The Challenges of Conserving Biodiversity: A Spotlight on Southeast Asia

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Abstract

Biodiversity is being lost at a rapid pace, mainly due to anthropogenic pressures from a growing human population. Southeast Asia is a biodiversity hotspot with high species endemism; however, it is also a region undergoing a biodiversity crisis. Unregulated wildlife trade, high rates of deforestation, and increasing human-wildlife conflict are threatening many Southeast Asian species. Mitigating many of these threats is difficult because the level of poverty of forest-neighbouring communities is a main driver to these activities. This, coupled with demand for wild-harvested animal products and fertile land for agriculture, has led to rapid biodiversity loss. Conservation work not only needs to mitigate these threats through applied conservation actions (e.g. restoration, protection, or reintroductions) but also needs to address these social drivers. This chapter outlines the complexities of biodiversity conservation in a Southeast Asian context and describes how a multidisciplinary approach is necessary for biodiversity conservation.

Keywords

Conservation · Habitat conversion · Poaching · Community education · Habitat restoration · Wildlife trade · Human-wildlife conflict · Habitat loss

Introduction

The world is in the midst of a biodiversity crisis, where the rate of species lost has increased to alarming levels, so much so that Earth may be undergoing a sixth mass extinction event (Thomas et al. 2004; Wake and Vredenburg 2008; Barnosky et al. 2011; Ceballos et al. 2015; McCallum 2015; Ceballos et al. 2017; Cowie et al. 2017). Many threats to biodiversity have arisen due to increased human populations and the subsequent increase in pressure on land use and natural resources. A region that encompasses many of these biodiversity challenges is Southeast Asia. With almost 9% of the world's human population, and only 3% of the world's land area (World Population Review 2020), Southeast Asia faces its own biodiversity crisis. Though it is home to over 22,000 endemic plant species and over 4000 endemic vertebrate species, less than 8.3% of the original vegetation cover remains (Myers et al. 2000).

There are many threats to the native fauna and flora of Southeast Asia. An online survey was given to individuals working in biodiversity

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conservation within the Southeast Asia region, with a series of questions to help identify the main issues, causes, and necessary mitigating actions in biodiversity conservation. There were 32 participants, and multiple answers were allowed for each question. Over-harvesting (including poaching and the wildlife trade) and habitat loss were identified as main threats to biodiversity conservation in Southeast Asia (Fig. 1a). Respondents also listed some of the causes for these and other concerns, such as lack of education and awareness, weak policy and enforcement, and unregulated development. The most prevalent conservation issues reported were development and a growing human population, corruption and a lack of government support for conservation programmes, and a lack of education and awareness (Fig. 1b). When asked about the efforts put in place to resolve these issues, the answer most provided was establishing education and awareness programmes (Fig. 1c).

The primary threats to conservation and causes of biodiversity decline in Southeast Asia identified in the survey are interrelated, and many of the conflicts are driven by the socio-economic background of local communities. The following discussion aims to highlight the challenges of biodiversity conservation, particularly within Southeast Asia, by discussing some of the emerging and pressing threats to species in this region.

Wildlife Trade

Two of the primary threats to biodiversity in Southeast Asia are the wildlife trade and the unsustainable harvesting of wildlife. Wildlife is exported from the region at a massive scale, with Nijman (2010) estimating that over 35 million Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)-listed animals were exported over a 10-year period (1998–2007), 30 million of which originated from free-ranging populations. Harvesting of wildlife is not a new activity, with households using hunting as a form of sustenance in the past and present (Rao et al. 2011; Pangau-Adam et al. 2012). However, in recent years, there has been an increase in the demand for wildlife products. Subsequently, harvesting rates of free-ranging wildlife have risen beyond that which could be considered sustainable (Krishnasamy and Zavagli 2020).

Wildlife trade and poaching has mostly been associated in the media with high-profile species in the past, such as rhinoceros and elephants, despite it being a large threat to many different groups of taxa. Scheffers et al. (2019) found that almost 20% of mammals, birds, reptiles, and amphibians are affected by trade. The demand for wildlife varies, with some species being used for medicine, food, ornaments, or pets. The use of different species also varies by country. For example, Nekaris et al. (2010) found that in Cambodia, slender and slow lorises (*Nycticebus* and *Loris*) are used for traditional medicine, while in Indonesia those species are traded as pets. Knowledge of the uses and demand for different taxa may help conservationists understand the drivers behind wildlife trade, as well as to devise potential actions to mitigate against these pressures.

Demand for a particular species can lead to a rapid increase in harvesting rates (beyond sustainable levels) and push the species towards the brink of extinction, even for those considered to be common throughout their range. This is the case for three species of songbirds endemic to Indonesia: black-winged myna (*Acridotheres melanopterus*), grey-backed myna (*A. tricolor*), and grey-rumped myna (*A. tertius*) (Nijman et al. 2018). Over 20 years, these species have undergone high levels of harvesting for pet markets (Nijman et al. 2018), and while two of the *Acridotheres* species were common until recent years, all three are now Critically Endangered (Birdlife International 2018a, b, c). Three of the four pangolin (*Manis*) species residing in Asia are listed as Critically Endangered due to their populations having undergone, or expecting to undergo, an 80% decline in three generations (approximately 21 years) (Challender et al. 2019a, b; Schoppe et al. 2019). Pangolins are now the most trafficked mammal in the world, driven by demand for their scales, which are used

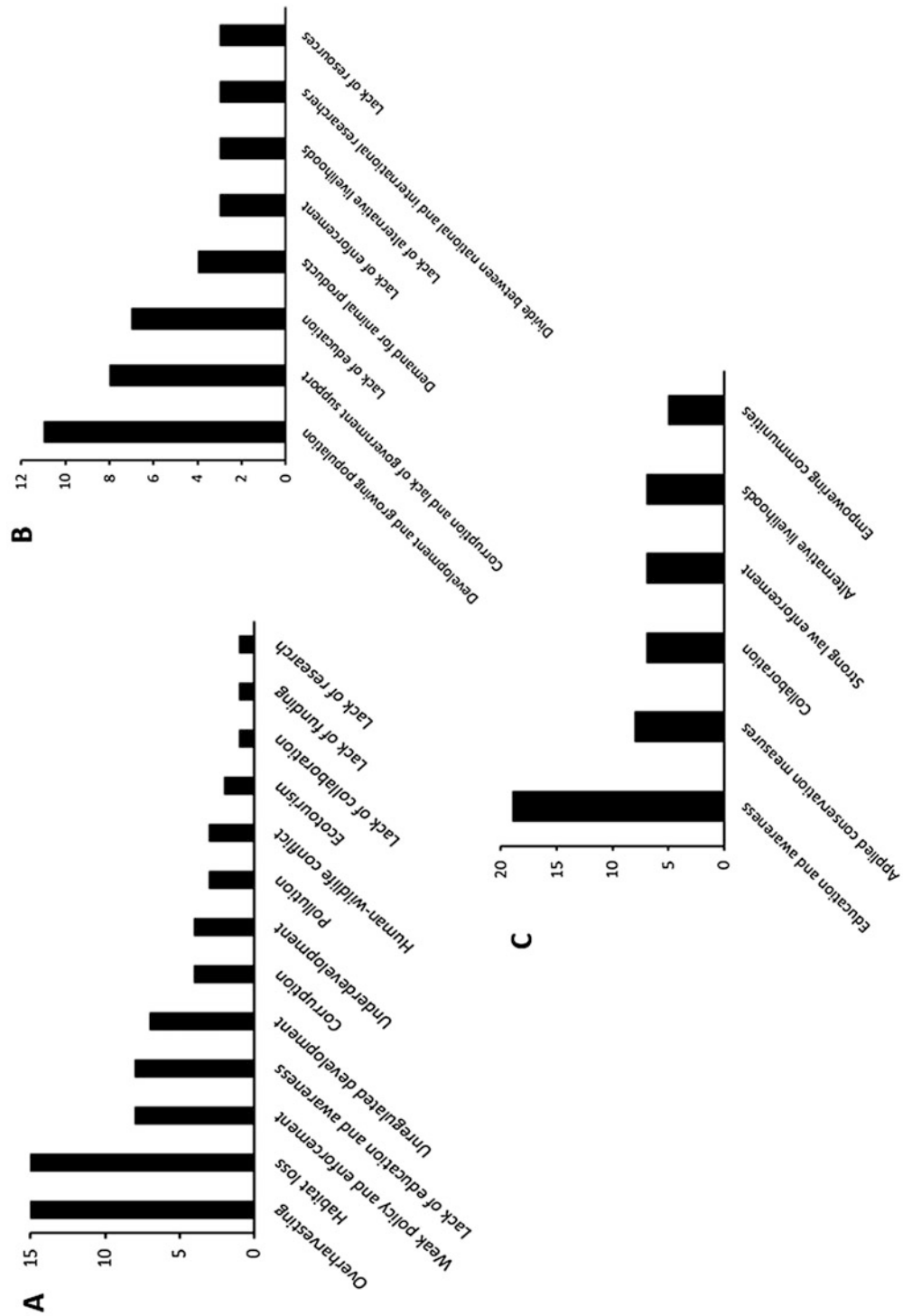

Fig. 1 Results of the survey from the 32 respondents identifying (**a**) the main threats to biodiversity conservation in Southeast Asia, (**b**) the causes of conservation issues, and (**c**) the efforts that have been put in place to resolve conservation issues.

in traditional medicine, and for their meat (Aisher 2016; Harrington et al. 2018). High harvesting pressures for the wildlife trade, often coupled with other threats such as habitat loss, have contributed to rapid reductions in free-ranging populations of wildlife.

There are various trade demands for wildlife, the most publicized being wildlife used as medicinal products (particularly tigers and rhinoceros). Some species are targeted as bushmeat, with the meat either eaten by the hunter's family or sold for income. Sandalj et al. (2016) investigated wild meat consumption in Vietnam and found that 85% of respondents had consumed wild meat at some point. Only 23% of respondents had consumed wild meat that was farmed (Sandalj et al. 2016). Interestingly, of those who did not try farmed wildlife, 14% reported an expected preference for the taste of wild over farmed meat (Sandalj et al. 2016). Dutton et al. (2011) found that wild bear bile (used for medicinal purposes) was preferred over farmed bear bile, with respondents willing to pay higher prices for wild bear bile. Dutton et al. (2011) also found that prices were dependent on the supply of farmed bear bile, with lower prices offered for wild bear bile when farmed bear bile was also supplied. The studies of Sandalj et al. (2016) and Dutton et al. (2011) highlight an important point—substituting farmed wildlife products does not necessarily lead to a lower demand of wild-harvested products. This suggests that, in order to combat the trade in wildlife, it is necessary to understand the drivers behind consumer demand for desired products.

The wildlife trade is not a simple market based on supply and demand, but is intertwined with socio-economic background, culture, and beliefs. Biggs et al. (2017) developed a theory of change framework to mitigate the drivers of wildlife trade, which highlighted the importance of strong policy and implementation and building community capacity. Although CITES (an international agreement) exists to ensure the trade of fauna and flora does not threaten their survival (CITES 2020), the actual protection of species depends on both national laws and local policy implementation. Application of conservation-based laws may be weak due to authorities having little knowledge of conservation regulations and/or a lack of resources (Lee et al. 2005). Enforcement is further complicated by corruption within government agencies, and interestingly, countries with high levels of illegal wildlife trade also tend to have poor governance (Biggs et al. 2017). In addition, Lee et al. (2005) stated that protecting species targeted for wildlife trade requires community awareness programmes, as many local communities are unaware of laws governing wildlife species. While it can be challenging for conservationists to elicit positive behavioural change in humans, it may be accomplished through well-developed outreach programmes.

Lack of law enforcement is a driver of increased wildlife trade, and poverty drives the supply of wild-harvested animals and poaching. With high levels of poverty and the lack of employment opportunities for additional income being a contributing factor to poaching (TRAFFIC 2008; Rao et al. 2011; Duffy and St John 2013), organizations have been introducing alternative livelihood projects (such as agricultural practices) that may alleviate harvesting pressure on free-ranging populations of wildlife. However, this may not necessarily translate to a reduction in poaching in all circumstances. A review of international and national experts' opinions on Southeast Asian wildlife trade stated that 80% of the time when interventions were implemented to alleviate poverty there was no significant change to the number of households engaged in poaching activities (TRAFFIC 2008). However, Wilfred and MacColl (2010) reported that a predictor of wildlife poaching for households in western Tanzania was income from crop and livestock sales. An increase in income from these livelihoods saw a decrease in levels of wildlife poaching (Wilfred and MacColl 2010). These studies show the complexity of the relationship between poverty, poaching, and supply for the wildlife trade, reinforcing the call from Duffy and St John (2013) for additional research to improve our understanding of this relationship. Nonetheless, a potential mitigating action for alleviating the pressure of poaching and

unsustainable harvesting on free-ranging wildlife populations could be the introduction of alternative livelihood projects and income.

The increase in wildlife trade has seen the establishment of non-governmental organizations (NGOs), such as TRAFFIC and Free the Bears, focused on creating strong policy to combat overharvesting for trade, as well as aiding wildlife confiscations. This has led to a demand for rehabilitation centres that rescue wildlife destined for trade and rehabilitate and reintroduce wildlife into their natural habitat whenever possible. Reintroduction of confiscated wildlife is difficult and requires a high level of species-specific knowledge within an in situ and ex situ environment, as well as extensive planning (Cheyne 2009). There is also an ethical debate on rehabilitation and release of confiscated animals and their conservation value (Palmer 2018); however, until the wildlife trade has been reduced or eliminated, there will always be a need for these rescue centres.

Success in reducing both the wildlife trade and poaching must not only focus on lowering demand for animal products but must also focus on addressing the socio-economic backgrounds of citizens of rural villages living close to threatened ecosystems and work to increase community engagement. A multidisciplinary approach is needed to address policy formation and implementation, product demand, education, and alternative livelihoods. This approach would require a high level of engagement between conservationists, policy-makers, law enforcement, and local communities.

Box 1 Poaching as Income

Interviews with poachers were conducted by the NGO Stay Wild Tiger Protection Trust in North Sumatra, Indonesia. Fifteen different interviews were conducted to gather initial information on the motives for and methods of poaching in the area. The majority (80%) used poaching as supplemental income, while three poachers used hunting as their sole income. Most of the animals poached were sold within the local community, and five people reported that their families sometimes consumed the meat. Five respondents used a gun as their method of hunting, two used only snares, and seven used a combination of both guns and snares. Between five and twelve snares were set by each poacher (Fig. 2). Poachers reported catching between two and ten animals per month, with 40% catching more than four animals per month. A wide range of animals were targeted (Table 1), though deer, wild pigs, and monkeys were the most common.

While most of the animals caught were mammals, there were also two bird species. One was the white-rumped shama (*Kittacincla malabarica*), a song bird that, while currently listed by the IUCN as Least Concern, has seen population declines, likely due to increases in the caged-bird trade (Leupen et al. 2019). One poacher reported targeting hornbills (family Bucerotidae), a group of birds poached for their casques, which are used to make ornaments (Beastall et al. 2016; Phassaraudomsak et al. 2019). The casques are often referred to as "red ivory", with the price per weight exceeding that of elephant ivory (Beastall et al. 2016). Phassaraudomsak et al. (2019) reported on hornbill products sold through online portals and found that the majority (73%) of casques were from helmeted hornbill (*Rhinoplax vigil*), while the rest of the products had been harvested from eight different species, over half of which are threatened with extinction. Due to intense hunting pressures exerted on the helmeted hornbill, the species' status changed following reassessment in 2015 from Near Threatened to Critically Endangered on the IUCN Red List (Birdlife International 2019).

Respondents reported a lack of money and inability to find alternative means of supplementary income as their primary reasons for poaching. Rao et al. (2011) reported that households living in poverty

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Fig. 2 Several different snare traps used by poachers to capture animals (left and right). One snare had captured a Javan mongoose (*Herpestes javanicus*) that was able to be released into the wild (middle). Photos from Stay Wild Tiger Protection Trust

Table 1 Summary of the animals that the interviewed poachers ($n = 15$) targeted and the local price that was obtained for the animals

Animal common name	No. of respondents poaching animal	Unit	Price (IDR)	Price (USD)
Deer	10	Kilogram	70,000	$4.90
Monkey	6	Animal	20,000–30,000	$1.40–$2.10
Wild pig[a]	5	Kilogram	30,000–40,000	$2.10–$2.80
Snakes	3	Metre	50,000	$3.50
White-rumped shama[b]	2	Animal	1,000,000	$70.40
Sun bear[c]	2	Animal	1,000,000–2,000,000	$70.40–$140.80
Porcupine[d]	2	Kilogram	25,000	$1.80
Hornbill	1	Gram of casque	80,000	$5.60
Wild chicken	1	Animal	150,000	$10.60
Mouse deer[e]	1	Kilogram	25,000	$1.80
Thomas leaf monkey[f]	1	Animal	50,000	$3.50
Slow loris[g]	1	Animal	70,000–100,000	$4.90–$7.00
Leopard cat[h]	1	Animal	50,000	$3.50

The price per unit is given in both Indonesian rupiah (IDR) and converted to US dollar (USD). Species or genus names for those that could be identified: [a]*Sus scrofa*, [b]*Kittacincla malabarica*, [c]*Helarctos malayanus*, [d]*Hystrix brachyura*, [e]*Tragulus* spp., [f]*Presbytis thomasi*, [g]*Nycticebus* spp., [h]*Prionailurus javanensis*

with few alternative livelihood sources relied upon hunting as a significantly higher source of income as compared to other activities such as farming. TRAFFIC (2008) reported that hunting was more likely to be conducted by low-income households as compared to middle-income or wealthy households. Nijman (2010) found that the wildlife trade was largely driven by economic forces, by generating high revenue nationally as well as by providing income to locals with few alternatives for income generation. While all of these studies, along with the interviews conducted by Stay Wild Tiger Protection Trust, demonstrate that poaching is often attributed to poverty, it is a complex issue requiring more research to understand the mechanisms behind it (Duffy and St John 2013).

Box 2 The Role of Captive Institutes in Breeding and Reintroductions

The confiscation of wild caught animals for the pet and wildlife trade has increased the demand for captive rescue and rehabilitation facilities. Captive institutes play a role in breeding captive wildlife and release of rehabilitated individuals into free-ranging populations, though reintroduction attempts are difficult, with high failure rates (Kleiman 1989; Mallinson 1995; Bowkett 2009). Captive populations are also used to safeguard the species from a genetic standpoint (Mallinson 1995).

The Cikananga Conservation Breeding Center (CCBC) in West Java was founded in 2007, with a focus on breeding and releasing species on the brink of extinction (Owen et al. 2014; Vernia et al. 2018). Much of its work is focused on endemic Indonesian songbirds, as many songbird species are threatened by increased poaching for the caged-bird trade (Nijman et al. 2018). The Javan green magpie (*Cissa thalassina*) (Fig. 3) is highly sought after by collectors due to their ability to mimic the song of other species. This has exacerbated the harvesting pressure on free-ranging populations, leading to rapid decline of the species (Eaton et al. 2015). There are less than 250 *C. thalassina* individuals estimated in the wild (Birdlife International 2018d). CCBC houses over half the global captive population of *C. thalassina* and utilizes captive breeding in an effort to safeguard the species (B. Ferns, pers. comm.). Additionally, CCBC has translocated captive individuals to European zoological collections, to further strengthen captive populations (B. Ferns, pers. comm.). Due to the presence of the ongoing threats within the species' natural habitat, captive individuals cannot yet be reintroduced to the wild.

CCBC also has a captive population of black-winged myna (*Acridotheres melanopterus*) that they breed and release into the wild (B. Ferns, pers. comm.) (Fig. 3). *A. melanopterus* are Critically Endangered with few individuals persisting throughout West Java (Shepherd et al. 2016; Birdlife International 2018a). CCBC has successfully bred this species in captivity (a difficult task for some species) and subsequently coordinated multiple reintroduction attempts. One population was reintroduced to Halimun Salak National Park, West Java, and was successful at reproducing in the wild (B. Ferns, pers. comm.).

Captive breeding and reintroduction are resource-intensive, and in order to ensure the persistence of the reintroduced population, threats to the population, such as poaching, must be reduced or removed (Robinson et al. 2020). Education and community engagement also contribute to the success of reintroduction programmes (Robinson et al. 2020). With many species

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Fig. 3 The black-winged myna (*Acridotheres melanopterus*), image supplied by Simon James (left), and the Javan green magpie (*Cissa thalassina*), image supplied by CCBC (right), are threatened with overharvesting for the songbird trade

throughout Southeast Asia declining, and wild populations becoming smaller, it is likely that reintroductions will become even more important in the future for species conservation.

Habitat Loss

Southeast Asia holds the highest number of threatened and endemic species in the world (Koh and Sodhi 2010). The region also boasts the highest rate of deforestation of any tropical region and is predicted to lose three quarters of its original forests and 42% of its biodiversity by 2100 (Sodhi et al. 2004). Singapore has already seen large-scale deforestation (>95% habitat loss) that resulted in high local extinction rates of species and at least a 28% loss in biodiversity (881 recorded species) (Castelletta et al. 2000; Brook et al. 2003). In Singapore, residual species are now dependent on protected reserves (Brook et al. 2003). Habitat loss is not restricted to forests, with an estimated 30% loss of mangrove ecosystems within Asia (Richards and Friess 2016). If current rates of deforestation and habitat conversion are sustained within Southeast Asia, there will be mass extinctions and high biodiversity losses (Brooks et al. 2002).

Much of the habitat destruction within Southeast Asia has been attributed to land conversion for agriculture (Fig. 4), with two types of plantations at the forefront—rubber and oil palm. Southeast Asia is one of the largest cultivators of rubber trees (*Hevea brasiliensis*), at one point holding 84% of the global rubber plantation area (Warren-Thomas et al. 2015). Although many rubber plantations are being converted to the more profitable oil palm, given the increased global demand for natural rubber, it is expected that rubber plantations will continue to expand (Warren-Thomas et al. 2015). African oil palm (*Elaeis guineensis*) plantations are used to produce palm oil, a highly traded vegetable oil and a crop highly publicized as a driver of deforestation in tropical countries. Both Vijay et al. (2016) and Koh and Wilcove (2008) found that 45–59% of surveyed oil palm plantations in Southeast Asia were developed in areas that were forested up to 30 years previously. Fitzherbert et al. (2008) noted that due to a lack of accurate records, it is difficult to ascertain whether oil palm plantations were the drivers behind deforestation or whether they were planted following land clearance for other reasons. However, with illegal oil palm plantations encroaching on protected reserves (Fitzherbert et al. 2008), it cannot be denied that oil palm plantations play a role in habitat loss in Southeast Asia.

Fig. 4 Forest that has been recently cleared and burned on the forest edge (left) and a plot of land that was previously forest but was cleared for a new plantation (right). Photos from Stay Wild Tiger Protection Trust

The conversion of forest to plantations results not only in habitat loss due to land clearance and a reduction in the overall amount of habitat available to species but also in a loss of biodiversity. Fitzherbert et al. (2008) found that oil palm plantations held less than half the number of vertebrate species supported by primary forest ecosystems and had lower species richness than disturbed (secondary or logged) forests. Aratrakorn et al. (2006) also demonstrated that the conversion of lowland forest to oil palm or rubber plantations resulted in a 60% reduction in bird species richness. In addition, while the conversion of native forest to oil palm plantations results in large biodiversity losses, there is also a loss in biodiversity with the conversion of rubber plantations to oil palm (Koh and Wilcove 2008).

Logging is a large driver of deforestation and habitat degradation in tropical countries, with protected reserves succumbing to illegal logging at times (Wilcove et al. 2013; Edwards et al. 2014). Selective logging may not result in high impacts on biodiversity as compared to forest conversion, but it can affect species abundance (Berry et al. 2010). Furthermore, logged forests are more likely to be converted to agricultural land and plantations due to their low conservation value. However, although logged forests reduce biodiversity and species richness when compared to primary forests, logged forests support higher biodiversity levels than forest conversion (Edwards et al. 2011, 2014; Konopik et al. 2015). Thus, the preservation of forest, whether primary, secondary, or logged, is beneficial for biodiversity conservation.

There are additional drivers to deforestation and habitat loss in Southeast Asia, including mining, fire (Hughes 2017; Sonter et al. 2018), and infrastructure development, which can be a major threat to endemic species (Alamgir et al. 2019). One such endemic species are orangutans—the only non-human great ape found in Asia. The Bornean orangutan, *Pongo pygmaeus*, inhabits the island of Borneo, while the Sumatran orangutan (*Pongo abelii*) inhabits most of Sumatra. One Sumatran population is quite special, however, as it constitutes a distinct and recently described species—the Tapanuli orangutan, *Pongo tapanuliensis* (Nater et al. 2017). Its range is restricted to Batang Toru, an area only a tenth the size of Sydney, Australia (Nater et al. 2017). This newly discovered species is threatened by a multibillion dollar hydropower and road-building scheme, which is ongoing despite the damage it will cause towards biodiversity (Wich et al. 2019; Laurance et al. 2020). Loss of native forest restricts surviving orangutans to small pockets of forest, and they are more likely to leave the forest in search of food sources (Meijaard et al. 2011). This increases human-wildlife conflict—they are viewed as pests and often killed, and their young sold as illegal pets,

despite being protected by law in Indonesia (Meijaard et al. 2011).

Multiple studies have demonstrated the linkage between habitat loss, fragmentation, deforestation, and a resulting loss of biodiversity and species abundance, along with increasingly isolated populations of native wildlife. As a result, many species action and recovery plans focus on preserving remaining habitat in an effort to reduce further losses. However, the success of forest protection is dependent on strong policy and local law enforcement, which as discussed previously is often weak (Lee et al. 2005). The needs of forest-border communities also must be considered, and if access to the forest is restricted, alternatives must be provided for local people such as planting additional community forests.

To counteract the effects of habitat loss on free-ranging wildlife, degraded or deforested land can be restored to expand habitat so that sustainable population sizes can be reached and maintained. However, this method is limited, as Turner et al. (1997) reported that after 100 years of being planted on intensively farmed land, secondary forest exhibits only 60% of tree species richness as compared to primary forest. This supports the idea that conserving existing habitat is better (in terms of biodiversity conservation) than trying to create new forest. Deforestation may also result in patches of forest within an open or uninhabitable matrix, leading to genetically isolated populations that cannot be sustained naturally. Corridors are used to reconnect fragmented habitats and allow movement of animals between otherwise isolated forest patches. Though there has been some scepticism to their practicality (Beier and Noss 1998; Christie and Knowles 2015), an increasing amount of research has demonstrated the positive effects of corridors on animal movements, population connectivity, and species richness within connected habitat patches (Aars and Ims 1999; Tewksbury et al. 2002; Haddad et al. 2003; Damschen et al. 2006; Dixon et al. 2006; LaPoint et al. 2013). However, the use of corridors should be proposed with caution, as it may inadvertently exacerbate habitat destruction and could aid the spread of invasive species, disease, or fire (Jain et al. 2014; Resasco et al. 2014). Haddad et al. (2014) noted such potential negative effects can be managed and are small compared to the positive effects of corridors.

Human-Wildlife Conflict

Human-wildlife conflict (HWC) has been a long-standing problem in tropical regions, where humans share a landmass with a vast diversity of wildlife. Simply put, HWC is a situation in which the requirements of wildlife overlap with the human population, creating costs to both human residents and wild animals (Distefano 2005). This has resulted in various wild animals being persecuted in Southeast Asia, especially those considered as pests or potentially dangerous to human life. HWC has contributed to the decline of many species, such as Sumatran tigers (*Panthera tigris sumatrae*) (Nyhus and Tilson 2004), and is therefore considered a major threat to biodiversity in this region.

One of the main driving factors of HWC is the ever-increasing human population. To fulfill the requirements of modern humans, there has been mass conversion of natural landscapes into agricultural, residential, or industrial areas. This has caused a great deal of habitat loss, degradation, and fragmentation, pushing humans and wild animals even closer together, as mentioned above.

In some cases, the increasingly easy access to nature reserves can also contribute to HWC. One example of this is the population of long-tailed macaques (*Macaca fascicularis*) in Muara Angke Nature Reserve, North Jakarta (Entoh 2011). The reserve is situated in the city and is very easily accessible. Because of this, the behaviour of macaques, which tend to avoid humans, has been altered due to regular feedings by tourists and local residents (Entoh 2011) (Fig. 5). Over time this population lost their fear of people and began causing problems for the residents of North Jakarta by raiding houses and biting visitors (Entoh 2011). Human-primate conflict is an issue in many parts of Southeast Asia. On Sulawesi, the moor macaques (*Macaca maura*)

Fig. 5 Long-tailed macaques feast on the food items thrown at them from moving vehicles in North Jakarta, Indonesia. Image supplied by Nathan Rusli

are involved with conflict due to crop raiding (Zak and Riley 2017), and on Java there are similar cases with the Javan gibbon (*Hylobates moloch*) (Lappan et al. 2020) (R. Oktaviani pers. comm.).

Climatic factors and stochastic events also play a role in human-wildlife conflict. An example of this are reticulated pythons (*Malayopython reticulatus*) which are highly adaptable to urban environments (De Lang 2017; Low 2018; Rusli 2020). In the metropolitan city of Jakarta, Indonesia, the pythons live in drains and sewer systems, preying on rats and other animals which inhabit the same environment. During the monsoon season, flooding often occurs, flushing the pythons out of their hiding places and greatly increasing the risk of conflict with humans (Rusli 2016; Rusli and Rini 2020).

Mitigating actions for HWC in Southeast Asia involve community outreach—educating local people about wildlife and how to coexist with it and minimizing the risk to both humans and nature (Tangley 1997; Rusli and Rini 2020).

Box 3 Human-Tiger Conflict with Forest-Edge Communities

Human-wildlife conflict has been a threat to tiger populations throughout the twentieth century, with the extinctions of the Javan tiger (*Panthera tigris sondaica*) and Bali tiger (*P.t. balica*) attributed to human-tiger conflict. This struggle has also contributed to the decline of Sumatran tiger (*P.t. sumatrae*) populations (Nyhus and Tilson 2004). While human-tiger conflict has decreased over recent decades (due mainly to a decreasing free-ranging tiger population), there are fears it may increase as tiger numbers rise (Nyhus and Tilson 2004; Goodrich 2010). This could lead to more conflict and retaliatory killings, which would undermine conservation efforts.

The issues between humans and tigers include not only the threat of people losing their lives but also the loss of income, such as through livestock attacks. One such case was recorded by Stay Wild Tiger Protection Trust, working with forest-edge communities near Gunung Leuser National Park, North Sumatra, Indonesia. Local farmers graze their cattle on the edges of the National Park as well as the karst forest that borders the protected area. In May 2020, two tigers in two different incidents killed adult cattle grazing near forest edges (Fig. 6).

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Fig. 6 Camera trap still of a Sumatran tiger returning to its kill (a cow carcass) on the forest edge. Image supplied by Stay Wild Tiger Protection Trust

In a previous study, Miller et al. (2016) found that most livestock attacks by carnivores occurred near the forest edge, which are areas regularly used for livestock grazing. Human-tiger conflict is more common with old, sick, or wounded tigers that have been driven into human-dominated landscapes (Goodrich 2010). However, in a case study by Stay Wild Tiger Protection Trust, both tigers were in good condition and returned over several days to feed on the cattle carcasses. This may indicate that tigers left the protected forest in search of prey. Hunting for bushmeat reduces tiger prey populations, which may lead to increased human-tiger conflict. This highlights not only how habitat loss and encroachment into habitat can increase human-wildlife conflict but also the hunting of prey species.

To reduce the risk of further livestock attacks by the tigers, rangers from local NGOs collaborated with government rangers to monitor the tigers as they returned each night to feed on cattle carcasses. Non-lethal methods such as noise deterrents were used to try to drive the tigers back towards the protected forest. To prevent the possibility of retaliatory killings, NGOs worked with local farmers and provided a compensation scheme, a technique often employed to reduce the effects of human-wildlife conflict (Nyhus and Tilson 2004; Goodrich 2010; Miller et al. 2016).

Box 4 Human-Snake Conflict in Indonesia

Indonesia is home to over 300 species of snakes, many of them endemic (Uetz et al. 2020). There are over 70 species of medically significant (highly venomous) snakes in Indonesia, and snakebite has been a neglected issue for many years (Indonesia Toxinology Society, 2020 (unpublished data)) (Adiwinata and Nelwan 2015; Warrell 2017). With the human population constantly on the rise, humans and snakes are pushed closer together, causing potential problems.

Snakes have developed several adaptations to defend themselves from predators. Many species use cryptic colouration to avoid detection. One example of this is the Malayan pit viper (*Calloselasma rhodostoma*), a common species in lowland forest and plantations

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in Southeast Asia. This venomous snake is brown in colour, with light and dark markings that resemble leaf litter. Unfortunately, due to its impeccable camouflage, people often step on them by accident. In some cases, this will prompt the serpent to bite in self-defence and inject its lethal venom.

Events such as this and other envenomations by venomous species have caused a deep-rooted fear of snakes for many Indonesians. This has resulted in the persecution of snakes. It is common practice to kill a snake on sight in Indonesia (Rusli 2016; Rusli and Rini 2020). Sadly, the act of killing a snake (usually by hitting it with a hard object, i.e. a stick or machete) can sometimes go wrong. When cornered and unable to flee, the final line of defence for most snakes is to bite. In the case of venomous snakes, this can be potentially life-threatening.

This is especially apparent on the island of Java, which has the highest population of humans in Indonesia (Badan Pusat Statistik 2019). Out of the 89 species of snakes found here, several species such as the reticulated python (*Malayopython reticulatus*) (Fig. 7) and Indonesian spitting cobra (*Naja sputatrix*) have adapted to live in urban and rural areas (Das 2010; De Lang 2017; Rusli 2020). Reticulated pythons are very successful in cities, living in drainage systems and preying on other urban fauna, just as they do in Jakarta. They are often involved in conflict with humans, especially during the monsoon season. This is also the breeding season for spitting cobras, when they are most active, increasing the likelihood of human encounters (Rusli and Rini 2020).

The Indonesia Herpetofauna Foundation is a local NGO focused on the conservation of amphibians and reptiles in Indonesia. As part of their conflict mitigation programme, they work with governments, NGOs, and local communities to reduce human-snake conflict in Indonesia. This is done through outreach and education, raising awareness about the ecological importance of snakes, common snakes in the area, what to do in a snake encounter, how to prevent snakebite, and the correct first aid for snakebite. Removal and relocation of conflict animals is another way to reduce human-snake conflict, which is also undertaken by several herpetologists and reptile enthusiasts in Indonesia.

Fig. 7 The reticulated python (*Malayopython reticulatus*) is threatened with human-wildlife conflict because they often inhabit urban areas and come into contact with people. Image supplied by Nathan Rusli

Threats to Biodiversity in Aquatic Ecosystems

While this chapter has focused mainly on terrestrial ecosystems, many of the threats discussed are also causing biodiversity losses within marine and freshwater ecosystems. Not only is this important in terms of biodiversity conservation, but fishing is a source of income and food security within Southeast Asia. Pomeroy et al. (2016) reported that fish are relied upon as a primary protein source and income provider in Southeast Asia, more so than in any other part of the world. However, habitat destruction, plastic pollution, and climate change threaten marine and freshwater ecosystems (Reid et al. 2019). Plastic from single-use packaging and microplastics are polluting marine ecosystems, but efforts are being made to educate coastal communities and provide alternatives. The NGO Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) engages local communities and governments to reduce plastic pollution on Danjugan Island and adjacent coastal communities in Southern Negros, Philippines, to help conserve marine ecosystems (Fig. 8). Urbanization along coastal zones results in sedimentation and pollutant discharge into marine ecosystems, which can lead to loss of coral reefs and essential ecosystem functions (Heery et al. 2018). Overfishing, illegal catches, and shark finning also pose threats to sustainable fishery management (Pomeroy et al. 2016; Dulvy et al. 2017; de Mitcheson et al. 2020). Degradation of coastal nesting sites, fishing mortalities, hunting, and egg exploitation have led to population declines in turtle species (Chan 2006; Hitipeuw et al. 2007). Lastly, some ornamental tropical fish may be targeted for wildlife trade (Ng and Tan 1997). All of these threats are similar to those faced by terrestrial ecosystems and are equally difficult to manage, relying on strong policy, law enforcement, public awareness and engagement, management systems, and an assessment of community needs.

Additional Threats

Although this chapter focuses on the primary and immediate threats to biodiversity in Southeast Asia, there are additional risks to consider. Climate change is predicted to have adverse effects on native fauna and flora, and Bickford et al. (2010) suggest severe consequences for reptiles and amphibians in Southeast Asia. Rising global temperature is predicted to negatively impact temperature-dependent sex determination, metabolic rates, and water availability for herpetofauna (Bickford et al. 2010). Additionally, with continued land clearance and urbanization, there is an increased risk of disease spread by domestic animals to free-ranging populations of wildlife and vice versa (Daszak et al. 2000; Cook

Fig. 8 Danjugan Island in the Philippines (left) and volunteers of PRRCFI cleaning up plastic washed ashore (right). Images supplied by PRRCFI

and Karesh 2012; Beineke et al. 2015). There is also the threat of zoonoses being passed from wild animals through wildlife trade and possible subsequent persecution of wildlife (Daszak et al. 2000; Karesh et al. 2005; Karesh and Noble 2009; MacFarlane and Rocha 2020). Further, invasive species pose a threat through predation, competition, hybridization, and environmental disturbance, particularly within insular ecosystems (Peh 2010; Doherty et al. 2016).

There are inherent challenges in conservation, namely, those of ensuring efficient implementation of conservation measures, and proper controls for conservation management. While ecotourism can increase the value of wildlife to local communities and can provide an alternative income and benefit some species (Buckley et al. 2016), it must be monitored to ensure sustainability and to ensure it does not pose a danger to free-ranging wildlife. Corruption within the government or within organizations tasked with protecting the environment also undermines policies that safeguard nature (Irland 2008; Wyatt et al. 2018). In addition, conservation work is underfunded, which limits the ability to utilize interdisciplinary collaboration and reduces overall capacity for conservation projects. Waldron et al. (2013) assessed countries based on threatened biodiversity and amount of conservation funding. Based on their model, Malaysia and Indonesia are in the top 40 most underfunded countries for biodiversity conservation (Waldron et al. 2013).

Another impediment to the implementation and efficiency of conservation programmes is a lack of appropriate research. Monitoring and analysis of wildlife and ecosystems in Southeast Asia is important to conduct not only for quantifying the rate of decline and loss of biodiversity but also for identifying the main issues and potential mitigating actions that will help to conserve biodiversity. There are many species in Southeast Asia at risk of going extinct even before they are formally described (Giam et al. 2010), meaning that rates of biodiversity decline may be underestimated. Conservation programmes should be evidence-based and formed based on previous research that identifies primary threats to the survival of the species, as well as on alleviating actions that have been shown to reduce, or are likely to reduce the decline of the species. Any mitigating action implemented should be monitored to demonstrate its effectiveness. This should also be the case for any actions taken to reduce social drivers, such as education and awareness campaigns, increased policy enforcement, and implementation of alternative livelihood programmes.

Conclusion

There are many different threats to biodiversity in Southeast Asia which are intertwined with both social development and governance within their respective countries. Poverty and underdevelopment may restrict both educational opportunities and income sources and may increase the dependence on natural resources or illegal activity for survival. A growing human population coupled with development for economic growth puts additional pressure on fertile land and increases land clearance. Protection laws and policies are undermined by corruption within authority organizations and under-resourced law enforcement. These are often the issues that drive the major threats to biodiversity, such as wildlife trade, habitat loss, and human-wildlife conflict. All of these aspects contribute to the decline of biodiversity in Southeast Asia.

The information in this chapter was provided not to present an in-depth examination of all causes of biodiversity loss, but instead to outline the complexities of conservation. As many of the threats to biodiversity are anthropogenic in nature, it is no surprise that the approach taken by conservationists has changed over the years. While protection status and the formation of national parks were used frequently in the past, there has been a movement to incorporate the needs of forest-neighbouring communities and to take a community-based approach. This is emphasized by the online survey results presented here, where education and community engagement, alternative livelihoods, and community empowerment were listed as important for

conservation work. This approach, coupled with applied conservation measures (such as research, policy, and applied conservation actions), could enhance the effectiveness of biodiversity conservation.

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