OCCASIONAL PAPER

The harvest of wildlife for bushmeat and traditional medicine in East, South and Southeast Asia

Current knowledge base, challenges, opportunities and areas for future research

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CIFOR

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Traditional Chinese medicine in Xi'an market.

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1 Wild meat harvest in Asia: An overview

1.1 The bushmeat crisis

Humans have depended on wild meat as a food source throughout the world. In Asia, humans have been hunting wildlife in tropical forests for over 40,000 years (Corlett 2007). However, in the last hundred or so years, many traditional hunter–gatherer societies of tropical Asia have undergone rapid changes, which often include advanced hunting methods such as the use of guns and the introduction of market forces (Corlett 2007). Increasingly, wealthy urban markets have also led to higher demand for wildlife products (Corlett 2007). Recently, wildlife harvesting has reached unsustainable levels due to a burgeoning human population and shrinking forests (Bennett and Rao 2002; Corlett 2007).

Rural people often rely heavily on wild meat, but in many areas, this vital source of food and income is either already lost or is being rapidly depleted (Bennett and Rao 2002; Milner-Gulland and Bennett 2003). The economic importance of wildlife amounts to billions of US dollars globally. Wildlife is important in both the developed and developing world for its consumptive and non-consumptive uses, present and potential nutritional value, ecological role and its sociocultural significance for human societies (Chardonnet et al. 2002).

The scale and dynamics of wildlife consumption, and the impacts of unsustainable exploitation both on wildlife populations and on rural peoples vary across Asia. This has implications for wildlife management and local livelihoods throughout Asia (Bennett 2007). While forest and wildlife conservation initiatives and institutions have existed since colonial times, they were largely directed at commercial and elitist interests, and not at the rural people whose livelihoods depended on forest resources (Ashton 2007); this is one of the major problems of conservation in the Asian tropics.

The bushmeat crisis is defined by the widespread unsustainable exploitation of wildlife and the recognition that this is undesirable for both conservation and sociocultural reasons. As a result, the challenges of conservation and the unsustainable use of wildlife-based resources have led to the "bushmeat crisis" (Nasi 2008). Due to the multifaceted nature of this issue, we must work at the interface of rural livelihood improvement and conservation of natural forests to determine how the goals of poverty alleviation and forest conservation can be aligned (Sunderlin et al. 2005).

1.2 The impact of the wildlife trade

The growing wildlife trade, including illegal trade, is a major threat to the biodiversity of East and Southeast Asia (Grieser-Johns and Thomson 2005; Koh and Sodhi 2010). Commercial poaching to supply regional markets and beyond with bushmeat and traditional medicinal products has exerted pressure on wildlife, especially mammals, which have reduced densities in many Southeast Asian regions (Steinmetz et al. 2006). The Javan rhino (*Rhinoceros sondaicus annamiticus*) was declared extinct from Vietnam in 2010, primarily due to poaching and weak law enforcement (Brook 2014).

While Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is the most important global initiative to monitor and regulate the international trade of wildlife to date, its credibility is conditional on the quality of the trade data, which are incomplete at best in Asia; CITES is also weakened by its lack of ability to enforce the treaty. Furthermore, the

open trade of large volumes of illegally sourced animals in many parts of Asia (e.g. Thailand) indicates a deliberate disregard for the law by traders from import and export countries (Nijman and Shepherd 2007). In another study, from 1997 to 2008, 66 surveys were conducted at bird markets in Medan, North Sumatra, where primates are openly sold, but little action against this illegal trade has been taken by the authorities (Shepherd 2010).

The illegal global wildlife trade is estimated to be a multi-billion dollar market, making it one of the largest illegitimate businesses globally, and often involves transnational criminal networks (Rosen and Smith 2010). This complexity has hampered enforcement of laws on the illegal wildlife trade, which have not been effective in most Asian countries. For instance, the international trade in bear parts from Myanmar is significant, and open, suggesting that the enforcement of trade regulations of bear species has largely failed (Shepherd and Nijman 2008). In addition, the illegal transport of large volumes of animals could lead to the spread of pathogens (Rosen and Smith 2010). Therefore, the high concentration of illegal wildlife trade seizures in Southeast Asia make this region a hot spot for future emerging infectious diseases, thus putting public health at risk (Rosen and Smith 2010).

1.3 Addressing the bushmeat crisis

The current bushmeat crisis in Asia is tightly coupled with the Southeast Asian biodiversity crisis and requires urgent and definitive action. However, attempts to address the problem continue to be hampered by socioeconomic factors, including poverty and a lack of: infrastructure, technical capacity and political will. In essence, any realistic solution will need to involve a multidisciplinary strategy, including political, socioeconomic and scientific inputs, in which all major stakeholders (government, nongovernment, national and international organizations) must partake (Sodhi et al. 2004). Initiatives should include public education and focus on ways to enhance the sustainability of agriculture, increase the capacity of conservation institutions, and improve the enforcement of current laws on wildlife management (Sodhi et al. 2010). Efforts need to be directed at both enhancing community-based conservation to engage local people and reducing the trade in endangered species of plants and animals (McNeely et al. 2009).

In Southeast Asia, there is an urgent need for better assessment of sustainable levels of exploitation, initiatives to make regulatory mechanisms more effective (e.g. monitoring selected wildlife trade hubs), and better licensing, registration and science-based monitoring of harvested populations (Nijman 2010). Regulations may need to be adapted to enable bushmeat harvesting where it is appropriate (such as harvesting of pigs in oil palm estates) but without undermining the protection of threatened species or protected habitats. Funding needed for some of these initiatives may be obtained by imposing small levies on exports of CITES-listed wildlife, for instance (Nijman 2010).

A key driver of the bushmeat crisis is the booming local, regional and international wildlife trade in Asia. In particular, there is a need to understand the economic and social factors influencing illegal and unsustainable wildlife trade in Southeast Asia (TRAFFIC 2008). As such, some scholars have encouraged more participation from political ecologists due to their engagement with a diversity of disciplinary perspectives, thus potentially offering a better understanding of the wildlife trade as a social and environmental concern (Singh 2008).

1.4 Current state of research

We conducted a literature review using Google Scholar with the following search words: "bushmeat; wildlife trade; traditional medicine; food security; sustainable; urbanization." These key words were used in conjunction with the following country/region names: "Asia, East Asia, South Asia, Southeast Asia, China, Japan, Korea, Mongolia, Taiwan, Bangladesh, Bhutan, India, Nepal, Pakistan, Philippines, Singapore, Thailand, Vietnam, Borneo, Sumatra, Sri Lanka, Brunei, Burma (Myanmar), Cambodia, East Timor, Indonesia, Laos, Malaysia, and Papua New Guinea." Despite several limitations with Google Scholar (Jacsó 2008), one major advantage over traditional databases (e.g. Web of Science) is in the access to 'gray' literature, including

reports from government and nongovernmental organizations, which may be important in this research area. In addition, Google Scholar appears to be as good, if not better than library databases for more traditional published academic literature (Kesselman and Watstein 2005).

This led to 28 separate searches, yielding 236 relevant papers, of which 172 are included in this review (Tables 1–4; Figures 1–4). Southeast Asia was the region discussed in the most papers (61%), followed by South Asia (22%) and East Asia (16%). The papers were categorized into four main themes — livelihoods, traditional medicine, wildlife trade and urbanization — with papers discussing more than one topic included under multiple themes. The most frequent topic discussed in the literature was 'livelihoods' (41% of all papers); 'wildlife trade' was the next most prevalent topic (30%), followed by 'traditional medicine' (19%) and 'urbanization' (9%).

For East Asia, the most common topic was the wildlife trade (34%), followed by traditional medicine (26%). More than half of the papers (10 out of 19) discussed both traditional medicine and the wildlife trade. Within East Asia, the focus was on China, which was discussed in 17 out of 19 papers. In South Asia, the most common paper theme was livelihoods, which was discussed in 57% of papers, followed by the wildlife trade, which was discussed in 17% of the papers. The dominant country in South Asia was India, with 12 of the 31 papers, followed by Bangladesh with 6 papers.

In Southeast Asia, the two most prevalent paper topics were livelihoods (38%) and the wildlife trade (33%). A large number of the papers discussed both livelihoods and the wildlife trade.

Table 1. The frequency and distribution of papers across three Asian regions and four key topics.

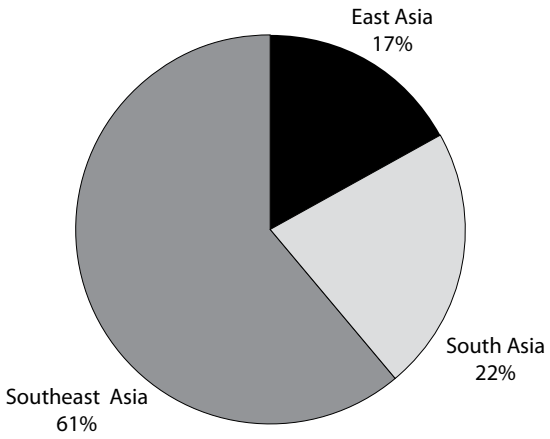
Region	# of Papers	% of Papers
East Asia	28	16%
South Asia	38	22%
Southeast Asia	104	61%
Total	**170**	**100%**

Note: Papers that discuss more than one topic and/or region are included more than once. Global reviews that did not mention specific regions in Asia are not included in the region data, but are included in the topic data.

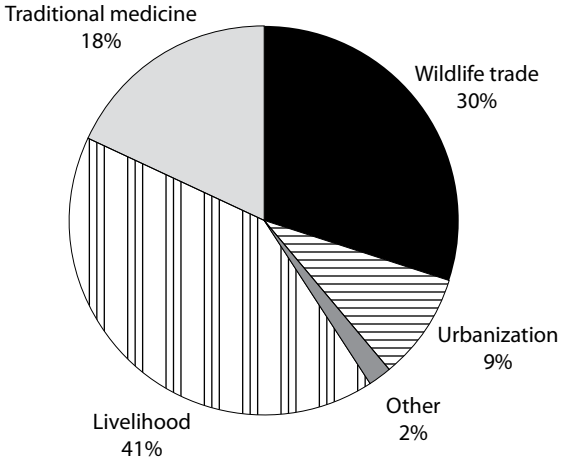
Topic	# of Papers	% of Papers
Livelihood	121	41%
Traditional medicine	55	19%
Wildlife trade	88	30%
Urbanization	27	9%
Other	6	2%
Total	**297**	**100% ***

* Percent of papers do not sum up to 100 due to rounding up of decimals.

Distribution of papers about Asia by region



Distribution of papers about Asia by topic



*Note: Papers that discuss more than one topic and/or region are included more than once.

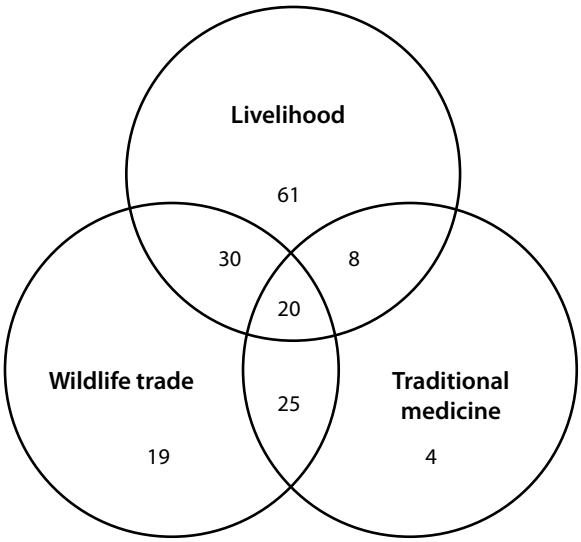


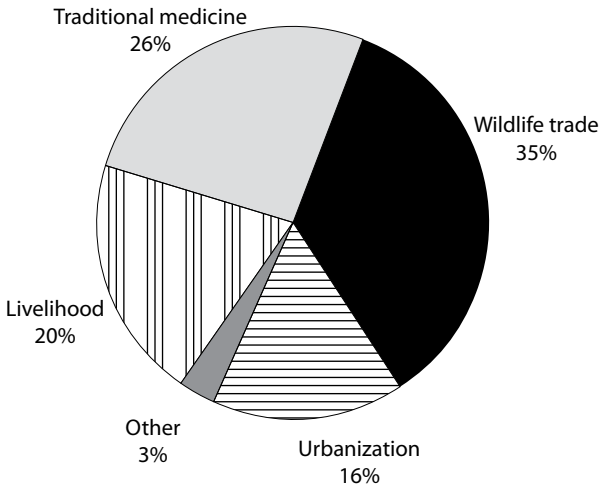
Figure 1. The proportion of papers across three Asian regions and four key topics. The Venn diagram shows the extent of overlap among the papers that addressed at least one topic.

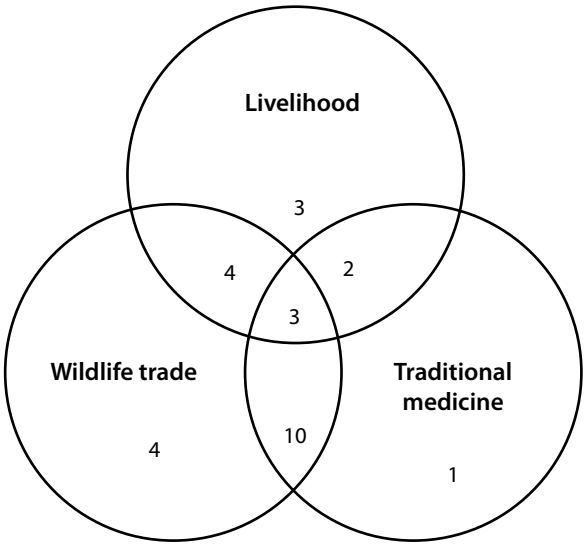
Table 2. The frequency and distribution of papers across five countries and four key topics in East Asia.

East Asia, papers by topic	# of Papers	% of Papers
Livelihood	12	20%
Traditional medicine	16	26%
Wildlife trade	21	34%
Urbanization	10	16%
Other	2	3%
Total	**61**	**100%**

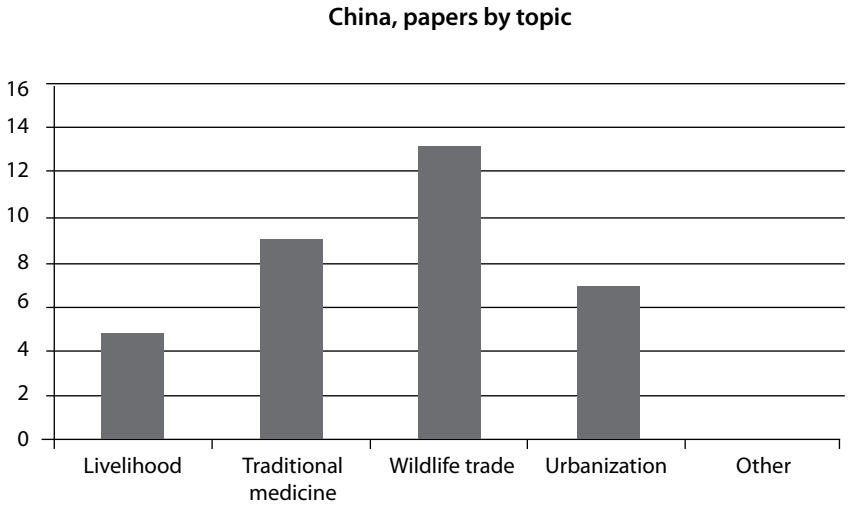
East Asian countries	# of Papers
China	17
Japan	0
Korea	0
Mongolia	0
Taiwan	0
Total	**19**

*Note: Papers that discuss more than one topic and/or country are included more than once.





Note: One paper on East Asia did not fall into any of these categories.



*Note: Papers that discuss more than one topic are included more than once.

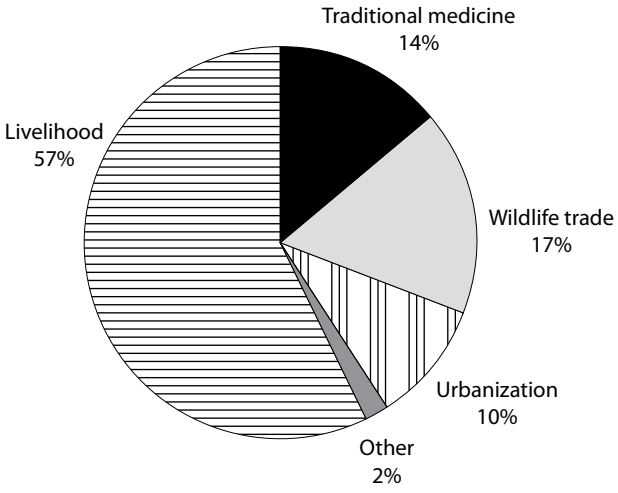
Figure 2. The proportion of papers across four key topics in East Asia. A frequency bar plot for China is shown. The Venn diagram shows the extent of overlap among the papers that addressed at least one topic.

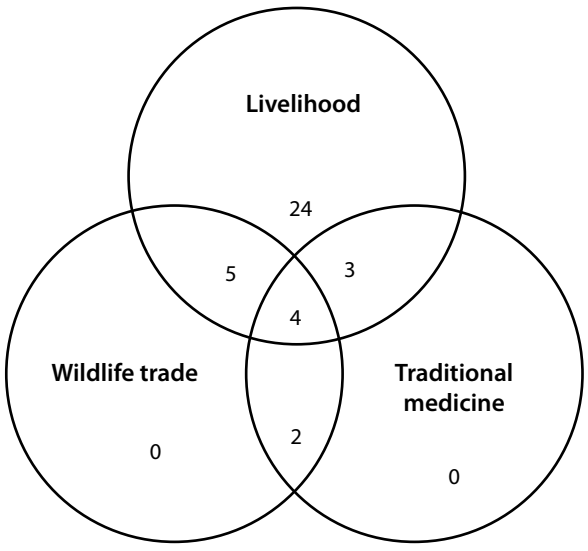
Table 3. The frequency and distribution of papers across six countries and four key topics in South Asia.

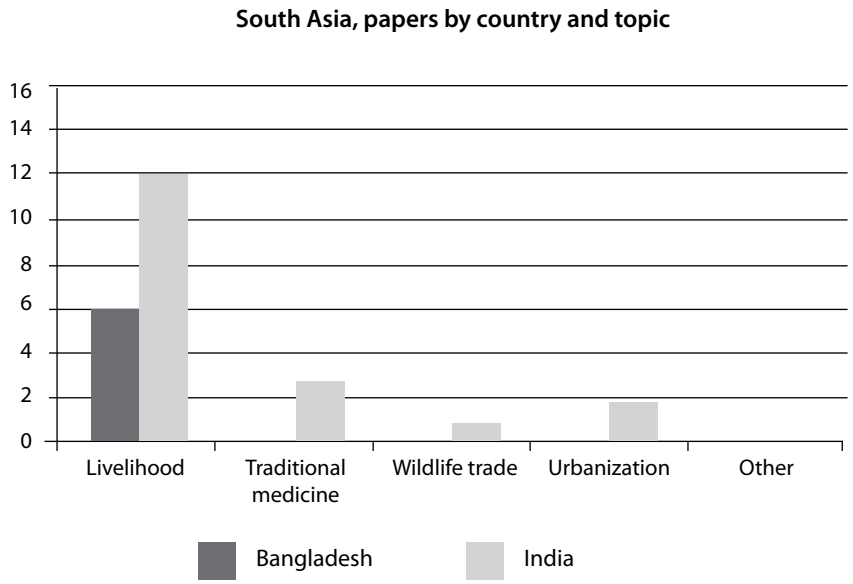
South Asia, papers by topic	# of Papers	% of Papers
Livelihood	36	57%
Traditional medicine	9	14%
Wildlife trade	11	17%
Urbanization	6	10%
Other	1	2%
Total	**63**	**100%**

South Asian countries	# of Papers
Bangladesh	6
Bhutan	4
India	12
Nepal	3
Pakistan	2
Sri Lanka	4
Total	**31**

Note: Papers that discuss more than one topic and/or country are included more than once. * Percent of papers do not sum up to 100 due to rounding up of decimals.







*Note: Papers that discuss more than one topic are included more than once.

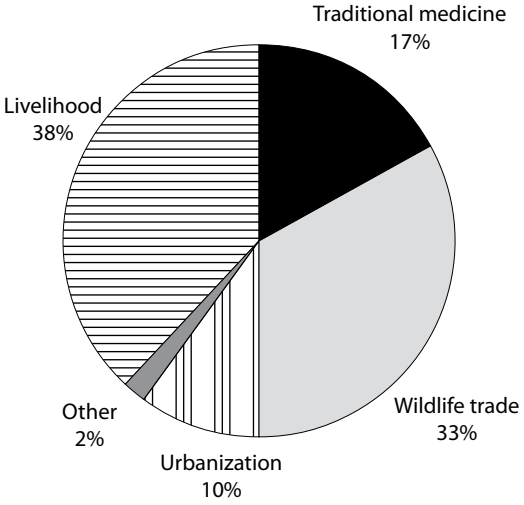
Figure 3. The proportion of papers across four key topics in South Asia. Frequency bar plots for India and Bangladesh (countries with the most number of papers) are shown. The Venn diagram shows the extent of overlap among the papers that addressed at least one topic.

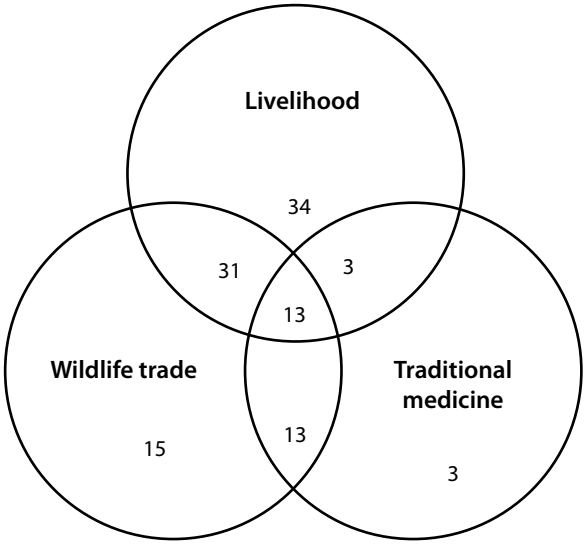
Table 4. The frequency and distribution of papers across 12 countries and four key topics in Southeast Asia.

Southeast Asia, papers by topic	# of Papers	% of Papers
Livelihood	71	38%
Traditional medicine	32	17%
Wildlife trade	62	33%
Urbanization	18	10%
Other	4	2%
Total	**187**	**100%**

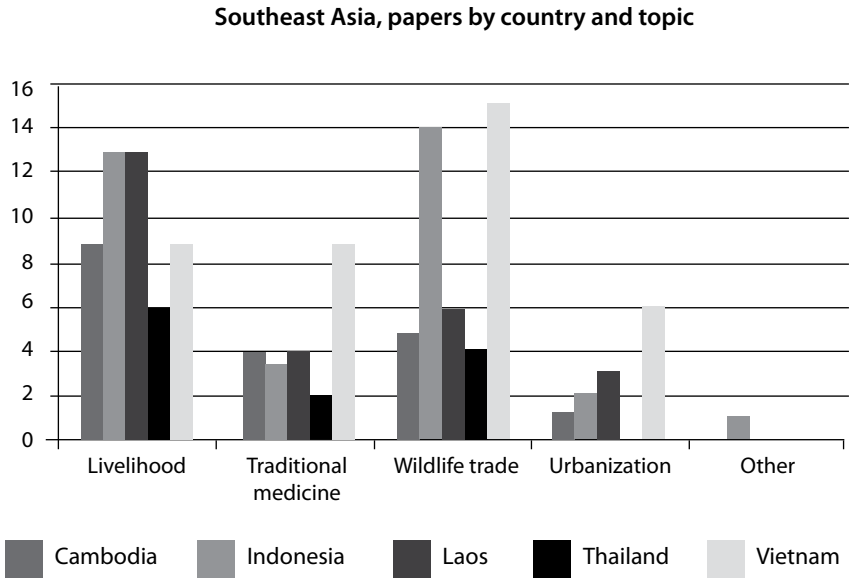
*Note: Papers that discuss more than one topic and/or country are included more than once.

South Asian countries	# of Papers
Brunei	0
Cambodia	11
East Timor	0
Indonesia	21
Laos	14
Malaysia	5
Myanmar	6
Papua New Guinea	2
Philippines	2
Singapore	0
Thailand	9
Vietnam	19
Total	**89**





Note: Two papers on Southeast Asia did not fall into any of these categories.



*Note: Papers that discuss more than one topic are included more than once.

Figure 4. The proportion of papers across four key topics in Southeast Asia. Frequency bar plots for Cambodia, Indonesia, Laos, Thailand and Vietnam (countries with the most number of papers) are shown. The Venn diagram shows the extent of overlap among the papers that addressed at least one topic.

The two countries discussed most commonly in the literature were Indonesia and Vietnam.

The review is divided into four sections and is summarized in the schematic diagram shown in Figure 5: (i) bushmeat consumption as a food security issue; (ii) wild meat harvest for traditional medicine; (iii) wildlife trade and urbanization; and (iv) recommendations and research opportunities from wild meat harvest in Asia. The first section describes the bushmeat crisis as a food security issue in Asia. We discuss how nutrition from bushmeat and rural livelihoods are intrinsically linked. The threats of overharvesting and solutions to making bushmeat more sustainable, as well as ways to address supply and demand, are discussed.

The second section of the review focuses on wild meat harvest for traditional medicine. We provide a brief cultural history of the medicinal use of wild meat in Asia. We highlight the issues related to unsustainable levels of harvesting medicinal products and increasing consumer demand. We also offer several potential solutions. Figure 6 illustrates the trade flow of wildlife medicinal products in Asia. The third section illustrates the links between urbanization and Asian wildlife trade and markets. We show how urbanization leads to rising demand and how connectivity and marketization facilitate wildlife trade. Some solutions are proposed. The last section provides some relevant recommendations and research opportunities for wild meat harvest in Asia in the areas of food security issue, traditional medicine demand and impacts of wildlife trade.

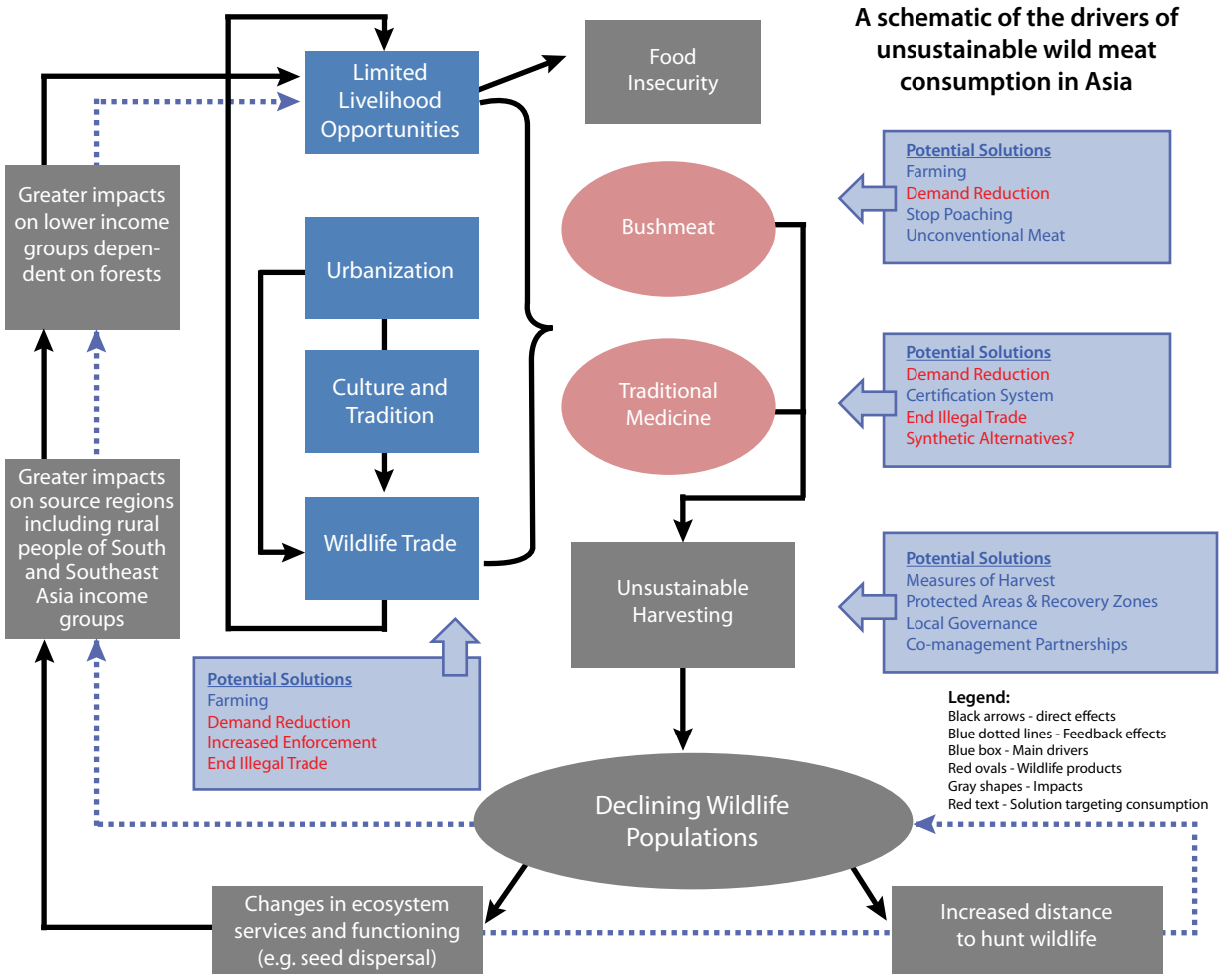


Figure 5. Schematic figure of the key drivers of wild meat consumption in Asia.

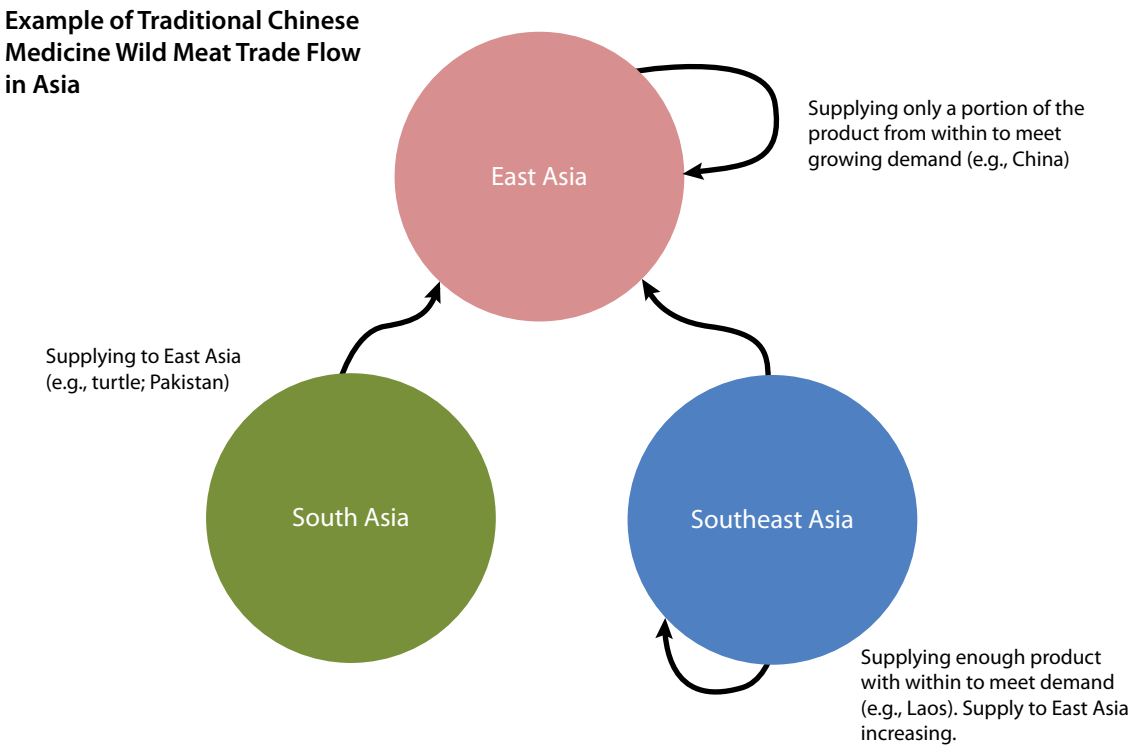


Figure 6. The supply and demand of traditional medicine in Asia.

2 Bushmeat consumption as a food security issue

2.1 Nutrition and livelihoods

Many rural people depend on bushmeat for their nutrition and livelihoods. At least 300 million of the poorest people in the world are almost entirely dependent on forests for their livelihoods (Kim et al. 2008). Even today, over 90% of the world's poorest people depend largely on forests for their livelihoods, and more than a billion people live within the world's most biologically diverse forests (Mukul 2008). Asia is no exception, where many rural and traditional communities depend on hunting as an important source of protein in their diets. Often, the forest is an intrinsic part of their culture and spiritual life and they depend on it for their survival. For example, local villagers collect resin, building materials, medicine and food from the forest in Cambodia (Schmidt and Theilade 2010). Hunting provides food, trade, culture and leisure for indigenous tribes in India (Aiyadurai et al. 2010).

For many rural people, the income from forest products, including game, can be substantial. In a global meta-analysis of 54 case studies, including 14 in Asia, results indicate that forest product income represents a significant revenue source, with an average contribution to household income of around 20% in the populations sampled (Vedeld 2004). Non-timber forest products (NTFPs), including wild meat, can be important as a source of income in remote villages such as those far from the Mekong River (Baird and Bounphasy 2002). NTFPs are estimated to contribute about half of the cash income of rural households in Laos, making them the most important safety net for the rural poor in the country (Ketphanh and Soydara 1998; Foppes and Ketphanh 2004). In India, wild meat contributed significantly (up to 25%) to the economies of indigenous communities (Hilaluddin et al. 2005).

Rural livelihoods are tied to food security in Asia. It has been demonstrated that land, rural livelihoods and food security are closely connected in Cambodia (Sedara et al. 2002). Economic analysis suggests that local communities in southern Cambodia, whose traditional livelihoods depend on the sustainable use of Ream National Park, stand to lose the most from the exploitation of timber and marine resources, while commercial loggers and fishing fleets stand to gain the most (De Lopez 2003). In Laos, the linkages between natural resource management, poverty and malnutrition have also been demonstrated (Johnson et al. 2010). In essence, through managing the ecosystems, food security may be enhanced for the poor in rural areas (Arnold 2008).

Perceptions and social factors can be crucial in understanding wild meat consumption and livelihood issues. For instance, in Nepal, socioeconomic factors strongly influence forest product collection. Compared with other households, the poorer ones have more limited access to community forestry (Adhikari et al. 2004). Poor households used the widest range of hunting methods, including modern implements such as air rifles, and poor living standards were linked to greater hunting effort. In another study, households with small farms were more likely to hunt and to make greater hunting efforts compared with those with large farms. This is because hunting was a supplementary source of food and was found to be inferior to agricultural production (Shively 1997). In Kalimantan, religion and the percentage of intact forest around villages were the strongest socioecological predictors of whether orangutans were killed or not (Davis et al. 2013).

In northeast India, where all segments of the society exploited wild meat equally, education might have a role in reducing wild meat harvesting; promoting awareness about conservation of

natural resources should be actively encouraged (Hilaluddin et al. 2005). The effect of household variables such as education, employment opportunities and distance to forests are shown to influence the cash income obtained from collection and the price increase of NTFPs in southern India (Hegde et al. 1996). In addition, understanding the perceptions of rural communities in dynamic, multiuse landscapes is important where people are often directly impacted by the decline in ecosystem services (Abram et al. 2013).

2.2 Signs and consequences of overharvesting

Overharvesting of wild meat can threaten the food security of those who rely on it. The overharvesting of many hunted species presents a serious threat to the nutritional needs of many humans as well as the existence of many animal species. There are numerous studies documenting depressed wildlife populations and local extinctions in Asia. Tribal communities are hunting species to decline in northeast India (Aiyadurai 2011). Hunting hornbills in local Bornean culture is unsustainable (Bennett et al. 1997). Consequently, the extirpation of species may also have an impact on local culture, through the loss of local ecological knowledge (LEK) among the younger generation, as was reported in southwest China (Kai et al. 2014).

Defaunation as a consequence of overhunting can have several negative outcomes and cascading effects on biodiversity and ecosystem services and functioning. This particular theme has been dealt with in depth in a separate recent global review (Swamy 2013). For example, the loss of some animal species can affect forest regeneration. Overhunting has caused persistent changes in tree population spatial structure and dynamics, leading to a consistent decline in local tree diversity over time (but not aboveground biomass or biomass accumulation rate) in a tropical forest community in Lambir Hills, Sarawak (Harrison et al. 2013). One study found that Malayan tapirs effectively dispersed small-seeded plants but acted as seed predators for the large-seeded plants, suggesting that they are not good substitutes for larger herbivores in seed dispersal (Campos-Arceiz et al. 2012).

Large fruit bats and fruit pigeons are particularly important for long-distance dispersal in fragmented landscapes and should be protected from hunting in tropical East Asia (Corlett 2009). Due to unsustainable hunting in several Malaysian states, the Bornean subspecies of the large flying fox, *Pteropus vampyrus natunae*, can no longer play a key role in pollination (Struebig et al. 2007). The scale of hunting, as measured through hunter and vendor interviews, across Central Kalimantan represents a serious threat to the long-term viability of flying fox populations (and potentially those of other species), and could have serious public health implications (e.g. Nipah and Hendra viruses; emerging infectious diseases) (Harrison et al. 2011).

When monitoring the sales of babirusas (an endangered, endemic, protected species of wild pig) in Sulawesi over almost a decade, it was found that, over time, dealers drove significantly farther to buy wild pigs, paid more for them and bought fewer. These trends are consistent with resource depletion, but they may also be due to market changes (Milner-Gulland and Clayton 2002). Similarly, distance to hunt increased in northeast Indian tribal zones, suggesting wildlife declines (Aiyadurai et al. 2010).

2.3 Solutions for sustainable harvesting

2.3.1 Measures of harvesting

For more sustainable harvesting of wild meat, it is important to understand the rates of harvest and use monitoring systems. However, wild food is typically excluded from official statistics on economic values of natural resources. While the provision of, and access to, wild food may be declining for dependent societies, as natural habitats sustain increasing pressure from development, conservation exclusions and agricultural expansion, it is difficult to know the extent of the decline (Bharucha and Pretty 2010).

In the existing literature, several measures of wild meat harvest are encountered but more are urgently needed. By quantifying hunting effort, harvest rates, and wild meat consumption and sales, it is possible to evaluate if the hunting of certain native species and large threatened species might be sustainable (Pangau-Adam et al. 2012).

In Sulawesi, the measures of wild meat harvests include estimating catchment and harvest per person (Alvard 2000). The target species, amount of bushmeat sold per month, frequency of hunting, and the methods used in the capture or culling of wildlife in Sri Lanka are also possible alternatives (Mylvaganam et al. 2006).

In Papua New Guinea, anthropological studies of subsistence hunting and published life-history data for Australasian marsupial mammals were quantitatively reviewed to determine the major sources of game and their annual harvest, and to estimate intrinsic rates of population increase and population densities. This was used to estimate extraction versus maximum sustainable production (MSP), which provided an initial estimate of the sustainability of hunting (Cuthbert 2010). Selective harvesting regimes are often carried out because age and sex classes contribute differently to population dynamics, and hunters frequently show preferences for large body size and trophy value (Milner et al. 2007). In Sri Lanka, if cardamom production and shifting cultivation are to be restricted under the conservation program, there could be additional pressure placed on another NTFP such as wild meat. A study of the natural regeneration capacity of selected NTFPs such as cardamom is important, as such information could be incorporated into the management plan of forests (Gunatilake et al. 1993).

Biological and ecological traits can predispose certain species and their populations to crashing rapidly if hunted. The high levels of hunting reported and the low reproductive rate of bats indicate there are likely to be severe negative effects on bat populations, and declines in the populations of several species have been documented. There has been at least one reported attempt to manage bat offtake that met with some success. Furthermore, voluntary controls on hunting have halted declines in bat numbers in the African tropics (Mickleburgh et al. 2009). Nevertheless, in northeast India, more research is required to estimate the offtake and consumption rates of wild meat (Aiyadurai et al. 2010). Although many hunting studies focused on mammals in India, few actually quantified hunting impacts (Velho et al. 2012). Furthermore, long-term wildlife monitoring is essential to assess the efficacy that any socioeconomic interventions have in bringing about wildlife recovery (Datta et al. 2008).

2.3.2 Protected areas as an opportunity

The "empty forest" syndrome — forest devoid of large-sized fauna — prevails across the tropics. As a result, a substantial shift toward improving the management and enforcement of tropical protected-area networks is required (Harrison 2011). Protected areas may present an opportunity to reconcile biodiversity conservation and human development, particularly in Asia where there is a high level of dependency on the reserves to support local livelihoods (Scherl 2004).

In Laos, the network of protected areas needs to be viable in the long term because of its significance for biodiversity conservation and for achieving poverty alleviation and development objectives (Chape 2001). To halt the unsustainable exploitation of commercially valuable species resulting in local extirpation of certain species in Myanmar, illegal hunting must be reduced and vulnerable species must be protected by: strengthening park management through enforcement; increasing the opportunity costs of poaching; and conducting research to determine the economic significance of hunting for livelihoods (Rao et al. 2010).

At the landscape level, sustainable management of bushmeat might include solutions such as configuring landscapes in a more game-friendly manner. This may include designating "hunted" and "no take" zones, as well as designing corridors and day-time refuges. Management might extend to implementing seasonal hunting restrictions. For instance, small but well-protected recovery zones set within forested areas might have contributed to population recovery of ungulates and increased the prey base for endangered tigers in Thailand's Thung Yai Naresuan Wildlife Sanctuary (Steinmetz et al. 2010). Nevertheless, the main mechanism for the reduction in mortality of the sambar deer in certain systems appeared to be largely influenced by biological traits (i.e. reproductive behavior) and not positive interventions (i.e. prevention of poaching) (Steinmetz et al. 2010).

2.3.3 Local resource management and governance

The bureaucratic or market institutions have largely failed to successfully conserve natural

resources globally. The Western idea of resource conservation through complete closure is not scientifically or socioecologically sustainable, as reported in Bhutan (Gupta and Karma 1990) and elsewhere in Asia. In contrast, local community and participatory management of resources may offer a more effective solution. The lack of local participation in management and inadequate dissemination of information around a newly established nature preserve hindered effective conservation in Guangdong province, China (Jim and Xu 2002).

It has been shown that buffer zones under local management may serve to protect both livelihoods and forests in Nepal (Khatri 2010). Participatory park management that involves indigenous peoples and that addresses their livelihood issues will probably succeed in its efforts to conserve wildlife (Nepal 2002). In Bangladesh, scientists have argued strongly for incorporating local people and their knowledge into park management decisions through a co-management system (Fox et al. 2007; Chowdhury et al. 2009).

Traditional, sustainable use of forest resources exceeds the benefits of commercial timber extraction by more than USD 200 per ha (net present value over a 90-year period) in Tapean forest, Cambodia. This suggests that areas of high cultural value and environmental significance might be best managed by local communities (Bann 1997). In East Kalimantan, villagers are worried about the declining quality of their forests and the environment. Because they also support development (e.g. access to education) and conservation efforts, giving villagers more control can offer benefits for both. Giving greater power to local people in the management of tropical forests can provide both environmental and development benefits (Basuki et al. 2011).

Furthermore, the traditional knowledge of ethnic indigenous people on conservation should be leveraged and practiced as the form of local law in order to manage hunting of vulnerable wildlife populations, e.g. cuscus hunting by Biak (Pattiselanno and Koibur 2009). Indigenous groups in Sri Lanka view the forest as their inheritance, and their rights to the forest are socially accepted. Communities descended from hunter–gatherers have particularly strong links with the forest. This suggests that what is accepted as legally appropriate is not necessarily accepted socially and culturally in some areas; indigenous peoples' rights to resources must be incorporated into management strategies (Wickramasinghe 1997).

Among the Asian countries, Vietnam, for instance, is transferring forest management rights back to local people. This has the potential to contribute to the household economy, but to varying degrees across households and villages. Consequently, the incentives for local people to participate in the management of decentralized forests largely depend on the presence of a practical benefit-sharing mechanism that addresses the requirements of the poor of the community (Nguyen 2008).

In principle, it is crucial to move toward more 'sustainable governance of natural resources' by allowing public examination of scientific ecological knowledge (Rist et al. 2007). However, it is likely that a multilevel governance framework may be required to resolve a potential mismatch between national policy and grass-roots governance for managing wildlife hunting. For instance, in India, species such as the Asian elephant (*Elephas maximus*) are still considered taboo to hunters but other species that were once taboo (gaur, *Bosgaurus*) are now being hunted. A month-long ban was previously upheld to prohibit tribal hunting during the wildlife breeding season each year, but this has now been reduced to a 16-day ban, which might be unsustainable (Velho and Laurance 2013). For this and other reasons, it is crucial for community-based conservation activities to be evaluated on their impact and legacy across Asia (Grieser-Johns and Thomson 2005; Drury 2011). Critically, the development of social capital should parallel community-based management, since many Asian traditional governance systems are lagging behind, particularly when it comes to managing modern hunting methods.

2.3.4 Differential impacts across various socioeconomic groups

The guidelines for harvesting should consider the differential use and dependency across different income groups in terms of forest resource use. In Tamil Nadu, India, where there was no restriction on forest use, higher income segments used the resources more heavily than lower income groups, and would be most affected by any restriction on

forest use (Hegde and Enters 2000). In Cambodia, it is more important to know the extent and characteristics of forest dependence, the status of key forest resources and competition for these resources, and the relationship between local use and management and official rules and regulations (McKenney et al. 2004).

The perspectives of resettled peoples (i.e. new migrants) should be contrasted with native residents of forests, who use traditional means of survival, and new initiatives designed to supplement their livelihoods and to reduce their dependence on forest resources. In a Vietnamese national park, it was reported that newly relocated villagers are unable to survive only on agricultural activity; tourism has done little to provide an alternate livelihood and the park environment is still threatened by the use of resources by new settlers in their fight to survive (Rugendyke and Son 2005). Many of the issues identified for protected areas are similar to existing forest carbon markets; they include lack of tenure and the biased distribution of resources, which particularly affects the landless populations in society (Coad et al. 2008). In addition, a policy related to bushmeat conservation may need to consider gender balance, distance to the provincial city, poverty level and dependency ratio (Viet Quang and Nam Anh 2006).

2.3.5 Resource co-management partnerships

In some instances, partnerships between government agencies and local communities can be beneficial for the sustainable management of wildlife resources. Despite a history of conflict with indigenous peoples, government officials in Sarawak appear willing to work with local people and community leaders to make resource management more sustainable (e.g. find alternatives to activities that threaten local wildlife) (Horowitz 1998). A social forestry program was launched in Bhutan where the people developed community and private forestry through the government's technical support. Through this program, locals became involved in forest management and harvested forest products on a more sustainable basis (Penjore and Rapten 2004).

Local people and sanctuary managers have been known to increase communication, to initiate joint monitoring and patrolling, and to establish wildlife recovery zones. While using local knowledge has its limitations, the process of engaging local people can promote collaborative action, as demonstrated in the conservation of some large mammals in Southeast Asia (Steinmetz et al. 2006). There is also a need to identify the barriers in achieving sustainable community forest management (CFM). In Thailand, this is in part because (i) the legal support for CFM is absent, so the Royal Forest Department fails to transfer appropriate technology to local communities; (ii) the scope for developing effective strategies for sustainable CFM by merging traditional knowledge with existing scientific knowledge is minimal; (iii) a formal institutional arrangement for CFM is absent; and (iv) community members' access to the technology of CFM is limited (Salam et al. 2006).

2.4 Addressing wild meat supply and demand

2.4.1 Farming and captive breeding

Another possible solution to make wild meat consumption more sustainable across Asia is to find ways to meet increasing bushmeat demand and provide alternative sources of protein and income, particularly for those who are less dependent on wildlife products for their livelihoods. It is possible to improve existing farming techniques to lower dependency on bushmeat, and to explore the potential farming of certain wildlife species. While captive breeding operations may reduce the supplies of wild-caught individuals, CITES-registered and nonregistered programs must be closely monitored and evaluated for legitimacy (Thomson 2008). Past reports suggest that there is a danger that breeding farms are being used to launder illegally caught wildlife (e.g. green python), as observed in Indonesia (Lyons and Natusch 2011; TRAFFIC 2012a).

In addition, farming as a solution may be controversial. Concerns about the viability of such farming, its cost effectiveness, and its impact on wildlife populations need to be carefully examined (Mockrin et al. 2005). Consequently, it is likely that farming may not be an effective tool in reducing demand for illegal wildlife products and may, in fact, stimulate greater demand for wild-caught products, as was seen in Vietnam (Drury 2009). Although a simulation study suggested

that medicine and trade may be possible for farmed tigers, the trade-off may potentially lead to declining habitats — which is a major issue across Asia (Abbott and van Kooten 2011).

2.4.2 Preference for wild meat

In the lowlands of Laos, local people consider wild game meat a delicacy over domesticated livestock, suggesting that hunting is not purely motivated by necessity (Hansel 2004). In Vietnam, trapping is widespread and is largely driven by financial gain and noneconomic benefits such as social esteem and enjoyment. It seemed that awareness of wildlife protection laws among the trappers was low and particular species were not specifically targeted (MacMillan and Nguyen 2013). In Myanmar, hunting is also indiscriminate, with offtake determined largely by relative abundance rather than intrinsic preference or legislation. As such, specific management and policy recommendations include the need to monitor the hunting impacts on vulnerable species, the delineation of no-take areas, and modification of the legal framework for wildlife conservation (Rao et al. 2005).

The popularity of wildlife consumption may also indicate the influence of these animals as social objects. In the modern-day context of prevalent social and environmental change across Laos, eating wildlife is commonly regarded as a form of national identity that combines an idealized tradition with a status-conscious modernity (Singh 2010). In some instances, through farm owner interviews, wild stock is the preferred option for restaurants, partly because wild individuals are cheaper than farmed ones. For instance, in Vietnam, wild porcupines are bought for half the price of farmed ones (Brooks et al. 2010).

2.4.3 Other possible options

Although agriculture is the predominant occupation, hunting (driven by the trade) may represent a significantly greater source of income than other livelihood activities. As such, management recommendations may include increased investment in enforcement, education and outreach, small livestock development, improved crop productivity, demarcation of no-take areas for wildlife, and biological monitoring of targeted species, particularly in Myanmar (Rao et al. 2011). In Pakistan, however, there is a need to reorganize the social sector and help local communities to fully benefit from the potential of ecotourism as an alternative form of sustainable livelihood (Bibi et al. 2013).

Another option to ensure food security is to look into other nonconventional animal species for food (e.g. ungulates, rodents, rabbits and hares, kangaroos, reptiles and bats) derived either from wild harvesting or farming. By considering the comparative food security and nutritional values, rodents appear to present great potential for becoming large commercial commodities for food use (Hoffman and Cawthorn 2012). Furthermore, hunting within oil palm plantations may not only reduce crop damage from wild boar but also yield large amounts of wild meat with relatively little bycatch of threatened animals, as reported in Jambi, Sumatra (Luskin et al. 2013).

Because of limited law enforcement, conservation efforts such as teaching local hunters to avoid endangered species or encouraging them to monitor local animal populations, may be a more effective bottom-up approach to minimize the negative effects of hunting (Scheffers et al. 2012). More critically, there is an urgency to assess demand, supply and exploitation scenarios, (e.g. snake markets as feed for crocodile farms in Cambodia) (Brooks et al. 2008). Understanding the market structure and consumer behavior demand may also facilitate the formulation of regulations.

3 Wild meat harvest for traditional medicine

3.1 Cultural history for medicinal use

Traditional medicine using wildlife products is deeply ingrained in many Asian cultures, which have been harvesting a multitude of species for thousands of years. In particular, the history of traditional Chinese medicine (TCM) has been discussed for China (Guo et al. 1997). In Cambodia, the use of plants and animals in traditional medicines is also popular (Ashwell and Walston 2008). The medicinal purpose, body parts used and cost of medicinal animal species traded and used in traditional medicine in Vietnam are well-studied (Van and Tap 2008). Primates use in traditional folk medicines and magic–religious rituals and remedies are often linked to folk beliefs (Alves et al. 2010). It is reported that traditional medicine is widely used and perceived as effective by a fairly large proportion of Lao people (Sydara et al. 2005).

Nagaland wildlife laws in northeast India have largely been ineffective due to cultural traditions of hunting for meat, perceived medicinal and ritual value, and community ownership of the forests (Bhupathy et al. 2013). Hence, traditional Asian medicine is on a collision course with wildlife preservation (Graham-Rowe 2011). It is important to consider socio-cultural factors when making management plans for wildlife (Alves et al. 2010). In the case of wildlife trade, culturally specific patterns are evident among different ethnic groups, even within a country. Revealing such patterns is the basis for developing conservation management plans (e.g. for Asian primate species) (Nekaris et al. 2010).

3.2 Unsustainable harvest of medicinal products

Traditional medicine products are often unsustainably harvested in Asia, largely driven by increasing human populations, and greater affluence, along with shrinking forest habitat. Unfortunately, some of these targeted species are globally endangered (e.g. tiger). As such, the conservation status of rhinos, elephants and tigers and the threats facing them (including harvest for medicinal purposes) demands novel conservation initiatives, policies and frameworks that can secure the long-term future of these iconic species (Clements et al. 2010).

In Taiwan for instance, the observed levels of usage and trade of turtle shells for traditional medicine appear to be unsustainable and may have a great impact on the chelonian fauna from source areas in China and Southeast and South Asia (Figure 6). For the sustainability of chelonian fauna in Asia, clear policies and close international cooperation for the regulation of the turtle-shell trade are urgently needed (Chen et al. 2009). Pangolins are used primarily as a food and medicinal ingredient in TCM. The animals are a prized resource, for which solid demand has led to their rapid decline (Wu and Ma 2007).

Anecdotal evidence from interviews with local hunters and park staff suggest that hunting for bezoar stones (visceral excretions found in langurs and used in traditional medicine) was the primary reason for the observed decline in Hose's langur in East Kalimantan, Indonesia, in just over a seven-year period. This demonstrates that, with increasing access to markets, hunting large fauna for medicinal purposes, even for short durations, can have a dramatic impact on population numbers (Nijman 2005). Further, recent cases of illegal hunting and trade in Malayan sun bears in Peninsular Malaysia, as exemplified by seizures, call for specific attention to these illegal activities (Shepherd and Shepherd 2010).

3.3 Increasing consumer demand

Harvest for food and use in traditional medicines are the two main forms of overexploitation. Overexploitation in China is widespread and is carried out by China's larger, poorer and more rural population, who operate a trade in wildlife products (Yiming and Wilcove 2005). Driven by consumptive use for food and traditional medicine, the large volume of both legal and illegal trade in wildlife has caused great damage to ecosystems and driven many species to the brink of extinction. Data gathered from trading hubs at ports, boundary markets, city markets and stores, indicate the large amount of wildlife traded in the region of Guangxi, Yunnan and Qinghai provinces, a direct result of the numerous wildlife markets available (Zhang et al. 2008). A growing human population, increased buying power and globalization, have all led to higher demand for products derived from wildlife, including those used in traditional medicines (Nijman 2010).

3.4 Potential solutions

An introduction of certification systems for traditional medicine products, synthetic alternatives and demand reduction are all possible solutions. For example, the TCM Endangered Species Certification Scheme was proposed recently to make TCM trade more accountable and transparent (SCBD 2011). Demand reduction is likely to be the most challenging solution, given the cultural customs and social status associated with many traditional medicine products. Often, it is difficult to act on personal rather than collective interests, and the symbolic role of wild meat in an extremely status-conscious society (e.g. Vietnam) makes reducing demand even more complicated (Drury 2011). Great demand exists for forest products, legally and illegally collected, for uses ranging from decorative to medicinal. As such, there is a need to cultivate a relationship with the press, and work with practitioners of traditional medicine to convince the public that its health needs do not require animal parts (Sumrall 2009). The joint government–industry tactic aimed at raising awareness about and reducing the illegal international trade in endangered species for Chinese medicine may be a viable approach (James 2009).

Other possible solutions include stopping the illegal online wildlife trade, increasing public awareness through campaigns and advocating sustainable wildlife consumption (Hongfa and Compton 2008). In particular, it is recommended to focus on understanding the demographics of Chinese and Vietnamese wildlife consumers and to find ways to change their behavior (TRAFFIC 2012b). Opinions about wildlife conservation carried out in Hunan province, China, before and after the severe acute respiratory syndrome (SARS) epidemic, revealed that post-epidemic consumption may be reduced due to a threatening disease outbreak related to wildlife consumption (Yang et al. 2007). Governments in Asia should strengthen the capacity of the agencies responsible for fighting the trade and increase their budgets. There is also a need to use education to encourage Vietnamese people to stop consuming illegal wildlife products (van Song 2008).

We also need to utilize local ecological knowledge for biodiversity conservation. A study highlighted the value of applying local hunters' knowledge in Vietnam to develop ecological study methods and conservation programs for pangolin species in Southeast Asia (Newton et al. 2008). In addition, surveys to identify the uses and users of wildlife (e.g. lorises) elucidate factors affecting wildlife medicine choices, and determine whether access to alternative therapies will be critical to reduce the use of wildlife medicines (Starr et al. 2010).

In recent years, illegal hunting has increased in Mongolia, putting considerable pressure on large mammal populations. This surge in hunting may be tied to increasing rural poverty, ineffective policies to regulate hunting, as well as a ready market for many wildlife products in the Chinese medicine markets of East Asia. A 'grounded theory' approach is needed to investigate local community attitudes toward wildlife utilization and to explore what local people consider as a sustainable wildlife management strategy in remote regions of Mongolia. Generally, important changes are needed if bushmeat sustainability is to be achieved, including alterations to property rights, greater government support, and improved marketing skills and employment opportunities from conserving wildlife in Mongolia (Pratt et al. 2004).

4 Wildlife trade and urbanization

4.1 Urbanization leads to rising demand

Increased urbanization and a growing middle class in Asia have increased demand for bushmeat and are fueling the lucrative illegal wildlife trade, and potentially undermining rural livelihoods and food security. Many from the middle class also view bushmeat as a luxury and a status item. A growing human population, increased buying power and globalization have all contributed to higher demand for wildlife products (Nijman 2010).

In Asia, the demographics of the urban bushmeat consumers are gradually being documented. In Vietnam, wild meat is widely consumed by successful, high-income, high-status males of all ages and educational levels — and is used as a way of communicating prestige and obtaining social leverage. As the country's population and economy continue to grow, the demand for wild meat and medicinal products is likely to rise (Drury 2011). The urban residents' attitudes toward bushmeat consumption are critical in understanding the social drivers of the wildlife trade. A recent survey conducted in Hanoi, Vietnam, focused on the attitudes and behavior of Hanoi residents toward wild animal consumption (Venkataraman 2007).

4.2 Connectivity and marketization facilitate trade

Vast improvement to existing infrastructure has greatly facilitated the wildlife trade in Asia. Improved infrastructure has made forested areas more accessible and opened up the possibility of trade with distant urban markets for wildlife products, often medicinal in nature (Corlett 2007). In addition, marketization has made trade more profitable for many rural, subsistence hunters. As rural–urban migration intensifies, bushmeat is often brought to cities to meet the demand of immigrants.

The increased demand from cities has led to a growing market for bushmeat, which in some cases has led to unsustainable harvests as it was more profitable for local people to sell bushmeat to markets than to use it for their subsistence. In Laos, due to market expansion into remote areas, households are trying to manage the transition from subsistence to market economies (Bouahom et al. 2004). The new exposure to external market forces has begun to generate drastic and novel changes in Laotian rural communities, with the development of village collectives to manage resources and negotiate with outside traders (Thongmanivong and Fujita 2006).

In Asia, China is the largest and most significant country driving the wildlife trade in the region. Little is known about Chinese wild animals and it is difficult, if not impossible, to assess the impact of trade on them. Although the first market survey was conducted in southern China in 1997 (Lau et al. 1997), not many more have been carried out since. This is despite the carnivore fauna in south China being among the most depleted of any continental area in the world (Lau et al. 2010). Turtles in Southeast Asia, especially in Vietnam, have been overexploited for more than a decade, largely because of international trade with and demand from China. Increased protection measures in such areas should have priority over trade control, given the complexity of the trade network and the lack of government resources to control it (Le 2007).

In Pakistan, turtles and their body parts collected from the wild are transported to wildlife dealers in Peshawar (Khyber Pakhtunkhwa), Lahore (Punjab) and Karachi (Sindh). These cities have international exits and are therefore

preferred by wildlife traffickers for the export of turtle consignments. The known turtle-part importing countries include China and its special administrative region Hong Kong, Vietnam and Korea (Noureen et al. 2012). Excessive hunting pressure, due in large part to commercialization, has reduced the populations of many tropical large mammal species in Sulawesi, Indonesia. Wildlife overexploitation is severe in Indonesia, especially on Sulawesi Island, where human resources and funding are inadequate to monitor the wildlife trade and enforce existing protection laws (Lee et al. 2005).

The existing protected area systems of the countries of the Greater Mekong subregion provide the last reserves of habitat and biodiversity. However, as expanding transport infrastructure combined with land conversion encroach on their boundaries, these remaining outposts are likely to become even more threatened unless realistic mitigation measures are designed and implemented to prevent these "economic corridors" from becoming wildlife trade superhighways (Shepherd et al. 2007).

4.3 Possible solutions

4.3.1 Stemming illegal trade

Illegal wildlife trade in the Himalayan region of China, for instance, is attributed to four factors. First, the China Wildlife Protection Law (CWPL) is still imperfect, especially concerning illegal trade and smuggling across borders. Second, CWPL is not fully enforced. Third, infrastructure in many nature reserves is undeveloped and human resources are lacking. Fourth, protection is hampered by differences in the laws of neighboring countries, differences in penalties and in the degrees of protection. Furthermore, national legislation is often not fully enforced in areas that are inhabited mainly by tribal and minority communities (Li et al. 2000). A significant volume of illegal wildlife trade has also been reported between China and Vietnam. The key steps to control the illegal wildlife trade between the two countries should focus on: (i) suppression of illegal wildlife markets and prohibition of the sale of wildlife food in restaurants (consisting of species listed in China's protection list); (ii) international cooperation in the control of the trade; (iii) tighter enforcement of CITES for both countries; (iv) control of invasion of exotic species and disease epidemics in the trade in China; and (v) education for wildlife conservation in China (Yiming and Dianmo 1998).

An alternative and probably better approach in reducing the illegal wildlife trade is a combination of making it more difficult to poach (i.e. situational crime prevention) and incentivizing local people to abstain from poaching (Pires and Moreto 2011). Illegal trade is due, partly, to an inadequate understanding of the species being traded and is facilitated by poor monitoring and enforcement at key trade hubs. As an initial step to fighting illegal trade, and to better understanding the effects of harvest on wild populations, there is a need for increased monitoring and enforcement, improving the knowledge base of species traded and educating consumers about the effects their demand for pets, for example, has on these species (Natusch and Lyons 2012).

Better border control (e.g. China–Myanmar and Yunnan–Vietnam) and law enforcement prohibiting the trade of endangered and overexploited animals is needed (Shepherd and Nijman 2007; Hongfa and Compton 2008). Current challenges are the deficiencies in wildlife trade management (particularly the short supply and low motivation of government personnel) and ineffective targeting of public awareness initiatives (Li and Wang 1999). Minimum technical and financial resources must be increased, and training must be provided to wildlife officials and those responsible for market management, transportation, public security and border control (Li and Wang 1999). In order for the reptile trade to be sustainable in Indonesia, existing regulations must be sufficiently enforced (Nijman et al. 2012).

The human-centered approach to Vietnam's diverse ecosystem, historic consumption of wildlife, rapidly developing economy and nascent environmental legislation has resulted in the continued degradation of a unique and important environment. Proposing a new framework in which to evaluate the illegal wildlife trade and other green crimes in Vietnam will require innovative strategies (Ngoc and Wyatt 2013).

4.3.2 Other considerations

Long-term, spatially explicit studies are important for the assessment of the sustainability of the wildlife trade, as they provide the potential for disentangling the influences of market dynamics from population declines, and contribute to interpreting changes in prices and quantities on sale in end markets (Milner-Gulland and Clayton 2002). While declaring a species to be endangered may offer higher protection status, data suggest that it may actually increase the trade in them, which was the case with the Javan hawk eagle (Nijman et al. 2009).

In the last 20 years, Laos has seen an explosion in wildlife trade, particularly of animals valued in traditional medicine. Income earned from wildlife trade may have allowed residents in a protected area (i.e. Nakai-Nam Theun National Park Area) to buy rice to feed growing populations, instead of clearing more forest to grow it. The situation presents an interesting dilemma for conservationists — attempts to control local wildlife trade could push villagers to clear more forest swiddens, and vice versa. Controlling both at the same time would probably have a negative impact on villagers' living standards. As wildlife trade is a bigger threat to the protected area's biodiversity than local systems of rotational swidden agriculture, management should focus first on dampening wildlife trade. In any case, forest conservation (and villagers' welfare) will benefit more from the alleviation of human population growth in the protected area than from control of its traditional agriculture, as high population growth (not swidden agriculture) was found to be the cause of forest loss in the post-Vietnam war period, (Robichaud et al. 2009).

5 Recommendations and research opportunities for wild meat harvest in Asia

5.1 Food security issues

The potential impacts of climate change and how it could impact the importance of bushmeat as a source of food security is a critical issue but is still unclear. This topic has recently been explored in a workshop on 'Community forestry in the context of climate change in Asia' (APFNet 2012). Additionally, local people depend on forests for their livelihoods, even in degraded and multiuse landscapes; therefore it is important to have a good understanding of the benefits associated with a heterogeneous landscape (Abram et al. 2013). The research and development community should focus more effort on reintegrating food production and conservation in smallholder-managed landscapes (Padoch and Sunderland 2013).

Forests are central to people's livelihoods and health in Indonesian and Malaysian Borneo, where there is a high level of awareness of the negative environmental impacts of deforestation, and concern over rising temperatures, air pollution and loss of clean water sources (Meijaard et al. 2013). Assessing traditional wildlife knowledge among recent migrants and identifying socioeconomic variables that can be used to identify more knowledgeable informants, as seen in Sumatra, Indonesia, is important (Nyhus and Tilson 2003).

While major opportunities to strengthen the contribution of forest and tree foods to sustainable diets may be available, several constraints need to be removed. They are related to cultural issues; the sustainable use of NWFPs; the organization of forest food provisioning; limited knowledge of forest food composition; challenges in adapting management of forests and trees to account for forest foods; and in integrating forest biodiversity into complex landscapes managed for multiple benefits (Vinceti et al. 2013).

The success of an environmental conservation program being implemented at Great Himalayan National Park, for instance, hinges on addressing the imbalances in resource creation or distribution as well as in the allocation of accountability of all the stakeholders including park management, NGOs, researchers, friends of the park, and the community (Pandey 2008). There is urgency to strengthening parks and protected area systems to improve food security (World Bank 2004).

However, a positive relationship between receipt of tourism benefits and support for conservation was not identified, suggesting that benefits from protected area conservation make no difference to local support for conservation (Walpole and Goodwin 2001). Furthermore, sustainability should not be understood in the sense of an active conceptualization and a reflected economic calculation of resource use, but in terms of a broad and highly flexible mode of subsistence. For example, a low population density and diversified patterns of use or non-use of particular forest products does not put pressure on single food sources (Wangchuk 1998).

5.2 Traditional medicine demand

More research on the supply chain of traditional medicine products should be initiated. In addition, there is a need to understand consumer behavior toward synthetic substitutes of wildlife products for traditional medicine. These substitutes could have potential benefits, by not only taking pressure off wild populations, but by removing the health risks that are associated with consuming products from wild animals. Additionally, it is important to better understand consumer behavior and attitudes toward conservation; we need to know how consumers feel about how the demand from traditional medicine is driving the

potential extinction of harvested species. In cases where traditional medicine potentially comes from farmed animals, more research needs to be done to understand if this takes pressure off wild populations or instead acts as a front for wild harvesting of individuals (i.e. wildlife laundering).

5.3 Impact of wildlife trade

It also becomes critical to consider ecological, ethico-legal and health concerns such as hunting, breeding and trade with endangered species, risks of transmission of zoonosis, quality of the products, and alternatives to preparations from endangered species (Still 2003). Sometimes, the trade can have opposing and uneven livelihood-eroding or -enhancing effects that warrant a deeper understanding. For example, in many upland areas of Laos, livelihoods are being negatively impacted by environmental degradation, the operation of government policies and by changing market relations (Rigg 2006).

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Appendix I

List of 172 papers included in the tables and figures and the respective subject category, geographic region and country in which each paper was grouped.

Key

Category				Region	
LH	Livelihoods	U	Urbanization	E	East Asia
TM	Traditional Medicine	O	Other, e.g. ecosystem services	S	South Asia
WT	Wildlife Trade			SE	Southeast Asia

Code	Country	Code	Country	Code	Country	Code	Country
BD	Bangladesh	KH	Cambodia	MY	Malaysia	TH	Thailand
BT	Bhutan	LA	Laos	NP	Nepal	TW	Taiwan
CN	China	LK	Sri Lanka	PG	Papua New Guinea	VN	Vietnam
ID	Indonesia	MM	Myanmar	PH	Philippines	n/a	No specific country/ countries of focus
IN	India	MN	Mongolia	PK	Pakistan		

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
1	Can domestication of wildlife lead to conservation? The economics of tiger farming in China		X	X			X			CN
2	Spatially explicit perceptions of ecosystem services and land cover change in forested regions of Borneo	X	X						X	ID MY
3	Household characteristics and forest dependency: Evidence from common property forest management in Nepal	X						X		NP
4	Wildlife hunting and conservation in northeast India: A need for an interdisciplinary understanding	X	X		X			X		IN
5	Wildlife hunting by indigenous tribes: A case study from Arunachal Pradesh, north-east India	X	X					X		IN
6	The potential for sustainable harvests by traditional Wana hunters in Morowali Nature Reserve, Central Sulawesi, Indonesia	X							X	ID
7	Primates in traditional folk medicine: A world overview		X							n/a
8	Managing ecosystems to enhance the food security of the rural poor	X								n/a
9	Asia's tropics are the most intensively used: Contrasting conservation strategies between South and East	X						X	X	n/a

No.	Title	Category				Region				Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
10	An overview of the use of plants and animals in traditional medicine systems in Cambodia		X						X	KH
11	Non-timber forest product use management and tenure in Pathoumphone District, Champasak Province, Southern Laos	X							X	LA
12	An economic analysis of tropical forest land use options, Ratanakiri Province, Cambodia	X							X	KH
13	The evolving role of tropical forests for local livelihoods in Indonesia	X							X	ID
14	Hunting wildlife trade and wildlife consumption patterns in Asia	X	X		X		X	X	X	n/a
15	Hornbills *Buceros* spp. and culture in northern Borneo: Can they continue to co-exist?	X	X						X	MY
16	Wild meat consumption in Asian tropical forest countries: Is this a glimpse of the future for Africa?	X			X					n/a
17	The roles and values of wild foods in agricultural systems	X								n/a
18	Wildlife exploitation: A market survey in Nagaland north-eastern India	X	X	X	X			X		IN
19	Biodiversity and its use at Taunsa Barrage Wildlife Sanctuary Pakistan	X		X				X		PK
20	Building sustainable livelihoods in Laos: Untangling farm from non-farm progress from distress	X			X				X	LA
21	The conservation impact of commercial wildlife farming of porcupines in Vietnam	X		X	X				X	VN
22	Sustained by snakes? Seasonal livelihood strategies and resource conservation by Tonle Sap fishers in Cambodia	X		X					X	KH
23	Snake prices and crocodile appetites: Aquatic wildlife supply and demand on Tonle Sap Lake Cambodia	X		X					X	KH
24	Asian tapirs are no elephants when it comes to seed dispersal					X			X	n/a
25	An overview of integrated approaches to conservation and community development in the Lao People's Democratic Republic	X							X	LA
26	The value of wildlife	X	X	X						n/a
27	Unregulated trade in turtle shells for Chinese traditional medicine in east and southeast Asia: The case of Taiwan		X	X			X			TW
28	Embracing collaborative protected area management for conservation: An analysis of the development of the forest policy of Bangladesh	X						X		BD
29	Trio under threat: Can we secure the future of rhinos, elephants and tigers in Malaysia?		X	X					X	MY
30	The costs and benefits of forest protected areas for local livelihoods: A review of the current literature	X								n/a

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
31	The impact of hunting on the mammalian fauna of tropical Asian forests	X	X	X	X			X	X	n/a
32	Seed dispersal distances and plant migration potential in tropical East Asia					X	X			n/a
33	Sustainability of hunting population densities, intrinsic rates of increase and conservation of Papua New Guinean mammals: A quantitative review	X							X	PG
34	Evaluation of the wildlife trade in Ba Be and Cho Don districts			X					X	VN
35	Empty forests: Large carnivore and prey abundance in Namdapha National Park, north-east India	X						X		IN
36	It's not just conflict that motivates killing of orangutans	X	X	X					X	ID
37	Economics and stakeholders of Ream National Park, Cambodia	X							X	KH
38	Reducing urban demand for wild animals in Vietnam: Examining the potential of wildlife farming as a conservation tool		X	X	X				X	VN
39	Hungry for success: urban consumer demand for wild animal products in Vietnam		X	X	X				X	VN
40	NWFP use and household food security in the Lao PDR	X							X	LA
41	Making conservation work: Linking rural livelihoods and protected area management in Bangladesh	X						X		BD
42	Endangered and in demand		X	X			X	X	X	n/a
43	Going, going, gone: The illegal trade in wildlife in East and Southeast Asia		X	X			X		X	n/a
44	Evaluating the legacy of an integrated conservation and development project around a tiger reserve in India	X						X		IN
45	Role of non-timber forest products in the economy of peripheral communities of Knuckles National Wilderness Area of Sri Lanka: A farming systems approach	X						X		LK
46	Sustainability of wildlife use in traditional Chinese medicine		X				X			CN
47	Blending cultural values, indigenous technology and environment: The experience of Bhutan	X						X		BT
48	Observations on subsistence hunting along the Phu Yai Mountain range Xanakham District, Vientiane Province, Lao PDR	X							X	LA
49	Initiating a hunting ethic in Lisu Villages, western Yunnan, China	X					X			CN
50	Hunting of flying foxes and perception of disease risk in Indonesian Borneo	X		X					X	ID

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
51	Emptying the forest: hunting and the extirpation of wildlife from tropical nature reserves	X		X						n/a
52	Consequences of defaunation for a tropical tree community			X		X			X	MY
53	Forest products and household economy: a case study from Mudumalai wildlife sanctuary southern India	X						X		IN
54	Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India contribution to rural income	X						X		IN
55	Conservation implications of wild animal biomass extractions in northeast India	X						X		IN
56	What is the role and contribution of meat from wildlife in providing high quality protein for consumption?	X								n/a
57	The state of wildlife trade in China		X	X	X		X			CN
58	Integrated indigenous resource management with wildlife conservation: a case study of batang ai national park Sarawak Malaysia	X							X	MY
59	TCM endangered species certification scheme		X							n/a
60	Stifled stakeholders and subdued participation: interpreting local responses toward Shimentai nature reserve in south China	X					X			CN
61	Finding the linkages between wildlife management and household food consumption in the uplands of Lao people's democratic republic: a case study from the nam et-phou louey national protected area	X							X	LA
62	The use of non timber forest products in northern Lao PDR	X							X	LA
63	Conservation governance in Nepal: protecting forest biodiversity and peoples livelihoods	X						X		NP
64	Conserving southeast Asia's imperiled biodiversity: Scientific management and policy challenges	X		X					X	n/a
65	Carnivores mammalia: Carnivora in South China: A status review with notes on the commercial trade		X	X	X		X			CN
66	Wildlife trade in southern China including Hong Kong and Macao		X	X	X		X			CN
67	Conservation of turtles in Vietnam: a survey of cat tien national park	X		X					X	VN
68	Wildlife trade and implications for law enforcement in Indonesia: a case study from north Sulawesi	X		X	X				X	ID
69	Wildlife trade in Yunnan province china at the border with Vietnam			X	X		X			CN
70	Illegal wildlife trade in the Himalayan region of China			X	X		X			CN

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
71	Modern hunting practices and wild meat trade in the oil palm plantation-dominated landscapes of Sumatra, Indonesia	X		X					X	ID
72	Wildlife laundering through breeding farms: Illegal harvest population declines and a means of regulating the trade of green pythons *Morelia viridis* from Indonesia			X					X	ID
73	Ten thousand tonnes of small animals: Wildlife consumption in Papua New Guinea a vital resource in need of management	X							X	PG
74	Factors influencing the illegal harvest of wildlife by trapping and snaring among the Katu ethnic group in Vietnam	X		X					X	VN
75	Focusing on Cambodia's high value forests: Livelihoods and management	X							X	KH
76	Conservation biology in Asia: The major policy challenges	X	X	X	X		X	X	X	n/a
77	People's perceptions about the importance of forests on Borneo	X							X	ID MY
78	Bats as bushmeat: A global review	X		X					X	n/a
79	Demographic side effects of selective hunting in ungulates and carnivores	X		X	X	X			X	n/a
80	Wild meat: The bigger picture	X		X					X	n/a
81	The trade in babirusas and wild pigs in north Sulawesi, Indonesia	X		X					X	ID
82	Wildlife farming: A viable alternative to hunting in tropical forests?	X		X						n/a
83	Assessing the threat of human consumption of tiger prey in the Bangladesh sundarbans	X						X		BD
84	The role of traditional forest practices in enhanced conservation and improved livelihoods of indigenous communities: Case study	X							X	BD
85	An assessment of the bushmeat trade in northern Sri Lanka	X		X				X		LK
86	Conservation and use of wildlife-based resources: The bushmeat crisis	X		X						n/a
87	Exploited for pets: The harvest and trade of amphibians and reptiles from Indonesian New Guinea			X					X	ID
88	Exploring cultural drivers for wildlife trade via an ethnoprimatological approach: A case study of slender and slow lorises *Loris* and *Nycticebus* in South and Southeast Asia	X	X	X				X	X	n/a
89	Involving indigenous peoples in protected area management: Comparative perspectives from Nepal, Thailand and China	X					X	X	X	NP TH CN
90	Pangolins in peril: Using local hunters' knowledge to conserve elusive species in Vietnam	X	X	X					X	VN

No.	Title	Category				Region				Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
91	A green criminological exploration of illegal wildlife trade in vietnam			X					X	VN
92	The household economy and decentralization of forest management in Vietnam	X							X	VN
93	Decline of the endemic Hose's langur *Presbytis hosei* in Kayan Mentarang National Park, East Borneo		X	X					X	ID
94	An overview of international wildlife trade from Southeast Asia	X	X	X					X	n/a
95	Trade in non-native CITES-listed wildlife in Asia as exemplified by the trade in freshwater turtles and tortoises *Chelonidae* in Thailand		X	X					X	TH
96	The role of Thailand in the international trade in CITES-listed live reptiles and amphibians			X					X	TH
97	Over-exploitation and illegal trade of reptiles in Indonesia			X					X	ID
98	Declaration of the Javan hawk eagle *Spizaetus bartelsi* as Indonesia's National Rare Animal impedes conservation of the species			X					X	ID
99	Exploring illegal trade in freshwater turtles of Pakistan		X	X				X		PK
100	Wildlife knowledge among migrants in southern Sumatra, Indonesia: Implications for conservation					X			X	ID
101	The big cat trade in Myanmar and Thailand			X					X	MM TH
102	Managing landscapes for greater food security and improved livelihoods	X								n/a
103	Linking ecodevelopment and biodiversity conservation at the Great Himalayan National Park India: Lessons learned	X						X		IN
104	Wildmeat or bushmeat? Subsistence hunting and commercial harvesting in Papua West New Guinea, Indonesia	X							X	ID
105	*Cuscus phalangeridae* hunting by Biak ethnic group in surrounding North Biak Strict Nature Reserve, Papua	X							X	ID
106	Trends of forestry policy concerning local participation in Bhutan	X						X		BT
107	Preventing wildlife crimes: Solutions that can overcome the 'tragedy of the commons'	X		X						n/a
108	Local community attitudes to wildlife utilisation in the changing economic and social context of Mongolia	X	X				X			MN
109	Hunting livelihoods and declining wildlife in the Hponkanrazi Wildlife Sanctuary, north Myanmar	X		X					X	MM
110	Hunting patterns in tropical forests adjoining the Hkakaborazi National Park, north Myanmar	X		X					X	MM
111	Hunting for a living: Wildlife trade, rural livelihoods and declining wildlife in the Hkakaborazi National Park, north Myanmar	X		X					X	MM

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
112	Forests, marketization, livelihoods and the poor in the Lao PDR	X		X					X	LA
113	Nature conservation and human well-being in Bhutan an assessment of local community perceptions	X						X		BT
114	Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural India, Bolivia and Mali	X						X		IN
115	Stable forest cover under increasing populations of swidden cultivators in central Laos: The roles of intrinsic culture and extrinsic wildlife trade	X	X	X					X	LA
116	Pro-poor conservation: The elusive win-win for conservation and poverty reduction?	X								n/a
117	Summarizing the evidence on the international trade in illegal wildlife			X						n/a
118	Conservation costs: Nature-based tourism as development at Cuc Phuong National Park, Vietnam	X							X	VN
119	Community forest management in Thailand: Current situation and dynamics in the context of sustainable development	X							X	TH
120	Human attitudes towards the conservation of protected areas: A case study from four protected areas in Bangladesh	X							X	BD
121	Local demand drives a bushmeat industry in a Philippine forest preserve	X		X					X	PH
122	Can protected areas contribute to poverty reduction? Opportunities and limitations	X								n/a
123	Conservation of Prey Long Forest complex Cambodia	X							X	KH
124	Livelihood alternatives for the unsustainable use of bushmeat	X	X	X						n/a
125	Land rural livelihoods and food security in Cambodia	X							X	KH
126	Recognizing local people's priorities for tropical forest biodiversity	X							X	ID
127	An assessment of wildlife trade at Mong La market on the Myanmar-China border			X	X				X	MM
128	The poaching and trade of Malayan sun bears in Peninsular Malaysia		X	X					X	MY
129	Civets in trade in Medan, north Sumatra, Indonesia 1997-2001 with notes on legal protection			X					X	ID
130	Illegal primate trade in Indonesia exemplified by surveys carried out over a decade in north Sumatra			X					X	ID
131	Transport infrastructure and wildlife trade conduits in the GMS: Regulating illegal and unsustainable wildlife trade			X	X				X	n/a

No.	Title	Category				Region				Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
132	The trade in bear parts from Myanmar: An illustration of the ineffectiveness of enforcement of international wildlife trade regulations		X	X	X				X	MM
133	Poverty technology and wildlife hunting in Palawan	X							X	PH
134	Contesting moralities: The politics of wildlife trade in Laos	X		X					X	LA
135	Appetites and aspirations: Consuming wildlife in Laos	X	X	X					X	LA
136	Southeast Asian biodiversity: An impending disaster	X	X	X	X				X	n/a
137	The state and conservation of Southeast Asian biodiversity	X	X	X	X				X	n/a
138	Traditional use of slow lorises *Nycticebus bengalensis* and *N. pygmaeus* in Cambodia: An impediment to their conservation		X	X					X	KH
139	Collaborating to conserve large mammals in Southeast Asia	X	X	X					X	TH
140	Population recovery patterns of Southeast Asian ungulates after poaching	X							X	TH
141	Use of animal products in traditional Chinese medicine: Environmental impact and health hazards		X	x						n/a
142	Intensive hunting of large flying foxes *Pteropus vampyrus natunae* in Central Kalimantan, Indonesian Borneo	X		X					X	ID
143	Confronting illegal wildlife trade in Vietnam: The experience of education for nature — Vietnam		X	X					X	VN
144	Livelihoods forests and conservation in developing countries: An overview	X	X							n/a
145	Use of traditional medicine in Lao PDR		X						X	LA
146	Hunting and wildlife use in some Hmong communities in northern Thailand	X							X	TH
147	Can biodiversity conservation go hand in hand with local livelihoods? A case of conflict resolution in Thailand	X							X	TH
148	Captive breeding of selected taxa in Cambodia and Viet Nam: A reference manual for farm operators and CITES authorities	X	X	X					X	VN KH
149	Recent land use and livelihood transitions in northern Laos	X		X	X				X	LA
150	What's driving the wildlife trade?	X	X	X	X				X	KH ID LA VN
151	Captive bred … or wild taken?		X	X						n/a
152	Creative experts' meeting on messaging to reduce consumer demand for tigers and other endangered wildlife species in Vietnam and China		X	X	X		X		X	CN VN

No.	Title	Category					Region			Country
		LH	TM	WT	U	O	E	S	SE	ISO Code
153	Improving forest dependent livelihoods through NTFPs and home gardens: A case study from Satchari National Park	X						X		BD
154	An overview of the use of plants and animals in traditional medicine systems in Vietnam		X						X	VN
155	Wildlife trading in Vietnam: Situation causes and solutions			X					X	VN
156	Counting on the environment: Forest incomes and the rural poor	X								n/a
157	Hunting: A serious and understudied threat in India, a globally significant conservation region	X						X		IN
158	Hunting practices of an Indo–Tibetan Buddhist tribe in Arunachal Pradesh, north-east India	X						X		IN
159	A matter of attitude: The consumption of wild animal products in Hanoi Vietnam		X	X	X				X	VN
160	Commercial collection of NTFPs and households living in or near the forests: Case study in Que Con Cuong and Ma Tuong Duong Nghe An, Vietnam	X							X	VN
161	The contribution of forests and trees to sustainable diets	X	X			X				n/a
162	Local attitudes towards conservation and tourism around Komodo National Park Indonesia	X							X	ID
163	Local perceptions and indigenous institutions as forms of social performance for sustainable forest management in Bhutan	X						X		BT
164	Anthropogenic factors and forest management in Sri Lanka	X						X		LK
165	Nontimber forest product gathering in Ritigala Forest Sri Lanka: Household strategies and community differentiation	X						X		LK
166	Crouching tiger hidden langur: World Bank support to biodiversity conservation in East Asia and the Pacific	X	X	X			X			n/a
167	The status and conservation of pangolins in China		X	X			X			CN
168	Changes in attitudes toward wildlife and wildlife meats in Hunan Province, central China before and after the severe acute respiratory syndrome outbreak	X		X			X			CN
169	The dynamics of trade in live wildlife across the Guangxi border between China and Vietnam during 1993-1996 and its control strategies			X			X		X	CN VN
170	Threats to vertebrate species in China and the United States	X	X	X			X			CN
171	Wildlife trade consumption and conservation awareness in southwest China		X	X	X		X			CN
172	International trade status and crisis for snake species in China			X			X			CN

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Bushmeat has always provided a source of nutrition and traditional medicine for local people throughout Asia; this important resource is becoming increasingly under pressure due to loss of forest and overharvesting because of rising demand from growing human populations and trade (legal and illegal). For this reason, the conservation of forests and sustainable use of wildlife are both imperative for improving rural livelihoods and poverty alleviation. A comprehensive literature review yielded 236 papers relevant to this topic, with the greatest number of papers discussing Southeast Asia (61%) followed by South Asia (22%) and East Asia (16%). Potential solutions that emerged from the review include the use of: measures of harvest to better gauge sustainable offtake levels, protected areas and recovery zones; improved governance; and the implementation of co-management partnerships. Potential solutions for the traditional medicine trade include urban demand reduction campaigns, introduction of synthetic alternatives, increased efforts to reduce illegal trade, and implementation of certification schemes for wildlife products. In all of these cases, a myriad of social implications, such as the importance and spiritual significance of bushmeat in different cultures, the preferences for bushmeat over farmed alternatives and the tradition of wildlife-derived medicines, must be considered. Areas for further research include: the study of climate change on bushmeat and food security; the traditional medicine supply chain; consumer reaction to synthetic alternatives; the use of bushmeat particularly for medicinal purposes in urban societies; and the negative effects of the growing wildlife trade on local livelihoods.

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