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# Dynamics of the global trade Asiatic Softshell Turtle (*Amyda cartilaginea* Boddaert 1770): Shifting trends in commerce and consequences for sustainability

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**Abstract.** Biodiverse countries such as Indonesia provide the exotic Asiatic Softshell Turtle (*Amyda cartilaginea* Boddaert 1770) for the wildlife trade. Deciding which trade model is detrimental to species survival in the wild can be a major challenge for Management Authorities (MA) in implementing CITES. The consequences for conservation, long-term use, and livelihoods are uncertain. The study used the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) trade database. The collection of raw data is based on trade reports for the species of freshwater turtles (testudinidae) for the period 2011 to 2021, export countries from Indonesia, export destinations for all countries and sources of harvested turtles from the wild. This research aims to study the freshwater turtle trading trends over the decade, compare total quotas to actual harvest, and recognize how the precautionary principle is applied in harvesting *A. cartilaginea*. Harvesting and trading are following the quota regulated under the Indonesian government. However, conservation efforts were less emphasized, so it is feared that there will be a population decline and even extinction in the future, while the population in the wild cannot be ascertained. The larger the harvest quota set and the shorter the harvest period, the larger the natural population that must be available.

## 1. Introduction

The extinction of an endangered species is part of a significant massive exploitation process, so there is a need for sustainable conservation to understand spatial, temporal dynamics and spatial demand [1]. In 2005, data were obtained with almost US \$24 billion worth of international trade in wildlife excluding fisheries and in the study of domestic trade, it was very difficult to assess [2]. Wildlife trade has significant economic and social implications, especially in terms of species conservation [3]. The Convention on International Trade in Endangered Species (CITES) was founded on the principle of a concern that ensures the survival of wild species and regulates international trade concerning their lives. CITES protects more than 35,000 species with risk and trade conservation categories regulated in export and import licenses [4].

The international wildlife trade that is a critical spotlight is on reptile species and their products. According to CITES data, it contributed 84% with the majority of these reptile skin products [5].



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Reptiles are animals that have high economic value because market demand for these various species both on a national and international scale is very high. According to [6], the reptile trade currently represents the second highest class of vertebrates after birds in the international animal trade. Furthermore, the increase in recreational activity and commercial reptile breeding has increased in recent years. When nominated in 2010, it reached 4.3 million euros in European Union trade and accounted for 22% of all imports by value replaced only by mammalian species [4].

At present, there is a large proportion of the risk of extinction in several groups of reptiles with freshwater and marine habitats [7]. The greatest threats include turtle species traded extensively for traditional medicine, pets, antiques and consumption [8]. This phenomenon, known as Allee's anthropogenic effect, ultimately leads to species extinction [9]. In addition, several species of turtles are highly sought after, such as *Cuora trifasciata* and *Amyda cartilaginea*, believed to be used as medicines in Traditional Chinese medicine (TCM), causing extreme price and trade spikes in the late 1900s.

Despite experiencing a pandemic, the trade of turtles in Indonesia is currently still high. Based on the 2020 Wild Plant and Animal Harvest Quota Realization Report, the actual capture quota for Asiatic softshell turtles reach 1316 individuals (domestic) and 25,034 individuals for export. The turtle trade will generate high foreign exchange, which of course, will benefit the country. However, the problem arises because of illegal trade, which is detrimental from an economic perspective and ecologically. In addition, illegal trading causes losses to the state because there is no income from trade taxes.

What is more worrying is that ecologically, illegal trade leads to uncontrolled exploitation. Harvesting of reptiles is also not based on established rules, where for *A. cartilaginea*, the requirements for capture have a minimum weight size of 7 kg and are not pregnant. As the only country with a quota for reptile exports, Indonesia should be under strict legal control for turtle harvesting.

Research on the turtle trade mainly only addressed overexploitation and the impact of overharvesting ecologically. This paper analyses trends in turtle trade over a decade, the number of individuals traded under CITES, the relationship between time and number of individuals harvested, a bibliographic search of research on the turtle trade in Indonesia over the last ten years, including the ecological characteristics of their habitat in areas with the highest yields. Trading systems that deviate from the regulations may disrupt sustainability. The results of this study are expected to be useful as input for management authorities who can support solving problems related to the over-exploitation of the *A. cartilaginea* trade system.

## 2. Materials and Methods

### 2.1. Materials and research method

This study uses the CITES trade database. The collection of raw data is based on trade reports for the species of freshwater turtles (*Testudinidae/tortoises*) for the period 2011 to 2021, export countries from Indonesia, export destinations for all countries and sources of harvested turtles from nature. The trading data from CITES extraction was then analyzed by simple regression to analyze the correlation between time (years) and the number of tortoises traded was statistically significant. In the discussion, the CITES trade report database will be compared with the 2011-2021 Wild Plant and Animal Utilization Quota issued by the Indonesian Management Authority, namely the Directorate General of Ecosystem Natural Resources Conservation (KSDAE). This study will determine whether there is any inconsistency or difference between the CITES data tabulation, the reference source, and the TSL Utilization Quota in Indonesia.

The CITES database reports all legal import/export records worldwide, including Indonesia by species and country per year. For tortoise species in Indonesia, the authors limit the information to be used by trade category: country of export destination, where the animal was raised in captivity or taken in the wild, and also the purpose of the trade (commercial, scientific or domesticated). This

study limits the trade analysis in registered turtles from the wild (source code "W"), following the study results conducted by [10].

A bibliographic search was carried out on a search engine manually using the keywords "tortoises," "freshwater turtle," "trade," "quota," and "commerce" to analyze research developments in the turtle trade in Indonesia. Besides choosing keywords, restrictions on bibliographic searches are also carried out by limiting comprehensive literature, namely journals from medium to high reputation (including articles and reports) and publication years from 2011 to 2021.

## 2.2. Data analysis

Regression analysis was conducted to determine the trends in tortoise trade over the last ten years. CITES data were re-analyzed to analyze the correlation between time (years) and the number of tortoises using Pearson's correlation [10]. To determine the development of the research, a bibliographic search by selecting articles that match the keywords, year of publication and type of publication. To find out the trading system and map of trade routes, an analysis of the distribution of the area of origin of turtles (with their numbers) was carried out using a basic map of Indonesia. Furthermore, a simple layout by adding the export destination country.

## 3. Results and Discussion

### 3.1. Number of tortoises traded over the decade by CITES

From CITES data extraction, species traded from Indonesia for tortoise during the 10-year (2011-2021) totaled 637,834 individuals. Traded turtles consisted of 4 families, namely: Testudinidae (50.40%), Trionychidae (1.38%), Geoemydidae (48.16%) and Emydidae (0.04%). The number and types of turtles traded based on the CITES database are presented in Table 1.

**Table 1.** The number of individual turtles traded over a decade.

Family	Number of Individuals Traded
Testudinidae	321,531
Trionychidae	8799
Geoemydidae	307,234
Emydidae	270

### 3.2. Quota versus actual harvest (realization)

Asiatic softshell turtle is a type of freshwater turtle from the Testudinidae family. *A. cartilaginea* is widespread in Southeast Asia, and Indonesia has the highest export quota in Southeast Asia. Based on the city book for harvesting plants and catching wild animals from 2011 to 2020, the total export quota and realization of *A. cartilaginea* can be seen in Table 2.

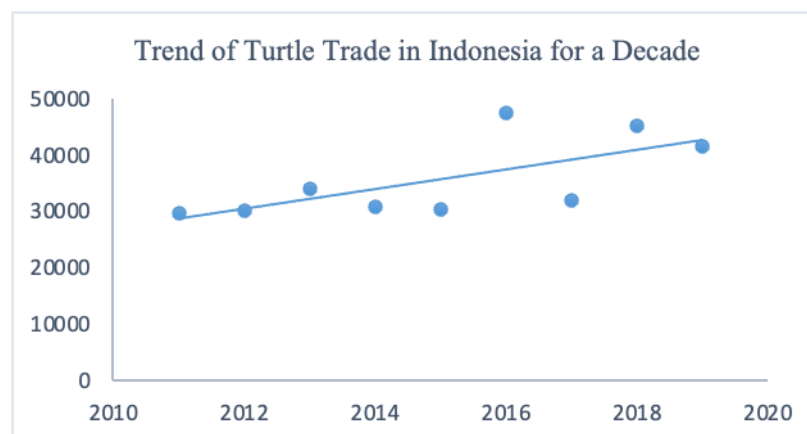
**Table 2.** Export quotas and realization of *A. cartilaginea* for a decade.

Years	Export Quota	Export Realization	Purpose
2011	23,400	24,764	Pet
	1800		Consumption
2012	25,200	24,764	Pet
	1800		Consumption
2013	25,200	24,764	Pet
	1800		Consumption
2014	25,200	25,000	Pet
	1800		Consumption
2015	25,200	25,000	Pet

Years	Export Quota	Export Realization	Purpose
2016	1800	23,400	Consumption
	25,200		Pet
2017	1800	23,400	Consumption
	25,200		Pet
2018	1800	23,715	Consumption
	25,200		Pet
2019	1485	23,715	Consumption
	25,200		Pet
2020	1485	25,034	Consumption
	26,600		Pet
	1568		Consumption

### 3.3. Turtle trading trends over the decade

Looking at the trade trend of tortoise over ten years, it turns out that the highest yield of tortoises is from the family Testudinidae, namely from the type of *A. cartilaginea*. Furthermore, the highest trading trend reached its peak in 2016, decreased in 2017, then rose again in 2018 and is stable in 2019. With this pattern, Indonesia is the most influential exporter in the Asian region for the turtle trade (Figure 1).



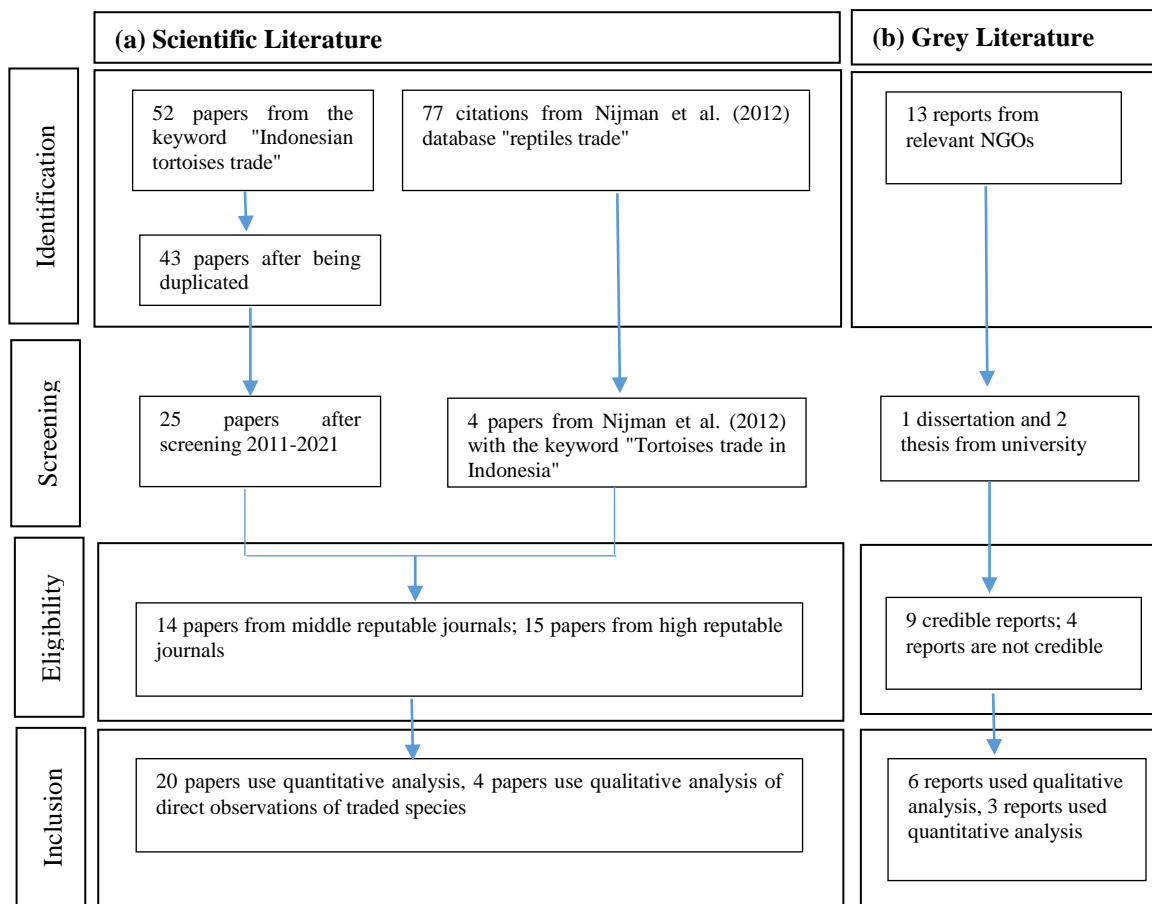
**Figure 1.** Trends in the turtle trade in Indonesia for ten years.

From the analysis, the correlation between time and the number of tortoises being traded was statistically significant and had a positive linear relationship ( $r = 0.916$ ;  $r^2 = 0.840$ ;  $p < 0.00001$ ). This means a strong relationship between the time and the number of traded tortoises (the  $r$ -value is close to 1). Thus, timing and the number of harvests are closely related. It is because the number of species of turtles and their trade is regulated under CITES. Furthermore, their use is limited to the use of wildlife quotas.

### 3.4. Map, trade routes, and quota of *A. cartilaginea*

Trade of *A. cartilaginea* decreased from decades in many regions, including Malaysia and Singapore (Figure 2). Harvesting soft-shelled turtles with intensive activities were carried out around the 1990s. From the data extraction results, the highest export quota is China (50.14%), but it is suspected that this import was re-exported by China to the USA. Apart from China, other export destinations were Singapore (43.68%), Malaysia (2.40%), Vietnam (1.20%), USA (0.87%), France (0.72%), Hong Kong (0.36%), Japan (0.33%), and Cambodia (0.28%).



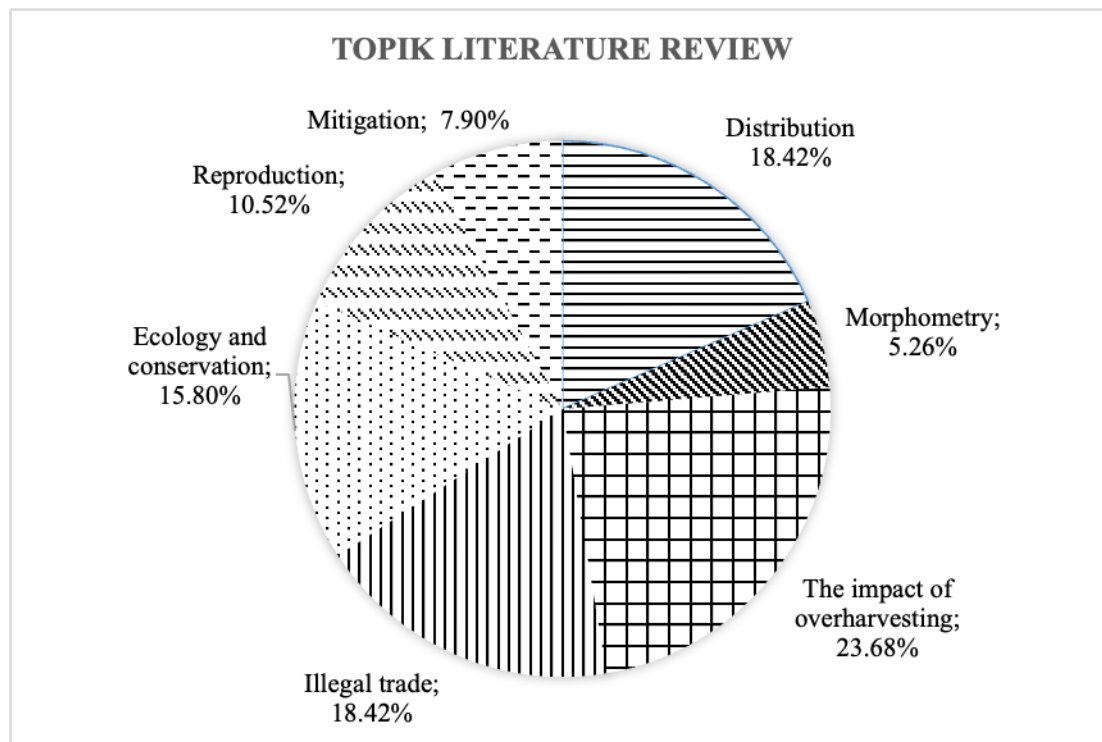


**Figure 3.** Literature review search strategy.

The development of research and topics discussed regarding the turtle trade in Indonesia from 2011 to 2021 are as follows: from a total of 38 credible pieces of literature, there are seven reports on turtle trade distribution (18.42%); two reports on yield morphometry (5.26%); nine texts with the topic of the impact of turtle harvest over-harvesting (23.68%); seven texts on illegal trade (18.42%); 6 texts on ecology, habitat characteristics and conservation (15.80%); four texts on reproduction in captivity (10.52%); and three texts on mitigation priorities (7.90%). A diagram of research topics can be seen in Figure 3. Thus, the overall average level of publication about the turtle trade between 2011 and 2021 is 43 papers and three reports each year.

There is a research gap: There is no research on population size, so the determination of the quota is only based on the realization of the previous year's quota. It should be evaluated periodically and then inconsistency between databases CITES and wildlife harvest quotas from Indonesia. The gaps mean there has been no research on the minimum population size in nature and the ability of these species to maintain their minimum sustainable population (MVP) through the reproduction process so that the theory of sustainable use is correct and according to the facts in the field.





**Figure 4.** Percentage of research topics.

### 3.6. The principle of sustainable harvest quota

Countries with abundant natural resources are specific targets for the illegal trade in protected wildlife. From the research results of [4] where data was obtained that between 2001 and 2012 there was a decline with the distribution of captive reptile imports decreasing by 40% for iguana reptile species and data on the percentage of 70% decreasing wild-caught reptiles which made the most significant number in the study period. Reptiles that come from captivity are priced at half the price for this period. This study also found a 50-fold increase in imports of cultivated reptiles such as turtle species in Asia and South America, the dominance of pythons in Sub-Saharan Africa, and the proportion of reptiles from various countries that decreased. The results show that the difficulty of market supply is due to the impact of international trade on the number of reptiles bred in consumer countries. In terms of conservation, it is obtained based on the species conserved and the number of requests from international trade. Species with a wide distribution and high population can make several indicators of the level of exploitation concerning the extinction rate obtained [11]. Knowledge is needed regarding the preferences and levels of consumer demand to understand the dynamics of the reptile trade in the future.

Indonesia is a world-renowned center for animal trade [12]. The reality in the field is that various types of freshwater turtles are sold legally (recorded in quotas) and illegally in markets, exotic pet shops, expos, and even online [12]. The results of [13] show that although Indonesian endemic freshwater turtles are still in demand, there is an increase in the trade in non-native species. This is because the number of breeders who have succeeded in cultivating turtles is not native Indonesian species. The species reported to be most trafficked that are not native to Indonesia are the Indian star turtle (*Geochelone elegans*) of India, the sulcata turtle (*Centrochelys sulcata*) of African origin and the pardalis tortoise (*Stigmochelys pardalis*), which is also native to Indonesia. Africa. This type is widely traded because of its beautiful and unique motifs, so it is in great demand as a pet (pet). There is a research gap: the high number of native turtle species being traded because they are not regulated in Indonesian law. Until recent times, the implementation of "hard law" on trade for species that are not native to Indonesia (including in the CITES database) has not been prosecuted, let alone not from



Indonesia. Their status is included in Appendix II. In addition, laws that currently cover the protection of native Indonesian species are still not effectively enforced, and traffickers rarely receive the heaviest penalties (specimens are confiscated only and have no deterrent effect).

Until 2020, the Directorate General of Natural Resources and Ecosystem Conservation cq. the Directorate of Biodiversity Conservation, the Ministry of Environment and Forestry as the management authority recorded 13 types of turtle species that are traded abroad (exports). Of the 13 species exported, 10 (76.92%) were traded live for consumption and 3 (23%) for pets. Types that are not for consumption are the Malayan snail-eating Turtle or locally known as the tiger turtle (*Malayemys subtrijuga*), Sulawesian tortoise, or *baning Sulawesi* (*Indotestudo forstenii*) and the Spiny turtle or thorn turtle (*Heosemys spinosa*). Based on this study, it has been recorded that since 2015, the number of turtle trade has increased in the number compared to the period before 2010. There has also been an increase in the number of non-native Indonesian species listed in CITES and endangered species that are illegally traded. [13] also mentions that species that are endangered and not native to Indonesia are still illegally traded in Indonesia, namely the nipora turtle (*Yniphora astrochelys*) and the radiata turtle (*Radiata Astrochelys*) both of which came from Madagascar. The number of turtle species exported from Indonesia shows a fluctuating trend, where the highest occurred in 2016 and decreased in 2017. This is due to the quota system in Indonesia, which implements harvests that are regulated based on the morphometry of weight and size used and not in individuals in the pregnant conditions so that there is time to reproduce in their natural habitat and concept of sustainable use can occur [7].

A decade since the publication of a paper by [14] and a report by [15], a thorny problem in the reptile and turtle trade system still revolves around the absence of accurate population sizes in nature. This actual population development data is fundamental to form the basis for determining utilization quotas. The gap in this research is that there is no actual data on the actual population size in nature. Therefore, the determination of the quota is only based on the actual quota of the previous year and the actual population size in nature is not considered. Whether a particular species can be harvested should differ from region to region and cannot be generalized. This research gap can be bridged by researching the minimum sustainable population size (MVP) based on estimated demographic parameters.

The following research gap is inconsistent between the CITES database and the Quota Book of Natural Plant Extraction and Wildlife Capture published by KSDAE, Ministry of Environment and Forestry. This difference can be seen in the total gross export of *A. cartilaginea* individuals differently in several years (2016 and 2017). Future studies need to examine whether these differences in data are due to decreasing population sizes of this species in nature and efforts to limit overharvesting.

The use of freshwater turtles, such as the species *A. cartilaginea*, is mainly for export purposes, where harvesting relies on natural products rather than captive products [14]. The harvesting technique for *A. cartilaginea* varies by location. In East Kalimantan, [15] reported that hunters harvest using baited hooks, except in the Sebuku area, where respondents used long sticks to locate the turtles. For *A. cartilaginea* fishing, fishing rods with bait are placed as much as 10-70 at certain distances along the river bank. Unlike East Kalimantan, in West Sumatra, the harvesting of *A. cartilaginea* is carried out with fishing poles and blunt sticks [16]. In the Air Hitam River of South Sumatra, professional hunters use fishing rods to catch *A. cartilaginea* [17]. The local population uses only a small amount of *A. cartilaginea* meat because some believe turtles should not be consumed due to their "halal" status. Only several certain ethnic groups use it as food, but it has become a major product in several regions such as East Kalimantan and Sumatra for the use of oil.

In general, hunters did not differentiate the harvest of *A. cartilaginea* based on male and female. *A. cartilaginea* in Indonesia is illustrated by the proportion of the same sex ratio between captured males and females [18]. And how to find a balance so that utilization remains sustainable? Simply put, the population size must be greater than or equal to the Minimum Viable Population (MVP). And sustainable harvest quota equal to population size minus carrying capacity.

Harvest size limits are imposed by Management Authorities and are based on individual weights. For sustainable use, we recommend the "Precautionary Principle": harvesting should absolutely be conducted when a population is experiencing an explosion and has been considered "pests"/disturbing to the surrounding community. Harvesting effort is intended to balance population size in the context of the natural ecosystem food chain. The application of the precautionary principle is the ideal size of harvest *A. cartilaginea* weighing less than 5.5 kg (pet) and more than 7 kg (consumption). This size limit was considered that this size is an effective measure and maximum/minimum breeding age. *A. cartilaginea* can reach adulthood after a carapace arch length (LMA), at least 25 cm and the long axis length of the carapace measured: >30 cm. For sex ratio 1:7 (1 female and 7 male); female: not laying eggs. The number of adult female *A. cartilaginea* individuals were caught based on several research results also illustrates that the population structure in the wild was well developed. The threat of sustainable harvesting *A. cartilaginea*: if a continuous adult female is caught. Harvesting individual females with higher reproductive potential are considered a threat to the concept of sustainable use. The sex ratio of female individuals that is greater than that of males indicates a good population condition because female individuals play a role in producing eggs to regenerate the next age class. Research on the impact of taking individual adult females of *A. cartilaginea* and estimating demographic parameters due to harvesting of adult females is also an understudied topic.

#### 4. Conclusion

Countries with abundant natural resources are specific targets for the illegal trade in protected wildlife. Indonesia is a world-famous center for the animal trade. Balanced harvest with approach Minimum Viable Population is relevant to international policy guidance governing wildlife and conservation. It explicitly bridges gap research and conservation frameworks better than quota/year. MVP can reduce the disruption of the natural trophic structure of populations, reduce the risk of instability in the population dynamics. The threat of sustainable harvesting *A. cartilaginea*: if a continuous adult female is caught. Since 2015, the turtle trade trend has shown an increase in the number of species traded compared to before 2010. The use of freshwater turtles such as *A. cartilaginea* is mainly for export purposes where harvesting relies on natural products rather than captive products. From the research results, the family Testudinidae of the species *A. cartilaginea* is the species with the highest export quota. The highest trading trend for tortoises was in 2016, decreased in 2017, and was stable in 2019. The results of the Pearson correlation found between the time correlation and the number of individual turtles traded were statistically positive and linearly positive ( $r=0.916$ ;  $r^2 = 0.840$ ;  $p < 0.00001$ ). The number of adult female *A. cartilaginea* individuals who were caught based on several research results also illustrates that the population structure in the wild is well developed. The threat of sustainable harvesting if the perpetual adult female is caught. For sustainable use and harvesting *A. cartilaginea*, we recommend the precautionary principle with approach Minimum Viable Population.

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### Author's contribution

All authors contributed equally to this work as the main contributor.