

Local harvest of pig-nosed turtle (*Carettochelys insculpta*) in the Kao River, Boven Digoel District, South Papua, Indonesia

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Abstract. Kusrini MD, Triantoro RGN, Manurung R, Setiawan RA, Kim N. 2024. Local harvest of pig-nosed turtle (*Carettochelys insculpta*) in the Kao River, Boven Digoel District, South Papua, Indonesia. *Biodiversitas* 25: 522-532. The pig-nosed turtle (*Carettochelys insculpta* Ramsay, 1886) has been harvested in the Papuan region, including South Papua Province, Indonesia. This study aimed to observe the harvesting characteristics of pig-nosed turtles around the Kao River in Boven Digoel District, South Papua, Indonesia. We interviewed harvesters, collectors, and village officials and participated in harvesting during harvest season, coinciding with the nesting season in August to early November 2022. The use of the pig-nosed turtle on the Kao River is primarily for eggs, not for meat. The collected eggs were incubated in an *ex-situ* hatchery until the juvenile form was sold to the collectors. All egg harvesters are local Papuans, while collectors or buyers are generally of non-Papuan descent. Harvesting is carried out by local people in land-owned nesting habitats as part of their inheritance-based customary rights. At least 23 clans from two tribes in the Kao River have the customary rights to harvest pig-nosed turtle eggs. Since harvesting has been carried out for more than 10 years, there is a need to ensure that harvesting will be sustainable without sacrificing the local communities' economic benefit.

Keywords: Freshwater turtles, harvesting, hunting, wildlife trade

INTRODUCTION

Wildlife harvest, a practice of removing animals, either lethal (i.e., hunting) or non-lethal (i.e., parts or products of animals that do not lead to the mortality of the host) from the habitat, has been practiced for centuries all over the world (Fromentin et al. 2022). Traditional hunting in tropical regions is vital in sustaining numerous indigenous communities (Harrison et al. 2016). However, it is well-documented that wildlife hunting can exert significant pressures on wildlife populations, potentially leading to their decline (Harrison et al. 2016; Benítez-López et al. 2017). In the specific context of Papua, Indonesia; wildlife hunting by local communities has garnered considerable attention (Pattiselanno 2006; Pattiselanno and Lubis 2014; Sawaki et al. 2022). The landscape of hunting in Papua has undergone notable transformations. Initially, it primarily served as a subsistence activity. However, with the rise in demand from transmigrant communities and the development of infrastructure like roads, hunting in Papua has evolved into a more commercial endeavor (Pangau-Adam et al. 2012; Pattiselanno and Krockenberger 2021). Additionally, adopting modern methods, such as using firearms and dogs, has significantly increased the volume of wildlife harvested (Sawaki et al. 2022; Pattiselanno et al. 2023). These developments raise important questions about the long-term sustainability of wildlife populations in the area (Pattiselanno and Arobaya 2011), especially when hunting pressure is correlated with trade, which is one of

the drivers for population decline (Hughes 2017; Hughes et al. 2023). Research has shown that seemingly intact forests might be empty or partially empty due to the removal of large numbers of wildlife by hunting, which leads to the empty forest syndrome (Antunes et al. 2016; Benítez-López et al. 2019)

In Papua, the most affected species by hunters are mammals and birds, particularly in forested regions (Pattiselanno 2006; Pattiselanno and Koibur 2018). Mammals such as deer (*Cervus timorensis* Blainville, 1822), wild pig (*Sus scrofa* Linnaeus, 1758), bandicoot (*Echymipera kalubu* Fischer, 1829), cuscus (*Spilocuscus maculatus* É.Geoffroy Saint-Hilaire, 1803), and tree kangaroo (*Dendrolagus inustus* Müller, 1840) are commonly pursued either local consumption or sold as meat (Pattiselanno 2006; Pattiselanno and Koibur 2018; Pangau-Adam et al. 2020). On the other hand, birds such as the northern cassowary (*Casuarus unappendiculatus* Blyth, 1860), Papuan hornbill (*Rhyticeros plicatus* J.R.Forster, 1781), and pinon imperial-pigeon (*Ducula pinon* Gaimard, 1823) are hunted primarily for local consumption (Pattiselanno and Lubis 2014). Additionally, reports on the hunting and harvesting of reptiles in Papua are relatively scarce.

Reptiles are under pressure from global trade, and Indonesia is one of the places where these animals are sold (Auliya et al. 2016; Marshall et al. 2020). In Papua, reptiles like crocodiles and turtles are typically targeted in coastal

areas or wetlands, primarily for their eggs, which are collected for either food or ranching purposes (Pattiselanno 2006; Tapilatu et al. 2017; Untari et al. 2020). In addition, turtles are an important resource for the community for food and their importance in traditional medicine or harvested for pets (Lyons et al. 2013; Burgess and Lilley 2014; Triantoro and Tuharea 2017). The collection of other reptile taxa, such as monitor lizards and snakes, is predominantly associated with the pet industry in Papua, especially concerning endemic species like *Varanus salvadorii* Peters and Doria, 1878 and *Morelia viridis* Schlegel, 1872 (Iyai et al. 2011; Natusch and Lyons 2012).

One of the widely distributed turtles from the southern part of Papua is the pig-nosed turtle (*Carettochelys insculpta* Ramsay, 1886), also found in Papua New Guinea and northern Australia (Eisemberg et al. 2018). The turtle has been used as a source of animal protein (both eggs and meat) for generations in some locations of Indonesian Papua and Papua New Guinea (Eisemberg et al. 2015, 2018; Triantoro and Tuharea 2017). Additionally, residents around Vriendschap River, Asmat District in South Papua Province, used pig-nosed turtles as dowry (Triantoro and Rumawak 2010). Pressure on the pig-nosed turtle population has increased in recent years, particularly in Indonesian parts of Papua and Papua New Guinea, mainly due to human population growth and the high utilization of these animals (Burgess and Lilley 2014; Eisemberg et al. 2015). In northern Australia, agricultural activities and drainage of watersheds have the potential to seriously impact its populations (Eisemberg et al. 2018). Due to high pressure in its population, especially for the harvest of its eggs, the pig-nosed turtle is considered Endangered by the Red List of the International Union for Conservation of Nature (IUCN) and listed in Appendix II CITES (Eisemberg et al. 2018).

The pig-nosed turtle is also legally protected by the Government of Indonesia; thus, no wild harvest is approved, although ranching has been allowed in the past few years. The national recommendation for pig-nosed turtle egg harvesting in 2022 is set at 10,000 eggs to be collected in Mimika and Asmat, both in Papua. Egg collection from the wild is intended for ranching activities, and only one company, CV. Alam Nusantara has obtained the necessary permit for this purpose, following the Minister of Environment and Forestry Decree (MoEF) No. 65/MENLHK/KSDAE/KSA.2/3/2021 dated 3 March 2021. Under this permit, only 50% of the collected eggs are allowed for use, while the remaining 50% must be released back into nature. Although it is protected and only a small proportion of eggs in the wild is allowed for ranching, the pig-nosed turtle is widely traded illegally, as shown by a high number of yearly confiscation reports, especially for hatchlings (Shepherd et al. 2020).

Information regarding the existence and use of pig-nosed turtles in Papua has pointed to the Asmat District as the main harvesting center (Triantoro 2016; Triantoro et al. 2017). However, it was reported that pig-nosed turtle was found around rivers in Merauke District especially in Torasi, Mindiptana, Geten Tiri, Tanah Merah, Asiki,

Sungai Digul in Kau, Waropko, Ulilin, Bupul, Sota, Wanggo, Muting and Sungai Bian Sub-districts, where its eggs were harvested for hatchery (Burgess and Lilley 2014). For more than ten years, the number of eggs illegally harvested from the rivers of Merauke has been considered very high, with an estimated 1.5-2 million eggs per year (Samedi and Iskandar 2000). However, the actual distribution of pig-nosed turtle breeding habitat and harvest hotspots in the river is unknown, either occurring in upstream, middle, or downstream rivers. This study aimed to obtain information regarding the use of pig-nosed turtles around the Kao River in Boven Digoel District, South Papua Province, including breeding locations, harvest characteristics and utilization processes.

MATERIALS AND METHODS

Study area

Kao River area (Figure 1) is part of the administrative area of Boven Digoel District, South Papua (4°98'-7°10' S and 139° 90'-141° E) in Indonesia. The Kao River is part of the Digul Drainage, which includes three main rivers: Digul River (length 683 km, width 215-3,209 m, current speed 4-7 km/hour) in the west, Kao River (200 km length, width 20-360 m, current speed 3-5 km/hour) in the east and the Andobo River (length 342 km, width 150-1,100 m, current speed 4-7 km/hour) in the north (Source: Department of Transportation of Boven Digoel District 2016).

Interview

A pilot survey was conducted in May 2022 to confirm the turtle nesting season in the Kao River area. Based on this information, data was collected from October to November 2022 following the turtle nesting seasons. To gather information on harvest and trade chains, we employed a non-probability snowball sampling technique whereby harvesters identify other individuals within the trade chains (Robinson et al. 2018). Individual interviews were conducted with each respondent after obtaining their approval for participation and ensuring their understanding of the study's objectives. Interviews were done in Bahasa Indonesia and then translated into English. There are 16 respondents consisting of 11 egg collectors, 4 brokers, and 1 village official. The term egg collectors refer to people who harvest turtle eggs in the fields, and brokers are first-hand buyers who buy the eggs or hatchlings. All egg collector respondents mostly act as leaders of the group of egg collectors. Informal and unstructured interviews were conducted after egg collectors completed harvest activities in locations, according to Kusriani et al. (2022) and Yudha et al. (2022). All respondents, except village officials, were asked about their characteristics (age, ethnicity, and length of employment), primary occupation, income, and whether the harvesting site was part of the inheritance. In addition, we asked all respondents about the history of harvesting in the Kao River and the trade chain.

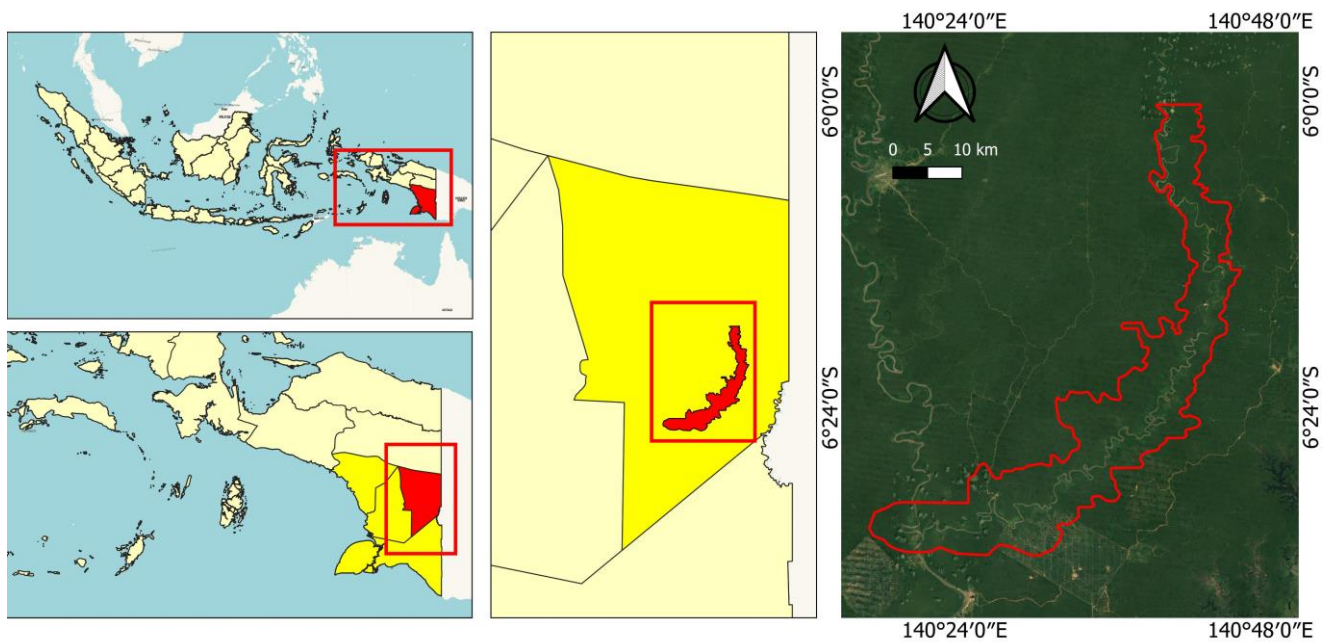


Figure 1. The research location of the Kao River is in the Digul River Basin, South Papua, Indonesia. Left and middle picture: Location of Kao River in reference to Indonesia and Papua Island. Right picture: Survey locations are in four villages and the surrounding river basins

Eggs harvesting sites

To obtain information on the extent of harvesting areas, we followed the pig-snouted turtle egg collectors during their activities for a total of 20 days following the study of Eisemberg et al. (2015) in the Kikori region, PNG. We visited 5 villages around nesting grounds and hunting lodges of the Kao River: Asikie, Sesnukt, Amboran, Anggamburan, and Geten Tiri, to record information on the harvest and number of eggs collected and other types of natural resources utilized. Using boats, we accompanied egg collectors to look for nesting sandbanks or potential nesting sandbanks found along ± 183.5 km river. Sandbanks identified by the respondents as traditional harvesting areas were mapped by taking coordinate points using GPS. We noted the condition of sandbanks and nests in the nesting sandbank, checking the possibility of any sign of predators or damaged nests. Mapping was performed using ArcMap 10.8 to analyze the extent of egg collection areas and the boundaries of customary rights, if any. Traditional harvest areas are processed using ArcMap 10.8 GIS software (Environmental Systems Research Institute, Inc.) and presented in map form. Data was analyzed using Microsoft Excel, and the results of the analysis were presented in the form of tables and graphs.

Process of egg harvesting, ex-situ hatchery, and trade chains

Accompanying egg collectors in their usual harvesting sites enables us to collect data on the egg harvesting process. In total, we conducted 20 collection trips where we noted the harvesting method and number of eggs collected. Afterward, we followed the harvested eggs, which usually were put in the hatchery, and noted the

locations, sizes, and material of the eggs hatchery. In addition, we noted the air temperatures and observed the maintenance of the hatchery. To understand the trade chains, we also noted various steps involved in the trade process and key players. The price of eggs traded was also noted and converted to USD. Based on the October 2022 mean currency exchange from the US Dollar (USD) to the Indonesian Rupiah (IDR), 1 USD equals IDR 14848. Evaluation regarding the legality and sustainability of the trade was made based on national legislation and the resulting estimation of the current level of egg harvesting.

RESULTS AND DISCUSSION

Harvesters' characteristics

All the respondents were males aged between 34 and 55 years. Their highest level of education was high school, except for two respondents who held bachelor's degrees, one a village official and the other an egg collector. All the respondents possessed proficient reading and writing skills and could communicate fluently in Bahasa Indonesia. The primary occupation for all the egg collectors ($n=11$) was harvesting pig-nosed turtle eggs, while they also engaged in fishing as a secondary job. Additionally, the egg collectors hunted other species of turtles and fish ($n=11$), particularly Arowana fish (*Scleropages jardinii* Saville-Kent, 1892)), for the purpose of sale. Occasionally, they would also hunt wild boar, deer, or birds. On the other hand, the brokers/middlemen generally mentioned farming and trading as their other occupations. All egg collectors confirmed that they had been involved in these activities

for over a decade, strongly emphasizing intensive egg harvest during the three-month egg-laying season and staying in the sites for at least 2 months or until the egg-laying season finished.

Pig-nosed turtle egg collectors interviewed possess a relatively high level of education, which is seen as unusual as the harvesting of wild animals on land and in water is generally undertaken by individuals with lower education (Kusrini et al. 2022; Nurazizah et al. 2022) unless the activity is primarily recreational (Yudha et al. 2022). This observation might be biased since the interviews were conducted with the leader of the hunting group, in contrast to the findings from another study in Vriendschap (Asmat), which revealed that most pig-nosed turtle egg collectors had no formal education or education below high school (Triantoro 2016). Based on the interviews, it was found that the respondents mostly pursued their studies outside the village, primarily in the Mindiptana Sub-district, and returned to the village after completing their education. Limited job opportunities compelled most village community members to focus solely on village activities.

According to the interviews, pig-nosed turtle egg harvesting is a seasonal and lucrative profession exclusive to clan landowners and was the egg collectors' primary income source. Based on data from the statistical bureau, the average monthly net income of informal workers for Boven Digoel District in 2022 is around IDR 1,888,849 or USD 127. On the Kao River, pig-nosed turtle harvesting was typically conducted in groups comprising 2-3 individuals, depending on the size of the boat and the distance to customary land. The group leader, who commanded respect and had a higher education level than the other members, led these hunting groups. Although the nesting period lasted only around three months, the economic value of pig-nosed turtle harvesting was significant, explaining why local inhabitants were committed to this activity. It is common for wildlife harvest activities to target multiple species, as seen in the case of pig-nosed turtle egg harvest in Vriendschap and snake harvest in West Java (Triantoro 2016; Kusrini et al. 2022). Moreover, wildlife harvest is often opportunistic or seasonal, leading these egg collectors to engage in other occupations (Wahab and Maulany 2020; Yudha et al. 2022).

Pig-nosed turtle egg collectors were predominantly local Papuans, while brokers or buyers were generally non-Papuan individuals. According to one informant, knowledge of egg incubation techniques was acquired orally from Javanese people (in Bahasa Indonesia: *orang Jawa*) which refers to buyers from Java origin. The term *bule* also referred to buyers who were considered foreigners and became buyers in 1997 (see section *Egg collection and ex-situ hatchery process* below). Among the brokers interviewed, two claimed to be from Makassar (Sulawesi), and one had Javanese-Chinese heritage and had resided in Asiki for a considerable period. Similar situations have been reported in Asmat and other regions of Papua (Burgess and Lilley 2014; Triantoro et al. 2017).

Harvesting eggs is strictly reserved for locals, as outsiders cannot directly harvest due to Papua's resource

ownership system (Pattiselanno 2006; Pattiselanno and Arobaya 2011). Consequently, egg collecting is primarily carried out by local communities. The egg collectors in the Kao River area possess family inheritance hunting areas or customary land known as *hak ulayat*. Egg collection is typically conducted in groups comprising relatives, and the customary land is restricted by natural boundaries such as tributaries and agreed-upon trees between clans. This customary land is a legacy and the result of war payments in the past. At least 23 clans from two tribes (oMandobo-Muyu and Muyu-Mandobo) have recorded breeding sites of pig-nosed turtle customary land around the Kao River (Table 1, Figure 2). Local communities around the Kao River also own harvesting areas around the Vriendschap River in Asmat (Triantoro 2016) and in Kikori, Papua New Guinea (Eisemberg et al. 2015).

Egg harvesting sites

Pig-nosed turtle's nest is mostly found on sandy dunes. The Kao River has a width of more than 120 m at high tide/flood. However, at low tide, the river width varies to 20-50 meters with perennial grass, i.e., Napier grass (*Cenchrus purpureus* (Schumach.) Morrone), on its edge. The number of dunes suitable for nesting habitat along the Kao River varies depending on water conditions. During a flood, sandbanks can be submerged partly or completely; afterward, the sands might look brownish as mixed with mud. All egg collectors remarked that these kinds of sandbanks are usually not suitable for nesting sites.

Table 1. Names of clans and tribes who own the customary land for pig nose turtle KMB harvesting on the Kao River, Boven Digoel, South Papua, Indonesia

Clan	Land area size (ha)
Tribe: Muyu-Mandobo	
Bandiop	100.25
Bangkok Kripok	2221.82
Jerewat	2500.22
Jononggoh	912.90
Jononggoh Oksan	325.80
Jononggoh Okwiran	1687.47
Kakim	926.55
Kakripan	1746.84
Karut 1	1198.88
Karut 2	967.98
Katumbot	718.58
Kayok	1878.49
Mogan	919.46
Tawan	1172.59
Yemyukaem	1349.73
Tribe: Mandobo-Muyu	
Artaga artaga	3732.05
Gemenub	9377.11
Gerendag-Guamkembian	2769.95
Hirowab-Kawab	10531.10
Kanggup	1161.53
Katinggoh	8437.97
Kinggo	7332.37
Mindipko	9918.21

Notes: Land area is measured from the riverbank along the clan boundaries

During the research, we identified 98 sandbanks along the river. However, only 7 of these sandbanks had nests, while 5 had traces of pig-nosed turtles. We also mapped 88 sandbanks with no nests, of which 64 were considered good nesting sites by the community but flooded at the time of the research (Table 2). Out of 7 sandbanks with nests, during 5 days of nesting observation, we discovered a total of 67 nests containing 715 eggs (mean eggs 14.5 ± 5.15 eggs/nest; range 4-24 eggs). The average number of eggs in a nest is higher than reported by Doody et al. (2003) in Australia, which is between 9.4 ± 2.54 to 11.5 ± 2.34 but, lower than the result by Triantoro (2012) in Asmat, which is 20.05 ± 5.60 ($n=79$, range =7-34 eggs). Some empty nests were attributed to theft by non-clan members, damage by monitor lizards, or flooding (Figure 3). Empty nests caused by human theft typically look like excavated holes concealed once more with sand.

The strategy devised by the thief bewilders egg collectors who carefully probe the sand in search of displaced grains (indicating a nest), only to find an empty nest when they excavate it. In another case, nests damaged by predators usually showed signs of broken eggshells or clawing marks (Figure 4). No eggs are usually found in predated nests or nests raided by theft.

Table 2. The number of sandbanks along the Kao River, Boven Digoel, South Papua, Indonesia (± 183.5 km) that have the potential to be nesting sites for pig-nosed turtles

Sandbank condition	N
Sandbanks with nests	7
Sandbanks with footprints or traces of old nests	5
Sandbanks without nests	22
Flooded Sandbanks	64

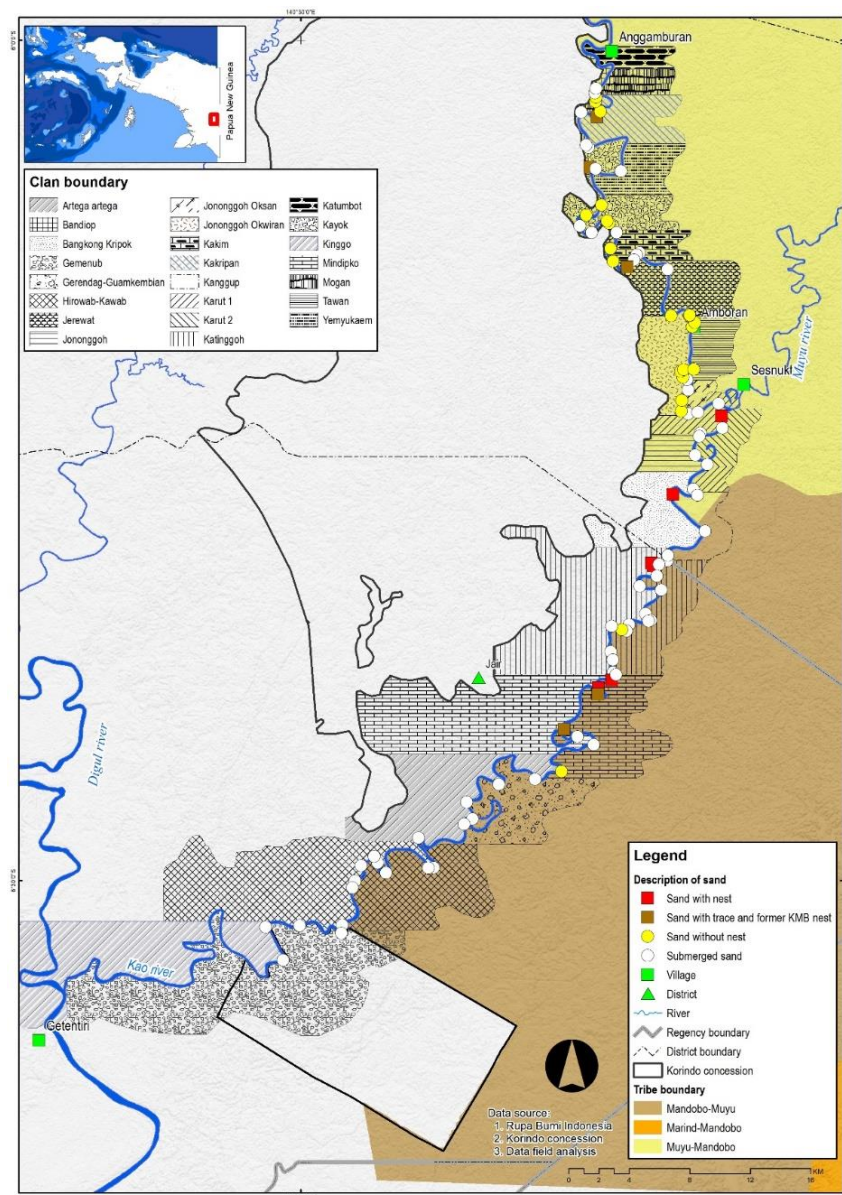


Figure 2. Distribution of harvested areas for pig-nosed turtles based on traditional land rights on the Kao River, Boven Digoel District, South Papua, Indonesia

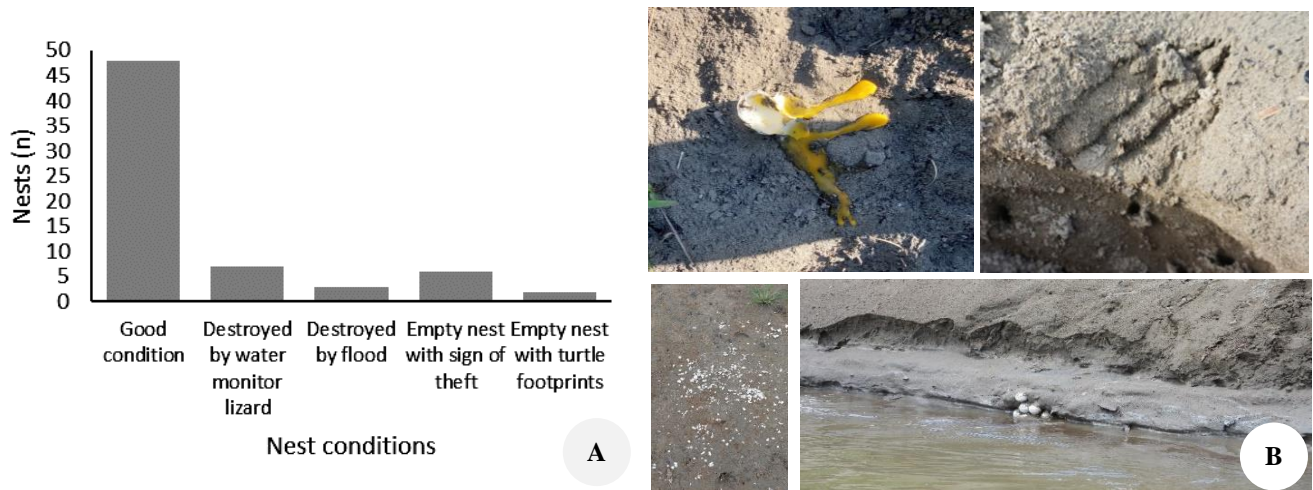


Figure 3. A. the number of pig-nosed turtle nests and their condition along Kao River, Boven Digoel, South Papua, Indonesia, from October to November 2022 (n=67). B. Nest damage due to natural predators (top and bottom left images) as well as nests being eroded by floods, resulting in damaged eggs



Figure 4. The process of harvesting and transferring eggs to the ex-situ hatchery. A. Sandy bank consisting mostly of fine sand is suitable as a nesting site for pig-nosed turtles; B. Egg collectors visit the nesting sand dunes, poke an iron rod to determine the position of the nest, dismantle the nest and remove the eggs; C. The eggs are placed manually in a bucket and then taken to a hatchery; D, E. Hatcheries are made of wood and covered by wire mesh and aluminum zinc corrugated sheets; F. Once the first eggs from the same batch hatched, the keeper will dig out other eggs and induce hatch by breaking the eggs with hand

Eggs collecting and ex-situ hatchery process

The breeding season for pig-nosed turtles along the Kao River spans from August to early November. This differs from the findings in the TRAFFIC report, which states that the breeding season in Papua occurs from September to February (Burgess and Lilley 2014). However, it aligns closely with the nesting season in Northern Australia i.e. Daly River, where pig-nosed turtles are known to lay their eggs during the dry winter months, specifically from July to October (Doody et al. 2009). Therefore, egg harvestings in the Kao River only occur during breeding seasons.

Traditionally, pig-nosed turtles are consumed for their meat (Burgess and Lilley 2014; Triantoro and Tuharea 2017). Currently, the primary use of pig-nosed turtles is for their eggs rather than their meat; thus, the primary motivation for harvesting pig-nosed turtles is their economic value rather than their consumption as food. Based on the interviews, egg collectors consider the eggs as valuable currency and refrain from eating them. One of the egg collectors' sons who accompanied the researchers echoed this sentiment. Therefore, the only part of the pig-nosed turtle that locals consume is the meat of adult turtles if they manage to capture one. The female pig-nosed turtle is considered mature to at least 38.0 cm of curved carapace length and 5.9 kg (Doody et al. 2003). However, there is no data on the size of a mature male, but it is expected that males are mature at smaller sizes (Georges et al. 2008).

The search for pig-nosed turtle eggs along the Kao River began in 1997, although one respondent mentioned that he had been trading since 1992. According to one account, the history of harvesting pig-nosed turtle eggs on the Kao River dates back to the arrival of *bule* foreigners who came to a stretch of sandbank to purchase eggs. The respondent recalls that in 1997, a foreigner arrived by helicopter at the sandbanks of the Kao River and bought the eggs harvested by the locals. To this day, that particular stretch of sand is known as the "Dollar" sand, in remembrance of the currency given by the buyers to the locals. A similar story of a helicopter landing on the sand bank to gather turtle eggs was also told in Burgess and Lilley's report (2014), although it took place in 2008 in an undescribed location. Nevertheless, this kind of legend story was told to show the lucrative market for pig-nosed turtle eggs.

There is almost no market for selling eggs in the Kao River, as the demand and price for hatchlings are higher. According to the egg collectors, egg sales only occurred initially when people began to realize the economic value of pig-nosed turtles. However, buyers later preferred to acquire hatchlings because eggs were more susceptible to damage during transportation. Once hatched, the juveniles were stronger and had a higher chance of survival during long journeys.

The search for pig-nosed turtle eggs is conducted in the morning when egg collectors observe the footprints of pig-nosed turtles on potential nesting sandbanks (Figure 4A). Typically, these egg collectors revisit the same nesting sandbanks where nests were found in previous years. They employ a wooden stick with an iron tip to probe the sand. The presence of loose sand indicates the presence of a nest

(Figure 4B). The egg collectors then proceed to excavate the sand and remove the eggs from the nest. Before placing the eggs in a plastic bucket, the egg collectors inspect their condition by holding the eggs through bright light to identify embryonic development and to determine the time of egg release (Figure 4C). Eggs that have undergone embryonic development indicate a release period of approximately 2-3 days prior. Eggs not undergoing embryonic development are considered unsuccessful and not transported to the ex-situ hatchery; the practice of egg collection for ranching is similar to the practice in Asmat (Triantoro et al. 2017). Failed eggs, including broken ones, are often discarded and sometimes consumed. The number of eggs harvested daily varied greatly, ranging from 0 to 200. In the rainy season, the egg harvest was typically low because the sandbanks were submerged by high tides, destroying nests.

Eggs were either brought to the leader of the egg collector (usually the clan leader) or sent immediately to the broker. The egg collectors' leaders or brokers will put eggs in artificial incubations or ex-situ hatcheries. The harvested eggs are incubated for 90-120 days until they hatch. According to this respondent, the hatching success rate was estimated to be 85-90%. The ex-situ hatchery typically consists of a square wooden box of varying sizes filled with river sand (Table 3, Figures 4D and 4E). It is placed in an open area within the yard of the hunting lodge (bivouac) or a fenced house to receive ample sunlight. During the day, the temperatures in the hatchery range from 32.1 to 41.4°C. A single wooden box can accommodate 500-3000 eggs arranged based on their arrival. Based on the mean number of 14.5 eggs/nest, the eggs were taken approximately from 34-2,985. It was separated into two to three compartments in larger wooden boxes to accommodate batches of eggs on separate days, each containing 2 to 3 layers of eggs arranged from bottom to top. According to egg collectors, having two layers of eggs is preferable, as three layers are more prone to damage. The earliest-arriving eggs are placed from the bottom to the top, each layer covered with sand. The other batch of eggs, which arrived later, is then arranged on the other side of the compartment and filled with eggs from the same batch. Once one part is filled, the process is repeated for the other part, starting from the bottom. Once assembled, the top part of the wooden box is covered with wire mesh and an aluminum zinc corrugated sheet to minimize disturbance by natural predators such as monitor lizards, rats, or snakes. During the day, the zinc sheet is opened, leaving only the wire mesh at the top. At night, the zinc sheet covers the top of the container.

Maintaining the appropriate temperature and moisture levels within the hatchery is important. There is no data on the humidity of the sand, but based on BPS Papua (2023), the mean daily humidity from October to December 2022 in Boven Digoel is 85-93%. Based on our observation, sand within the hatchery is periodically sprinkled with water to remain moist adequately, especially during dry periods. Rainwater is also allowed to enter the hatchery by opening the zinc sheet when it rains, facilitating the necessary moisture for the eggs. When the first egg from

one batch is hatched, the keeper will dig out layers of sand where the section of the eggs batch is located. Hands will break unhatched eggs to facilitate hatching (Fig. 4f). When eggs hatch, once buyers are interested, hatchlings could be sold immediately. However, if the price is unacceptable, the hatchling could be kept for 1-2 months before being sold to other buyers.

Trade chain

The trade chain of pig-nosed turtles in the Kao River consists of several stakeholders. At the bottom of the chain are the egg collectors who work under the traditional clan's leadership. The resulting eggs are usually put in the hatchery and then sold to the broker. Harvesting pig-nosed turtle eggs requires substantial funds, as it relies on oil-powered boats. Egg collectors reported that each trip required an investment ranging from IDR 200,000 to one million rupiah (USD 13.5-67.3). The total capital expenditure per season varied between IDR 5,000,000 and IDR 25,000,000 (USD 336.8-1683.7). In some cases, brokers provided capital assistance, including motorboats made of fiber and fuel oil. Consequently, egg collectors were required to deposit the harvested eggs with the broker at a pre-agreed price. In some instances, egg collectors deposited eggs instead of hatchlings, but the agreed price was based on the number of hatchlings hatched. Therefore, egg collectors rarely returned to the village to save costs and stayed in temporary huts or bivouacs. These huts were typically traditional wooden platforms with roofs made of coconut leaves. The relationship between egg collectors and brokers was often close, with capital assistance provided to ensure the egg collectors' loyalty to the buyers.

Although it is hinted that the first buyer is a (bule), nowadays, all buyers are Indonesian but usually not of Papuan ethnicity. However, they might be a long-term settler in Papua. Reports from Traffic indicated that the high economic value of pig-nosed turtles had attracted outside buyers, who persuaded local people to engage in turtle harvesting (Burgess and Lilley 2014). Brokers and high-level middlemen as buyers played a significant role in educating the community about the collection and process of ex-situ hatchery. They guided proper egg collection, ensuring the eggs were positioned correctly in the bucket and the hatchery to mimic their original natural placement. They also assisted in designing hatcheries. Egg harvesting and incubation activities have been reported in various

locations in Papua, particularly Asmat (Burgess and Lilley 2014; Triantoro et al. 2017). The dimensions and design elements of the pig-nosed turtle hatcheries reflect the practices followed by the local community along the Kao River as they strive to collect the eggs and promote the successful hatching of the pig-nosed turtle population.

Hatched eggs from the hatchery will be bought either by low-level brokers who sell the hatchling to other higher-level middlemen, or sold directly to high-level middlemen. Brokers usually live in the nearby villages, while intermediary buyers or high-level middlemen live in bigger cities, i.e., Merauke. Hatchling that is sold to high-level middlemen, in turn, will be sent to a subsidiary branch of the company that has the concession to sell pig-nosed turtles from the Ministry of Forestry and Environment in the previously approved number quota (Figure 5). Pig-nosed turtles are protected animals based on national regulations, making the sale of this species illegal without a special permit. The permit was given to a registered company under the Ministry of Forestry and Environment and only for ranching purposes. This company should not only have to report the number of turtles they bought and sold but also the local source and the names of the brokers and the local egg collectors, if possible.

The sale of hatchlings typically takes place from December to January. Before the pandemic, the price of hatchlings ranged from IDR 55,000 (USD 3.7) to IDR 70,000 (USD 4.7) per head. However, during the pandemic, the prices experienced a significant decrease, falling within the range of IDR 10,000 (USD 0.7) to IDR 15,000 (USD 1) per head. The impact of the pandemic resulted in reduced demand and plummeting prices, leading to minimal harvest and sales from 2020 to 2021. Upon the researchers' arrival at Sesnukt Village, one of the respondents possessed approximately 50 hatchlings that hatched in 2021. These hatchlings remained unsold and were kept in a small pond behind the respondent's house. Detailed reports by TRAFFIC have highlighted variations in egg and hatchling prices in Papua. For instance, in 2010, hatchling prices were documented to range from IDR 30,000 to 35,000 (USD 3.33-3.89) (Burgess and Lilley 2014). These price fluctuations clearly illustrate the influence of the market. During low prices, the returns obtained from sales may not cover the costs associated with the harvest process.

Table 3. The pig-nosed turtle hatchery's dimensions belong to the people around the Kao River, Boven Digoel, South Papua, Indonesia. Temperature was taken between 10 am to 12 pm, except for two nests taken at 4 pm (*)

Code	Length (m)	Width (m)	Height (m)	Depth of sand (cm)	Main material	Day temperature (°C)	Distance from ground (cm)
KPSA-1 Kao	2	2	0.7	31	Wooden board	38.3	20
KPSA-2 Kao	2	2	0.65	34	Wooden board	32.1	15
KPSA-3 Kao	0.55	0.55	63	38	Plastic bucket	34.1	0
KPSA-4 Kao*	2.15	0.4	0.45	-	Wooden board	32.6	-
KPSA-5 Kao	1.9	0.98	0.77	36	Wooden board	41.4	20
KPSA-6 Kao	2.05	1.4	0.66	32	Wooden board	39.9	26
KPSA-7 Kao*	2	2	60	-	Wooden board	-	-
KPSA-8 Kao	1.6	0.4	0.36	-	Wooden board	32.6	-

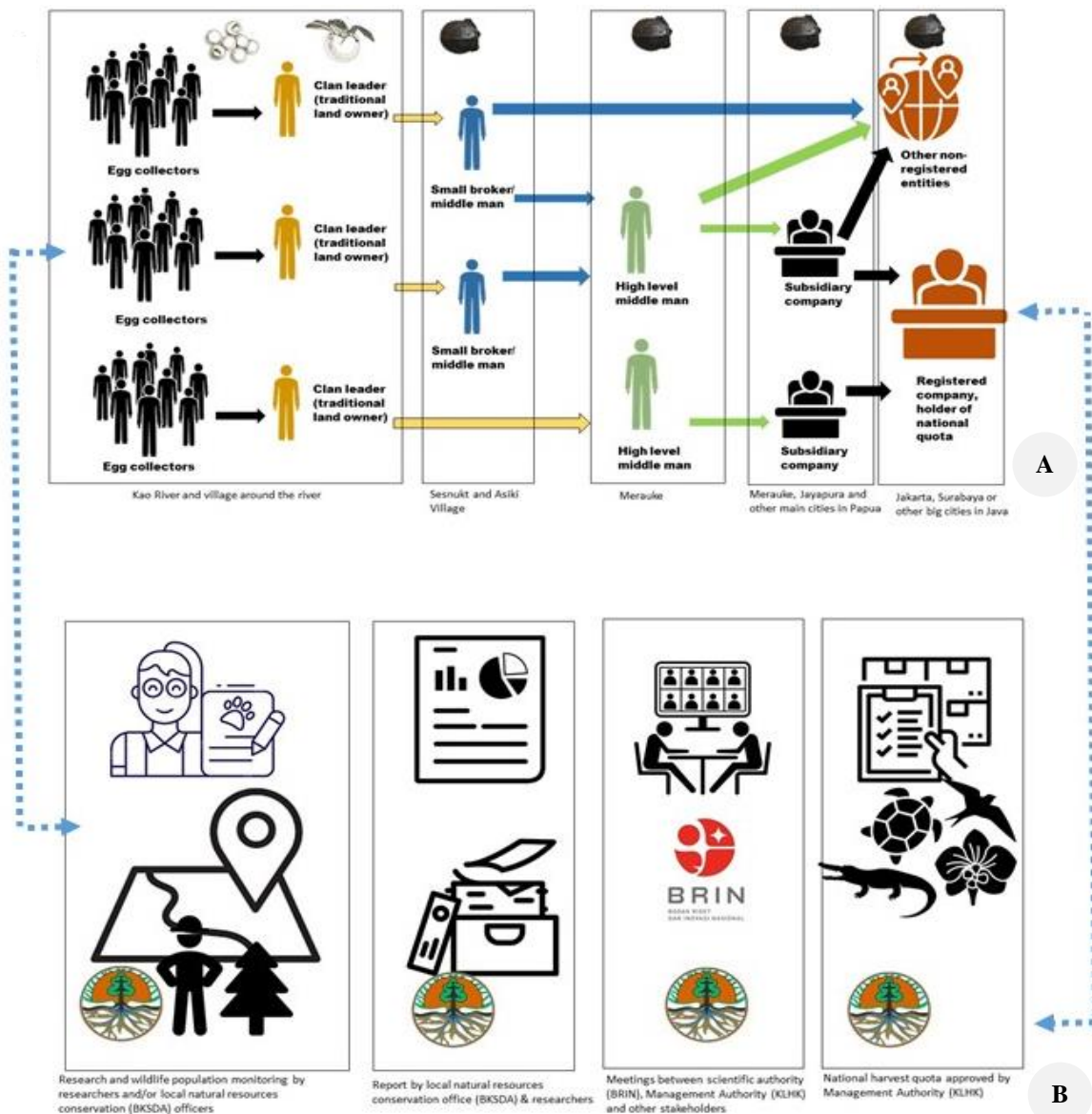


Figure 5. A. Trade chain of pig-nosed turtle egg harvest in Kao River, Boven Digoel, South Papua, Indonesia from the egg collectors, through brokers and middlemen and to entities that will distribute the pig-nosed turtle outside Papua. Egg collection and hatching occur in Kao River and the surrounding village. In other steps, the commodity will change from eggs to hatchlings; B. The process of determining the quota of wildlife harvest is based on research and wildlife monitoring by BKSDA. Reports from this activity are then used to propose a quota by the BKSDA to BRIN and MoEF. Meetings will be held to discuss the quota recommendation before the quota is approved by the MoEF. A and B are linked through research on harvest and wildlife monitoring in the location and also by the license given by MoEF to a registered company

Conservation implications of egg harvesting

Harvesting natural resources with economic value is frequently observed in various locations, particularly in Papua, often without considering the risks to their long-term sustainability (Pattiselanno 2006; Triantoro et al. 2017). Small-scale harvesting for community consumption generally has a minimal impact on the harvested wildlife population, but continuous commercial-scale harvesting, including hunting, can lead to detrimental consequences (Pangau-Adam et al. 2012; Triantoro and Tuharea 2017). This situation is also evident along the Kao River, where the harvesting of pig-nosed turtle eggs occurs annually, similar to other areas, without any notable conservation

efforts (Triantoro et al. 2017). Despite pig-nosed turtles being protected animals, the harvesting of these turtles in Papua has taken place for over a decade (Burgess and Lilley 2014). There has been no significant reduction in turtle eggs harvested during the breeding season, except during the pandemic in 2020-2021. This indicates that harvesting will persist as long as there is high demand from external sources.

Therefore, it is essential to assess the annual number of eggs harvested to determine the extent of the egg harvest. However, harvest differs between clan and year. During this research, a respondent mentioned that from the end of August to the end of October 2022, he had harvested eggs

three times, totaling 3,700 eggs (1,600, 1,200, and 900 eggs per harvest). The same respondents also reported that the number of hatchlings harvested in 2019 was 2,100. To calculate the number of hatchlings that could be sold from the eggs, we need to multiply the number of eggs by the percentage of hatchling survival. There are differences between hatching success in hatcheries reported by respondents (80-90%) and reports by Burgess and Lilley (2014), which indicated 70-80%. Using the cautionary principle, if we took the lowest hatching success rate (70%), it is estimated that approximately 2,100 hatchlings in 2019 originated from 3,000 eggs.

In this study, we could not obtain the specific count of eggs collected for each clan. Consequently, we are assuming that the harvest mentioned by the respondent represents the harvest for one clan. Using the number from this respondent, the number of eggs harvested from the clan is between 3,000 and 3,700. Using the lowest number of harvests for one clan as 3,000, we can estimate that the number of egg harvests along the Kao River could reach 69,000 eggs per harvest season (23 clans x 3000 eggs).

The allowable number of catching rates (quota) for the annual pig-nosed turtle harvest are set based on research and wildlife monitoring by researchers (either from the National Research and Innovation Agency or BRIN as the scientific authority of CITES, universities, or NGOs) or/and BKSDA (Nature Conservation Agency). BKSDA should then submit a proposed quota for its work areas. Based on the report and the proposed quota, BRIN will submit a recommendation that includes harvest locations and the number of harvests allowed in designated locations. Meetings will be held between various stakeholders before the Ministry of Environment and Forestry (MoEF), as the management authority of CITES approved the quota for the year. After the quota is approved, the registered company that holds a license from the Government can obtain pig-nosed turtles as long as it does not exceed the quota (Figure 5).

As mentioned previously, the quota for pig-nosed turtles is only from Asmat and Mimika. There is no quota for Boven Digoel, especially from the Kao River. During a meeting in November 2023 for the recommendation of wildlife catching rates (quota), the director of the Secretariat of Scientific Authority for Biodiversity (SKIKH) from BRIN is responsible for a recommendation for quota. The SKIKH remarked that since there is no report on the distribution, no quota is proposed regarding the extent of pig-nosed turtle harvest in the Kao River (Amir Hamidy, pers. Communication). On the other hand, a proposed quota from Asmat and Mimika is given by the BKSDA, along with a supplementary report based on monitoring in the area.

Since the locality of legally ranching pig-nosed turtles is from Mimika and Asmat, it is inevitable that pig-nosed turtles from Kao River are considered illegal and might be sold to an unregistered company. Moreover, the estimated number of eggs harvested in Kao River alone exceeds the recommended quota. Some respondents expressed awareness of the protected status of pig-nosed turtles and the illegality of pig-nosed turtles harvesting from the Kao River. Therefore, most respondents refrained from

transporting the eggs or hatchlings out of the area for trade due to the risk of legal consequences. High-level middlemen typically traveled to Asiki to acquire the hatchlings and transport them to Merauke. However, one respondent working as a broker expressed his desire to become a part of a subsidiary of the legal company and sought guidance from the BKSDA. This would ensure price stability and reduce the risk of a law violation (law enforcement interventions). As a broker who collected other commodities, he relied less on the results of pig-nosed turtle harvesting, as the harvest was unpredictable; furthermore, there were instances of fraud between collectors and brokers regarding prices, and the availability of hatchlings from nature was undefined.

In summary, traditional ownership of pig-nosed turtle breeding areas has benefited local communities economically. However, these ranching activities are not considered legal formally and thus need to be regulated. The total national quota provided is still relatively small when compared to the overall egg yield from the pig-nosed turtle nesting areas in Papua. This disparity between the quota and the natural egg population has resulted in the continuation of illegal egg harvesting and the trade of hatchlings. The authorities should consider egg collection and ranching practices along the Kao River as legal, as proof that pig-nosed turtles' distribution and production are sustainable, thus enabling the Kao River to be part of the locality for a legal national quota. Hence, a mechanism is required to enable the community to engage in legal harvesting activities without compromising economic, legal, and conservation benefits. Collaboration among the Government, communities, and nearby companies is crucial to ensure the sustainable existence of pig-nosed turtles.

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