, S., van Vliet, N., Cornelis, D., et al. (2016). Eating and conserving bushmeat in Africa. *Afr. J. Ecol.* 54 (4), 402-418. doi: 10.1111/aje.12392

Ziembicki, M. R., Woinarski, J. C. Z., and Mackey, B. (2013). Evaluating the status of species using Indigenous knowledge: novel evidence for major native mammal declines in northern Australia. *Biol. Conserv.* 157, 78–92. doi: 10.1016/j.biocon.2012.07.004