Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Natural Sciences
Department of Biology

Marta Sawicka Karlsen

Local Ecological Knowledge for Improved Biodiversity Conservation at Indawgyi Wildlife Sanctuary, Myanmar

Master's thesis in Natural Resources Management
Supervisor: Eivin Røskaft
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ABSTRACT

Myanmar faces huge challenges in terms of environmental conservation. The continuous economic pressures to exploit the natural resources are devastating to its amazing biodiversity. Protected areas (PAs) have been established in the last two decades to combat the biodiversity loss, but the resources available to conservation work have been insufficient, resulting in limited effectiveness of the PAs. It is therefore urgent to find some effective alternative ways of tackling these challenges. Involving local communities and utilizing local ecological knowledge (LEK) have gained increasing recognition in recent decades, as they have repeatedly shown to offer cheap alternative to the traditional scientific methods, particularly in developing countries, where environmental conservation funding is sparse. Here I examined the potential of using LEK to improve the effectiveness of the conservation work at Myanmar's largest lake, at the Indawgyi Wildlife Sanctuary (IWS). Two hundred and twenty semi-structured interviews were conducted in June- July 2019. The data included demographic characteristics of the respondents and their knowledge of five turtle species recorded at IWS, environmental processes, threats to biodiversity, PA rules, and their views on conservation. The results revealed that the quality of LEK at IWS was quite good, with many respondents providing accurate information on the species, habitats, population trends, and threats they were facing. Information provided by the respondents indicates that the turtles at IWS face an uncertain future, with population declines driven by local consumption, foreign demand, and habitat loss. There were significant differences in LEK between different demographic groups. Respondents without high school and university education, the elders, and Indawgyi natives exhibited the highest levels of species knowledge. The environmental awareness at IWS was high, without major differences between demographic groups, and the conservation attitudes were very positive. However, the majority claimed that the PA rules were not respected. Based on the results, I conclude that the levels of LEK at IWS present great potential for involving the local people in the conservation activities. Furthermore, I discuss the management areas that should be addressed to improve local compliance and the effectiveness of the PA management, by adopting a more participative approach and including the local community in the management decisions.

SAMMENDRAG

Bevaring av biologisk mangfold i Myanmar står overfor store utfordringer. Det kontinuerlige økonomiske presset for å utnytte landets naturressurser truer de naturlige økosystemer. Verneområder har blitt etablert de to siste tiårene for å bekjempe tap av biologisk mangfold, men midlene øremerket for bevaringsarbeidet har vært utilstrekkelige, slik at effektiviteten av verneområder har vært begrenset. Det er derfor viktig å etterlyse alternative løsninger for effektiv håndtering av de mange utfordringer. Involvering av lokalsamfunn og bruk av lokal økologisk kunnskap (LEK) har ofte vist seg å være billig og pålitelig alternativ til tradisjonelle vitenskapelige metoder. Jeg undersøkte potensialet av å bruke LEK for å forbedre effektiviteten av bevaringsarbeidet ved Myanmars største innsjø, Indawgyi Wildlife Sanctuary (IWS). To hundre og tjue semi-strukturerte intervjuer ble gjennomført for å samle inn data. Innsamlet data inkluderer respondentens kunnskap om fem truede skilpadder registrert ved IWS, kunnskap om miljøprosesser, trusler mot biologisk mangfold, holdninger til naturvern, kunnskap om verneområdereglene og demografisk informasjon om respondentene. Resultatene viste at kvaliteten på LEK ved IWS var ganske god, med mange respondenter som ga nøyaktig informasjon om artene, habitater, populasjonstrendene og truslene de sto overfor. Informasjon fra respondentene tyder på at skilpaddene ved IWS står overfor en usikker fremtid, med populasjonsnedgang drevet av lokalt forbruk, utenlandsk etterspørsel og tap av habitat. Det var signifikante forskjeller i LEK mellom forskjellige demografiske grupper. Respondenter uten videregående- og universitetsutdanning, eldre personer og folk som var født i Indawgyi område hadde de høyeste nivåene av kunnskap om skilpaddene. Miljøbevisstheten ved IWS var høy, uten store forskjeller mellom demografiske grupper, og naturbevaringsholdningene var veldig positive. Flertallet hevdet imidlertid at verneområdereglene ikke ble respektert. Jeg konkluderer at nivåene av LEK viser et stort potensial for å involvere lokalbefolkningen i bevaringsarbeidet ved IWS. Jeg diskuterer de ledelsesområdene som bør håndteres for å forbedre den lokale overholdelsen av reglene og effektiviteten av verneområdeledelse, ved å adoptere en mer inkluderende tilnærming til ledelsen og inkludere lokalsamfunnet i beslutningsprosessene.

INTRODUCTION

Global biodiversity loss driven by anthropogenic activities, including habitat destruction and degradation, overexploitation, pollution, climate change and introduced invasive species, threatens the life on Earth as we know it. The health and integrity of ecosystems depend on maintaining their biological diversity, which is crucial for the many services they provide to humans, including clean water, food, climate regulation, soil formation and nutrient cycling, pollination, protection from soil erosion and extreme weather (Hooper et al., 2005; Cardinale et al., 2012; Naeem et al., 2012; IPBES, 2019). Protected areas (PAs) have been established worldwide as a means of conserving biodiversity since the late 1800s, when the first PA, Yellowstone, was created, but their coverage has increased substantially only in the last 50 years (Chape et al., 2005). The Strategic Plan for Biodiversity 2011-2020 by Convention on Biological Diversity (CBD), known as the "Aichi biodiversity targets", was formulated with a vision of protection, restoration and sustainable use of biodiversity by 2050. One of the main goals is to expand world's protected areas to at least 17% of terrestrial and 10% of marine habitats supporting high biodiversity, by 2020 (CBD, 2011). Some of the main goals of the UN's 2030 Agenda for Sustainable Development also address environmental protection issues (UN General Assembly, 2015). However, many of the critical biodiversity and sustainable development goals will most likely not be achieved as planned this year (2020), and the anthropogenic pressures on the natural ecosystems continue (CBD, 2014; IPBES, 2019).

Designating PAs has traditionally been a top-down process, with the threats to biodiversity and the goals for conservation defined by conservation experts, scientists and policy makers, but rarely involving local communities. Furthermore, restrictions on the traditional use of resources in PAs have frequently been imposed without much consideration for the impact of such measures on the local livelihoods (Cox et al., 2010). This kind of conservation tradition, often referred to by critics as "fences-and-fines" or "fortress conservation" (Beymer-Farris & Bassett, 2012), was practiced due to belief that local communities lacked the knowledge and ability to manage common resources sustainably (Hardin, 1968). However, in the late 1900s, new ideas started to emerge, advocating for more inclusive approach to conservation, embracing local community participation (Feeny et al., 1990; Ostrom, 1990). Numerous studies indicated that involving local communities in the conservation work and utilizing local, traditional and indigenous knowledge, could offer a cheap and efficient alternatives for natural resources management (Gadgil et al.,1993; Berkes et al., 2000; Kareiva , 2006; Andrade & Rhodes, 2012;

Padmanaba et al., 2013; Bennett & Dearden, 2014; Reed et al., 2016; Porter-Bolland et al., 2012; Campos-Silva et al., 2018). Moreover, there is a lot of evidence that excluding local resource users from the conservation processes often leads to adverse effects on local communities and compromises the success of the conservation work (Porter-Bolland et al., 2012; Beymer-Farris & Bassett, 2012; Christie, 2004; Ferraro, 2002). Long-term positive effects of PAs are inherently linked to local compliance, which cannot be achieved, if the local livelihoods are negatively affected by the rules of the PA. Strict restrictions and exclusion, even though initially bringing about some positive biodiversity outcomes, normally end up producing short-term success, without local people benefiting from it (Christie, 2004).

Local and indigenous communities often occupy remote areas retaining a lot of unspoiled natural habitats and abundance of species. Indigenous communities control a quarter of the Earth's land surface, overlapping with 40% of all land-based PAs and ecologically valuable, pristine environments (Porter-Bolland et al., 2012, Garnett et al., 2018). The sustenance of these communities is reliant on healthy ecosystems and requires a deep understanding of the natural processes, knowledge of local flora and fauna, and dealing with environmental feedbacks (Berkes et al., 2000). Local and traditional ecological knowledge (LEK/TEK) are therefore highly adaptive, dynamic systems, much like the concept of "adaptive management", characterized by nonlinear, multi-equilibrium view of ecosystem dynamics in an unpredictable world, requiring flexibility and feedback learning (Berkes et al., 2000). Consequently, community-based approaches and knowledge systems that are different from the western science are today widely accepted and integrated into the frameworks of many leading national and international organizations and programmes involved in biodiversity conservation and sustainable resource management, including IPBES, CBD's Aichi targets, the UN agenda for sustainable development, and other UN affiliated organizations, such as FAO, IUCN and UNESCO.

The interest in LEK (TEK) can be traced back to ethnoscience (folk taxonomies) and human ecology (traditional knowledge of environmental processes), and their subsequent integration to deal with conservation, sustainability and resource management issues (Berkes, 2018). Berkes et al. (2000) defined TEK as "cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment". In other words, TEK is a combination of the observational knowledge of the land and species, including distributions, life histories and behavior; the practical component

linked to the use and management of natural resources, requiring knowledge of ecological processes; and a belief component (religion, ethics), related to human's place in the natural world. The main difference between TEK and LEK, is that, given a longer time frame, allowing the transmission of knowledge across generations, the former bears a historical and cultural continuity of the resource use and a deeper rooting of the values and belief system in that knowledge. LEK, on the other hand, mainly concerns people's current empirical knowledge of the local ecosystems, which does not require the cultural transmission between generations or an embedding within a particular worldview system (Gilchrist, Mallory & Merkel, 2005; Berkes, 2018). This aspect of the ecological knowledge is also the main focus of this study. LEK was found to be a useful supplement to, and in some cases as effective as scientific methods, to gather information necessary for conservation and resource management. Examples of applications of LEK include assessment of fish stocks, population trends and management of fisheries (Johannes, Freeman, & Hamilton, 2000; Haggan, Neis, & Baird, 2007; Hamilton, de Mitcheson & Aguilar-Perera, 2012), collecting population trends information on mammals (Ziembicki, Woinarski & Mackey, 2013; Turvey et al., 2014), mapping distribution, abundance and population trends of tortoises (Anadón et al., 2009), gathering information on the history of flooding, ecology and management of a wetland used for planning of a rehabilitation project (Robertson & McGee, 2003), assessing the status of a giant salamander population (Pan et al., 2016), evaluation of population trends in freshwater cetaceans (Turvey et al., 2013), or evaluating the state of forests (Lyver et al., 2018), to name a few.

However, economic development, modernization and cultural transformation, currently expanding to even the most remote parts of the developing world, were shown to alter the traditional values, beliefs and practices, and erode the accumulated local, traditional and indigenous knowledge, which also proved to have a negative impact on biodiversity (Redford & Stearman, 1993; Benz et al., 2000; Voeks & Leony, 2004; Pilgrim et al., 2008; Shen et al., 2012). Evaluating LEK is, therefore, crucial with respect to involving local communities in the conservation work- to be able to design adequate community outreach and education programmes, and to identify individuals that hold the most relevant information (Davis & Wagner, 2003). Thus, one of the main goals of this study was to evaluate LEK- based largely on the local knowledge of threatened chelonian fauna- and the potential of integrating it in the conservation work at one of Myanmar's PAs- Indawgyi Wildlife Sanctuary (IWS).

Myanmar is a part of the Indo-Burma Biodiversity Hotspot, ranking as one of the world's top ten biodiversity hotspots, in a region that faces serious challenges in terms of protecting its amazing biodiversity (Tordoff et al., 2012). The human population is much higher than in any

other biodiversity hotspot, and development is often prioritized over nature conservation by the national authorities (Tordoff et al., 2012). The widespread custom of wildlife consumption and use in traditional medicine, in Southeast Asia, is driving many threatened animal species to the brink of extinction. The demand for wildlife across the region is growing, along with the growing human population, and is facilitated by the wildlife trade. Wild animals, even in the officially protected areas, are suffering from high rates of exploitation (Hughes, 2017). Staggering numbers of different animal groups, including turtles, snakes, seahorses, pangolins, tigers, elephants, rhinos, bears, primates and lizards, are traded locally, regionally and internationally, as food, traditional medicine, collectibles and pets, with the Southeast Asian countries being the main suppliers, as well as consumers. This trade benefits largely from the loopholes in the regulations, and a significant share of it is illegal (van Dijk et al, 2000; Nijman, 2010; Tordoff et al., 2012; Krishnasamy & Zavagli, 2020). The wildlife trade and consumption are also increasingly recognized as a global public health issue, as they are linked with emergence of zoonotic diseases, most recently, the COVID-19 pandemic, suggested to have originated at a wildlife market in Wuhan, China (Ji et al, 2020; Johnson et al., 2020). Furthermore, the agricultural expansion and commercial logging have driven high rates of deforestation in the region, the lowland forests were replaced by cash crops plantations, wetlands were converted to rice fields and mangroves to aquaculture farms. Many large rivers have been dammed for irrigation and hydropower, resulting in alteration and destruction of habitats crucial to survival of many species. Poverty and dependence on the natural resources, combined with low environmental awareness, lack of alternatives and unresolved land tenure issues, contribute to unsustainable and harmful harvesting practices and extensive encroachment in many PAs. At the same time, the resources allotted to conservation are inadequate, resulting in staff and equipment shortages, lack of suitable training and poor law enforcement (MacKinnon, 1997; Tordoff et al., 2012).

In Myanmar, many natural habitats have been preserved for a long time, owing to a long period of political and economic isolation (Rao et al., 2013). However, the economic growth following country's opening up to the rest of the world in recent years, even though positive in terms of lifting many people out of poverty, has had detrimental effects on nature, by changing the consumption patterns and increasing exploitation of the natural resources (Rao et al., 2013; Prescott et al., 2017). And environmental degradation is also becoming a serious social issue, as many rural communities, accounting for 70% of Myanmar's population (World Bank, 2018a), are highly dependent on natural resources and healthy natural ecosystems. Well

planned and managed protected areas can certainly help to mitigate some of the adverse effects of rapid development that Myanmar has been tackling. The formal protection of Myanmar's natural ecosystems has improved substantially in the last two decades, increasing from only 1% of the total protected terrestrial area in 1997 (MacKinnon, 1997), to around 7% in 2019 (Istituto Oikos and BANCA, 2011; Norwegian Environment Agency, 2019). However, that coverage is still far behind the targets set by the CBD (2011). As in many other countries in the region, biodiversity conservation in Myanmar has been lagging, with weak environmental policy (Rao et al., 2013) and late integration of environmental protection to the governmental decision-making level, that did not happen until 2011 (Norwegian Environment Agency, 2019). Moreover, the formulation of the National Biodiversity Strategy and Action Plan (MOECAF, 2011) was rather slow- first adapted in 2012. Limited environmental safeguards, poverty, corruption and ethnic conflicts in parts of the country, all impede the conservation efforts and contribute to high deforestation rates and depletion of fauna in the affected areas, supplying the illegal timber and wildlife trade in the region (Rao et al., 2010; Tordoff et al., 2012; EIA, 2015; Aung, 2019). Additionally, the multilateral and bilateral conservation funding has been historically much lower in Myanmar compared to the other countries in the region (Tordoff et al., 2012; Rao et al., 2013), and with the national investment prioritizing other issues, the resources dedicated to the management of the PAs are limited. Consequently, of the 44 officially recognized protected areas in Myanmar today, the majority still lack comprehensive management systems, the ecological data for many of them are lacking or outdated, and the law enforcement is weak (Rao et al., 2002; Istituto Oikos and BANCA, 2011; Tordoff et al., 2012; Rao et al., 2013). Given the dire situation of biodiversity and the limited funding available to conservation work in Myanmar, it is therefore highly relevant to consider low-cost supplementary measures, such as involving local communities in conservation activities, to help improving the effectiveness of the country's PAs.

Order Testudines (turtles and tortoises), comprising 348 species, or a total of 467 taxa-including subspecies (Rhodin et al., 2017), is currently considered one of the most threatened vertebrate group on the planet, with the threat levels resembling those of Primates and salamanders (Rhodin et al., 2018). An estimated 60% of the extant chelonians are globally threatened, i.e. classified as critically endangered (CR), endangered (EN), or vulnerable (VU) on the IUCN Red List (Rhodin et al., 2017; Rhodin et al., 2018). The greatest threats include overexploitation related to subsistence harvesting, and the largely unregulated wildlife trade (Gibbons et al., 2000; van Dijk et al., 2000; Rhodin et al., 2018). However, destruction and

degradation of habitats have also contributed substantially to the plummeting turtle populations worldwide (Buhlmann et al., 2009). Despite their long history on Earth, dating back more than 200 million years, as well as their remarkable structural and physiological adaptations that enabled turtles to survive in changing environments all this time, currently, they are facing many unprecedented threats (Buhlmann et al., 2009; Pough et al., 2016). Certain life-history traits that make chelonians particularly vulnerable to exploitation include long life-expectancy of adults associated with delayed sexual maturity, as well as high egg and juvenile mortality. Thus, harvesting of the adults leads to rapid population declines, as juveniles do not mature fast enough to counteract the loss of the reproducing adults. Additionally, turtles with colonial nesting, including all sea turtles and many freshwater turtles, are especially vulnerable to over-exploitation, making it easy for humans to collect both eggs and adults during the large breeding aggregations of animals around the nesting sites (Pough et al., 2016).

Indo-Burma Biodiversity Hotspot hosts a great diversity of turtle species, making the region pivotal for turtle conservation (Buhlmann et al., 2009; Tordoff et al., 2012; Mittermeier et al., 2015). Throughout Southeast Asia, turtles are exposed to continuous exploitation, driven by the insatiable demand for their meat and use of turtle derived products in traditional medicine (Gibbons et al., 2000; van Dijk et al., 2000; Tordoff et al., 2012). Myanmar alone is home to over 30 species of chelonians, including the marine species (www.reptile-database.org), and all turtles in the country are granted protection under the Wildlife Law (Shwe & Grindley, 2012). However, due to all the aforementioned challenges that wildlife protection in Myanmar is facing, the unsustainable harvesting and trade of turtles persists (van Dijk et al., 2000; CITES, 2010). Unfortunately, turtles do not get as much attention as other animals that are considered more iconic or charismatic. For example, regular species surveys, and other conservation and awareness activities at the study site, located at Myanmar's largest lake, and hosting a number of threatened turtle species, have so far focused on birds, fish, primates and ungulates (Ramsar, 2016). The only survey of turtles was conducted in 2012 by Shwe & Grindley (2012).

Given the precarious situation of chelonians in Myanmar, Southeast Asia and globally, it is critical to monitor their distributions, status and population trends, and identify current and potential threats. That knowledge is critical to design appropriate conservation strategies, which is particularly pertinent in the designated PAs, that may well be the only safe havens for this ancient group of animals.

Objectives

The paucity of official data on turtles in Myanmar calls for systematic mapping and surveillance, which is difficult due to limited resources and complicated political situation in the country. LEK could provide a cheap, quick and effective method of obtaining much necessary information, as suggested by a number of studies (Johannes, Freeman, & Hamilton, 2000; Robertson & McGee, 2003; Haggan, Neis, & Baird, 2007; Anadón et al., 2009; Hamilton, de Mitcheson & Aguilar-Perera, 2012; Turvey et al., 2013; Mmassy & Røskaft, 2014; Turvey et al., 2014; Pan et al., 2016; Lyver et al., 2018). With this study, I sought to examine the potential of involving local community and using LEK at Indawgyi Wildlife Sanctuary (IWS) in Myanmar, to help improving the effectiveness of the park management. My research question is thus: can LEK be used as a conservation tool and contribute to more effective resource management at the IWS?

To answer this question, I have formulated four objectives for the study:

1) evaluate LEK at IWS, based on knowledge of chelonian fauna and general environmental awareness, and identify the main demographic and socio-economic factors that influence it;

2) assess local community's awareness and attitudes to the biodiversity conservation at IWS;

3) identify the main factors influencing compliance with the PA regulations;

4) use the information from the surveys to evaluate the status of threatened turtle species at IWS.

METHODS

STUDY SITE

Indawgyi Wildlife Sanctuary (IWS) is located in northern Myanmar (Figure 1), Mohnyin Township in Kachin State (midpoint 25°10′40′′N, 96°22′55′′E). The sanctuary covers a total area of 814.99 km^2, encompassing the lake, the five surrounding forest reserves in its watershed, and the Indaw Chaung River with its riverside marshland (UNESCO, 2017; UNEP-WCMC and IUCN, 2020). The climate is humid subtropical, characterized by hot, wet summers with average temperature of about 27°C (March- September) and dry mild winters, with average temperatures 17°-18°C (December- January) (UNESCO, 2017). Indawgyi is the largest natural freshwater lake in Myanmar, stretching approximately 25 km north to south, and 8-13 km east to west at its widest part, with maximal depth of 22 m. About 30% of the site is wetland, but most of it has been converted to rice fields. Three main streams, flowing from the hills in the

southwest, southeast and northwest, and a number of smaller secondary streams, feed into the lake. The Indaw Chaung River in the northeast is the main outflow. Evergreen and mixed deciduous forest, bamboo and hill pine forest cover the hills in the watershed of the lake (Ramsar, 2016; Mjelde et al., 2018).

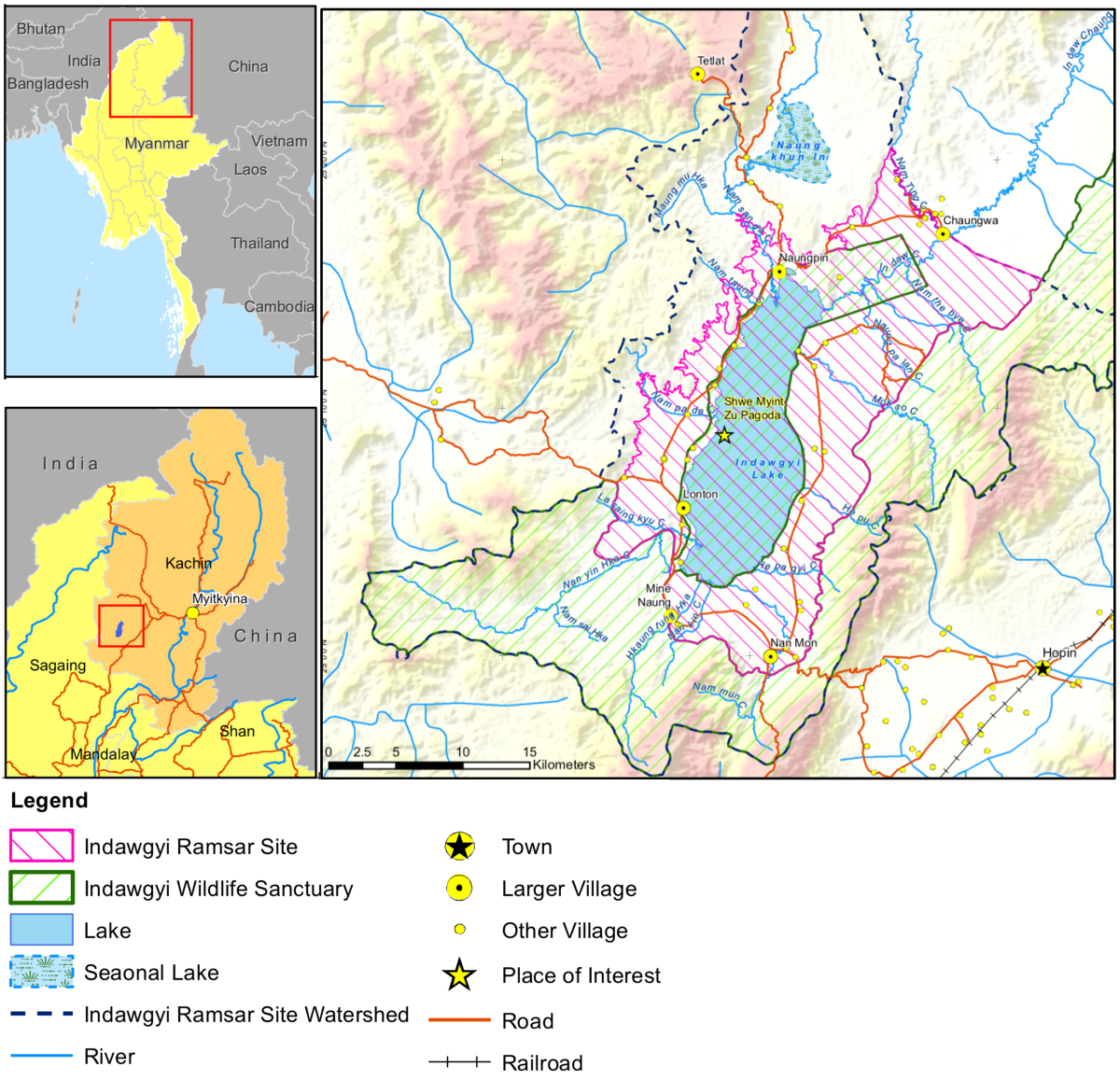

Figure 1. Map of the study site, adapted from Ramsar (https://rsis.ramsar.org/RISapp/files/39544631/pictures/MM2256_map1508.pdf)

IWS was gazetted in 2004, and under the IUCN Protected Area categories it can be classified as Category IV (Oikos & BANCA, 2011). Indawgyi has been internationally recognized for its rich biodiversity and it was declared ASEAN Heritage Park in 2003, a Ramsar Site in 2016, and UNESCO Biosphere Reserve in 2017 (UNESCO, 2017). The UNESCO designation

introduced a zonation regulating different degrees of human activity (FFI, 2017). The strictly protected core zones cover fish breeding areas of the lake and the intact parts of the primary forests. Buffer zones allow low impact resource use, including community forestry, fisheries, collecting NTFP, grazing and eco-tourism. Development zones consist of the villages and the adjacent agricultural fields, and are intended for sustainable development activities, such as organic farming, responsible tourism and waste handling (FFI, 2017).

Surveys in the sanctuary have recorded 448 birds, 38 mammals, 41 reptiles, 34 amphibians and 50 butterfly species, as well as 165 species of trees and medicinal plants (Oikos and BANCA, 2011). The lake and the wetland are home to many species of plants and animals, including large numbers of migratory and resident water birds. Between December and March, Indawgyi is a stopover for many migratory birds from China and Siberia, and more than 20.000 individual birds have been recorded during the winter migration season (Ramsar, 2016). The site was designated an Important Bird Area by Bird Life International in 2004 due to the presence of many threatened bird species, including Slender-billed Vulture (*Gyps tenuirostris*), White-rumped Vulture (*Gyps bengalensis*), Sarus Crane (*Grus antigone*) and Rufous-necked Hornbill (*Aceros nipalensis*), to name a few. Several globally threatened chelonian species have been recorded at IWS, including Asian brown tortoise (*Manouria emys phayrei*), the endemic Burmese peacock softshell turtle (*Nilssonia formosa*), Yellow tortoise (*Indotestudo elongata*), Asian softshell turtle (*Amyda cartilaginea*), Myanmar box turtle (*Cuora amboinensis lineata*), and possibly- Burmese eyed turtle (*Morenia ocellata*) and Burmese narrow-headed Softshell Turtle (*Chitra vandijki*) (Kuchling et al., 2004; UNESCO, 2014; Momberg, 2016). Mammals of global conservation concern, that occur in the forests surrounding the lake, include inter alia Chinese Pangolin (*Manis pentadactyla*), Hog Deer (*Axis porcinus*), Shortridge's Langur (*Trachypithecus shortridgei*), Bengal Slow Loris (*Nycticebus bengalensis*), Clouded Leopard (*Neofelis nebulosa*), Eastern Hoolock Gibbon (*Hoolock leuconedys*) and Himalayan Black Bear (*Ursus thibetanus*) (UNESCO, 2014). The diversity of fish in the lake comprises more than 90 species, with 7 new species considered endemic to Indawgyi, discovered in recent years (Ramsar, 2016).

The population at Indawgyi is about 50,000, spread over 36 villages, and the residents belong to different ethnic groups, including Shan, Bamar and Kachin. The main sources of livelihoods include rice-, peanut-, soybean- and seasonal vegetables cultivation, fishing in the lake and subsistence livestock farming. Collecting non-timber forest products is widespread, and logging

and hunting are practiced by a smaller number of the residents. There are illegal gold and jade mines just outside the IWS and a number of local people are involved in mining activities. There is very little tourism at the sanctuary due to lacking infrastructure and limited facilities. However, the Shwe Myint Zu Pagoda festival attracts thousands of domestic tourists (pilgrims) every year (Than, 2011; UNESCO, 2014; Ramsar, 2016; FFI, 2017).

Rapidly growing human population is the main threat to the biodiversity in the sanctuary, leading to increased demand for natural resources. Expanding hill cultivation results in deforestation. The fish stocks in the lake are being overexploited, with destructive fishing practices exacerbating the problem. Many households depend on charcoal to meet their energy needs, resulting in high demand for firewood. Timber and bamboo are collected to provide the construction and building in the area. Gold and jade mining in the hills adjacent to the sanctuary cause increased turbidity of the rivers, and consequent sedimentation and mercury pollution in the lake. Moreover, lack of organized waste management and rubbish disposal on the shores of the lake threaten lives of many aquatic species and water birds, jeopardizing the integrity of the lake ecosystem (Than, 2011; UNESCO, 2014; Fauna & Flora International, 2017).

STUDY SPECIES

The assessment of LEK was largely based on the local knowledge of five threatened turtle species that were recorded at IWS: Asiatic Softshell Turtle (*Amyda cartilaginea*) in Trionychidae family (Figure 1 a); Burmese Box Turtle (*Cuora amboinensis lineata*) in Geoemydidae family (Figure 1 b); Elongated Tortoise (*Indotestudo elongata*) in Testudinidae family (Figure 1 c); Asian Forest Tortoise (*Manouria emys*) in Testudinidae family (Figure 1 d); and Burmese peacock softshell turtle (*Nilssonia Formosa*), family Trionychidae (Figure 1 e). Data on the local knowledge of these turtles were collected using interviews, and the information from respondents included typical habitat, abundance and threats to the turtles (see details in Data collected). Table 1 summarizes the most important information about the selected turtles based on an extensive review of the available literature on the species. The sources cited in the table served as the basis for the evaluation of the respondents' species knowledge.

Table 1. Information about five threatened chelonian species recorded at IWS that were considered in this study, including the sources of information for each species (last row).

Species	**Asiatic Softshell Turtle**	**Burmese Box Turtle**	**Elongated Tortoise**	**Asian Forest Tortoise**	**Burmese peacock softshell turtle**
Distribution	Mainland Southeast Asia, Borneo, Sumatra, Java and Bali	South Asia, mainland and insular Southeast Asia	Widely distributed from the south of Himalaya, through the mainland and peninsular Southeast Asia	Eastern India, through southern Bangladesh, Myanmar, Thailand, peninsular Malaysia, Sumatra and Borneo	Endemic to Myanmar
Habitat	Muddy streams, rivers, peat swamps, marshes, ponds and lakes, occasionally found in mountain streams	Slow flowing rivers, lakes, swamps, mangroves and rice fields	Deciduous, scrub and evergreen forests, at elevations of up to 600 m	Stays close to streams in dense hilly wet forests, bamboo forests and dry evergreen forests, at elevations 600-1500 m.	Large rivers and their tributaries, streams and lakes
Diet	Aquatic invertebrates, fish, some fruits and seeds	Aquatic plants, fungi insects and worms, and some fruit.	Leaves, fruits, flowers and fungi, occasional slug and carrion	Variety of plants, bamboo shoots, fungi, fruits, some insects and frogs	Mostly carnivorous, feeding on fish, as well as some plants
Max. snout-vent length	70 cm	25 cm	33 cm	60 cm	Reported between 40 and 90 cm
Reproductive behaviour	Sexual maturity at about 2 years; clutch size: 3 to 50 eggs; multiple clutches of varying sizes produced during the nesting season	Sexual maturity at 5-6 years; clutches of 1- 6 eggs are laid twice a year	Sexual maturity at 10-14 years; clutch sizes of 1-7 eggs produced once or twice during the nesting season	Sexual maturity at about 15 years; nest made of forest litter, one clutch of 30-60 eggs; female defends the nest the first days after laying	Maturity time unknown. Females nest on sandy riverbanks during the dry season and lay clutches of 20-25 eggs
Conservation status	IUCN Red List- VU; CITES- Appendix II; Myanmar- protected by Wildlife Law and Fishery Law	IUCN Red List- VU; CITES- Appendix II; Myanmar- protected by Wildlife Law and Fishery Law	IUCN Red List- CR; CITES- Appendix II; Myanmar- protected under the Wildlife Law	IUCN Red List- CR CITES- Appendix II, Myanmar- protected by the Wildlife Law	IUCN Red List- EN CITES - Appendix II Myanmar- protected by the Wildlife Law and Fishery Law
Threats	Animals and eggs are extensively exploited for food and use in TCM	Local and regional demand for meat, use in TCM, and international pet trade	Subsistence hunting; international wildlife trade, use in TCM, pet trade, habitat loss (logging, wildfires)	Subsistence hunting (often using trained dogs), wildlife trade- Asian food markets and pet trade, habitat loss (logging)	Local demand for meat and eggs, illegal trade to China, bycatch and illegal fishing methods; mining, and loss of nesting habitats
Sources	Das, 2015; Min, 2012; Platt, et al., 2012; Shwe & Grindley, 2012; Kuchling et al., 2014; Auliya et al., 2016; Rhodin et al., 2017	McCord & Philippen 1998; Van Dijk et al., 2000; Schoppe, 2008; 2009; CITES, 2010; Platt, et al., 2012; Shwe & Grindley, 2012; Das, 2015; Ernst & Lovich, 2016	van Dijk et al., 2000; CITES, 2010; Platt, et al., 2012; Shwe & Grindley, 2012; Das, 2015; Ihlow et al., 2016; Rahman et al., 2019	van Dijk et al., 2000; Platt, et al., 2012; Shwe & Grindley, 2012; Das, 2015; Stanford et al., 2015	van Dijk et al., 2000; Kuchling et al., 2004; Platt et al., 2012; Shwe & Grindley, 2012

a)

b)

c)

d)

e)

Figure 2. Photos showing five threatened turtle species that occur at IWS: a) *Amyda cartilaginea* at Lake Indawgyi, Myanmar, photo: Wai Mon Thet; b) *Cuora amboinensis lineata* in Myanmar, photo: Hans-Dieter Philippen (Schoppe & Das 2011), c) *Indotestudo elongata* in in Doi Phu Nang National Park, Thailand, photo: Flora Ihlow (Ihlow et al., 2016); d) *Manouria emys phayrei* in Kaeng Krachan National Park, Thailand. Photo: Craig Stanford (Stanford et al., 2015), *Nilssonia formosa* juvenile caught in fishnet in Indawgyi lake, photo Marta Karlsen.

DATA COLLECTED

A total of two hundred twenty semi structured interviews, combining close- and open-ended questions, were conducted in ten villages at the Indawgyi Wildlife Sanctuary, from June 13th to July 9th, 2019 (see the questionnaire in the Appendix). The questionnaires were prepared in

English, and about one month before the field work, they were sent for a review and translation into Burmese to a field assistant, who later helped me conducting the interviews. Before I arrived at the study site, the field assistant tested the questionnaires with a couple of respondents, to make sure that the questions were appropriately formulated and understood by the local people. A couple of questions were subsequently adjusted to make them more comprehensible. In each village, twenty-two houses were randomly selected after consulting the village headman. The interviews were conducted on a one-to-one basis, usually in respondents house or workplace, and were administered in Burmese- all respondents, regardless of different ethnicities, understood and spoke Burmese. In the selected households, the potential respondents were first informed about the purpose of the interview- the interest in turtles that can be found at Indawgyi, and local community's relationship with nature and the protected area. We ensured that the answers would be completely anonymous and asked if one person in the household could spare 20-25 minutes for the interview. All respondents were at least 18 years old, and only one person per household was interviewed. No recording equipment was used, and photographs were only taken with the consent of the respondents.

First, the demographic and socio-economic data were recorded, including respondent's age, education, ethnicity, religion, occupation, origin- born at Indawgyi/migrant, landholding status, total household income, number of people living in the household, and type of resources harvested from nature.

The next part of the interview included questions regarding knowledge of five selected turtle species. The answers from this part were used to evaluate local knowledge of the turtles and to assess the status of the threatened turtles at the sanctuary. Two photographs of each species were presented, and the respondents were asked whether they could recognize the animal. For each claim of a recognized species, a number of follow up questions were asked, including the typical habitat for the species, how often they were encountered, were there any changes in the abundance of these animals over time, and in the case of claims of population declines- what were the main drivers of the declines. Furthermore, for each species, we asked whether the animals (and their eggs) were collected, and following up confirmative answer, what was the main purpose for collecting.

To establish more general ecological awareness of the respondents, the questions covered awareness of natural resource declines at the sanctuary, knowledge of different types of

ecosystem services, awareness of the threats to nature at IWS as well as the respondents' attitudes to nature conservation.

Local compliance is critical for an effective park management. Therefore, it is vital to assess local awareness of the rules and whether these rules are respected. Such information can help the park authorities to identify priority areas for designing community outreach and education projects. Thus, a number of questions covered these issues. Even though it was made clear that the interviews were anonymous, and the answers could not be traced back to the respondents, asking directly whether the respondent followed the PA rules could have been perceived as intrusive, and could have affected the reliability of the answers. Thus, rather than asking about their own practices within the PA, the respondents were asked about their general view on local compliance with the PA regulations- by asking whether the PA rules were respected. However, individual practices were considered by establishing the resource use for each respondent (see natural resource use in the respondents' characteristics below).

Furthermore, to examine if there was anything that could help to ensure a higher degree of compliance with the PA rules, I asked about the respondent's view on what the best compensation for the opportunity losses related to establishing of the PA would be.

Finally, the respondents were asked if they had any turtle shells or items made from turtles, and whether we could take photos of these items (such items were only shown to us under two interviews).

RESPONDENTS' CHARACTERISTICS

Age and gender

Respondents were classified into five age groups for the descriptive statistics, to better illustrate the differences between the groups. Group 1 comprised 18-25-year olds (10.5% of respondents), group 2, 26-35-year olds (22.3% of respondents), group 3, 36-45-year olds (26.8%), group 4, 46-55-year olds (24.5%), and group 5, respondents over 56 (15.9%). In further analyses (using linear mixed effects models) age was treated as a numerical variable to reduce the number of the explanatory variable categories. 48% of the respondents were women and 52% were men.

Religion

Religion was excluded from the statistical analyses as 100% of the respondents were Buddhists.

Ethnicity

The majority of the respondents (66%) were of Shan ethnicity, 23% were Bamar, 11% were mixed Bamar/Shan, and less than 1% (2 respondents) belonged to other ethnic groups (one person was Kachin and the other, Rakhine). Due to large differences in group sizes between the ethnicities, the Bamar, Bamar/Shan, Kachin and Rakhine respondents were merged into one-mixed ethnicities group, so that the analyses compared the Shan group with the other ethnicities group.

Occupation/ main source of income

Occupation categories, that initially included farmers (58%), fishers (14%), business owners (14%) and other occupations- including laborers, teachers, retired and unemployed (14%), were reduced to only two categories. The "other occupations" group was merged with fishers and business owners, for a total of 42% of the respondents. Thus, only two groups were compared- the farmers group versus the other occupations.

Income

The monthly per capita income varied from MMK 0,- to MMK 1,000,000,-. It was estimated for each respondent by dividing the total household income by the number of people living in the household. For the descriptive statistics, three income groups were used: group 1 with monthly per capita income of MMK 0-40,000, group 2 with MMK 40,000-80,000, and group 3 above MMK 80,000. Group 1 accounted for 27% of respondents, group 2 for 50% and group 3 for 23%. That puts the majority of the respondents (77%) below the poverty line (World Bank, 2018b), as a monthly income of MMK 80,000 corresponds to about USD 1.86 per day. In the mixed effects models, income was treated as a numerical variable.

Education

People that did not have any formal education accounted for 12 % of the respondents (with monastery education normally replacing primary school attendance), 31% had primary education, 20% middle school education, 30% finished high school and 7% had university/college education. For the analyses, education was reduced to three categories, by merging the no-education and the primary school categories into one group (Education 1), and by treating the high school and the university categories as one (Education 3), whereas the middle school category was kept unchanged (Education 2).

Origin

People that were born at Indawgyi comprised 73% of respondents, whereas the migrants accounted for the remaining 27%.

Landholding status

Landowners accounted for 59% of the respondents, whereas 41% did not own land.

Natural resource use

Natural resource use was established by asking what kind of resources the respondents collected within the PA, or from nature- in the case of respondents that did not know about the PA, mostly people from Ma Pyin village, located more than 4 km away from PA. Respondents were asked whether they collected fuelwood, timber, mushrooms, medicinal plants, forest fruit and vegetables, fish, birds and other animals. Based on the answers, low natural resource use was assigned for up to 2 of the resources mentioned, average use for 3-6 resources and high use for more than 6 resources mentioned. The low use group comprised 24% of the respondents, the middle group 37%, and the high use group 39%. 72% of the respondents reported collecting forest fruit and vegetables, 73% used mushrooms, fuelwood use was reported by 64%, fish by 61%, timber by 51%, medicinal plants by 47%, bamboo 44%, and birds by 22%. None of the respondents admitted to hunting or collecting other wild animals, but a couple respondents said that they used to hunt before the PA was established. When asked whether the traditional resource use was affected by the establishing of the PA, 35% answered that their resource use was not affected, 61% answered that the traditional resource use changed because of the PA, and 4% did not know (these respondents claimed they did not know about the PA and therefore could not relate to anything that was linked to the PA restrictions).

DATA ANALYSES

Data collected using the surveys formed the basis for all statistical analyses. Before the analyses, local knowledge of turtles and ecological awareness were evaluated by rating the individual answers, based on the background information acquired from scientific papers, published and unpublished reports, and personal communication with the Forest Department, under the Ministry of Natural Resources and Environmental Conservation in Myanmar.

Species knowledge assessment

For the species knowledge, five categories were considered: 1) species recognized/not recognized (due to a misunderstanding with my translator, "recognized" here indicates the respondents' familiarity with the species and does not include knowledge of the vernacular name), 2) typical habitat, 3) population trend, 4) main drivers of the species decline/ threats, 5) is the species (and its eggs) collected/consumed. The knowledge scores for each category, defined as 0 for incorrect answers and 1 for correct answers, were summarized for each respondent. The total score ranged from zero points for the lowest level of knowledge, to five points for the highest level of knowledge, such that poor knowledge was defined as scores of 0-1 points, average knowledge, 2-3 points, and good species knowledge, 4-5 points.

Environmental awareness assessment

The assessment of environmental awareness was split into four categories: 1) respondent's awareness of the environmental change at Indawgyi (based on natural resources declines), 2) awareness of different types of ecosystem services (nature's benefits to people), 3) awareness of threats to the integrity of ecosystems at IWS, 4) awareness of the benefits of biodiversity conservation. The total ecological awareness score ranged from 0 points for poor awareness, to 3 points for high awareness. For the awareness of the natural resources' declines, a number of alternatives gave points, including decline of fish stocks, timber, firewood, bamboo, birds and wild animals. If the respondent noticed decline of only one resource, only one point was awarded, two points were given for mentioning two-three resources, and three points for mentioning more than three resources. Evaluation of ecosystem services' (ES) knowledge was based on the Millennium Ecosystem Assessment conceptual framework (2005), categorizing the ecosystem services into provisioning, regulating, cultural and supporting. Knowledge of only one type of ecosystem services gave one point, mentioning two types gave two points, and mentioning three or four of ES, gave three points. The biodiversity of Indawgyi is facing many threats, including overpopulation, overexploitation, deforestation, mining, pollution, harmful harvesting practices, expanding agriculture and foreign demand. Mentioning one gave one point, two-three threats gave two points, and awareness of more than three threats was awarded three points. Some respondents claimed that natural processes (natural wildfires, sedimentation) and lack of alternatives presented the greatest threats to biodiversity at IWS, which did not give any points. However, respondents' beliefs regarding alternative livelihoods were addressed by

the final question, about measures that could help to improve local people's respect for the PA rules.

The conservation awareness score was a summary of points for answers regarding reasons for PA establishment and the necessity of nature conservation. Points were awarded if "overexploitation", "nature recovery" or "future generations" were mentioned as the main reasons behind the PA restrictions. No points were given for "not sure"- or "somebody else wants to take advantage of the resources"- answers. Furthermore, one point was awarded if the respondent answered that biodiversity conservation was necessary, with an additional point if reasons for conservation were mentioned (e.g. cultural values, stewardship, ecosystem services, future generations, climate).

Species knowledge, environmental awareness and compliance analyses

The differences in the species knowledge and the environmental awareness across the demographic/socioeconomic factors, were analyzed separately. First, the descriptive statistics and plots were used to show the differences in the mean values between different demographic groups- for each demographic factor separately. The differences across the groups were examined using χ^2- test. The effects of the combined effects of the demographic factors on the species knowledge and general ecological awareness were then analyzed with linear mixed effects models, using the lme4 R-package (Bates, 2015). Local species knowledge and general ecological awareness were modelled as response variables in separate analyses. In order to select models with optimal fixed and random effects structure, the Akaike Information Criterion corrected for small sample sizes (AICc) was used to rank the models, utilizing a top-down strategy for model selection, described by Zuur et al. (2009).

To select appropriate random effects for the models, it was assumed that knowledge of species and ecological awareness could vary depending on the conditions in the village (e.g. infrastructure, access to education), as well as the household's proximity to the protected zones (likely to harbor greater abundance of species and better quality habitats compared to non-protected area). Therefore, both distance to PA (n=7) and village (n=10) were considered as random factors, to account for the non-independence of the records within the same village and observations in similar distances to the PA (Figure A1, Appendix).

The most complex model, including all fixed effects and interactions, were used to establish the random effects structure (Zuur et al., 2009). Ultimately, random intercept for village provided a more optimal predictor for both species knowledge and general ecological

awareness, with a lower AIC, more categories, as well as contributing to a larger proportion of the total variation, compared to PA proximity. With the random effect in place, the best fixed effects structure was determined by comparing the AICc scores of the candidate models and selecting the best model based on the lowest AICc. If the model selection process resulted in more than one optimal model (models with $\Delta AIC<2$), both models were analyzed and compared, but only the best model was presented.

To analyze the effects of the demographic factors on the compliance with the rules of the PA, generalized linear mixed effects model was fitted, using the glmer function from the lme4 R-package (Bates, 2015), with the respect of the rules modelled as a binary response variable (rules respected/rules not respected). The fixed effects in the candidate models were different combinations of demographic variables, and random intercept for the village was used again, to account for the possibility of non-independent observations within the villages. Model selection process was based on the AICc score, as above.

The mean values in the results section were reported with standard error (±SE) and the significance level for the tests was set at $\alpha = 0.05$. All statistical analyses were executed in R studio, version 3.6.1 (R Core Team, 2019).

RESULTS

LOCAL ECOLOGICAL KNOWLEDGE AT IWS

Local knowledge of species

Individuals that were classified as having poor species knowledge comprised 22% of respondents (scoring 0-1 points), 48% had average knowledge (2-3 points), and 30% were considered to have good knowledge of the species (4-5 points). Age had a clear effect on the species knowledge (χ^2=36.35, df=12, P=$2 \cdot 10^{-4}$). The oldest respondents had the highest scores, whereas the youngest scored lowest (Figure 3 a). There was also a clear effect of education (χ^2=28.82, df=6, P=$6.6 \cdot 10^{-4}$), but contrary to age, education had a negative effect on the species knowledge (Figure 3 b), as respondents with lower education had higher scores compared to people with higher education. It was particularly those who completed high school and university that had the lowest scores, compared to people with no education or primary education and those with middle school education. Men seemed to score higher than women (Figure 3 c), but the difference was not significant (χ^2=1.83, df=3, P=0.61). Respondents that

were born at Indawgyi scored a bit higher than migrants (Figure 3 d), but the difference was only slightly significant (χ^2=7.26, df=3, P=0.06). There was no significant difference between landowners and people without land (χ^2=1.39, df=3, P=0.71), (Figure 3 e).

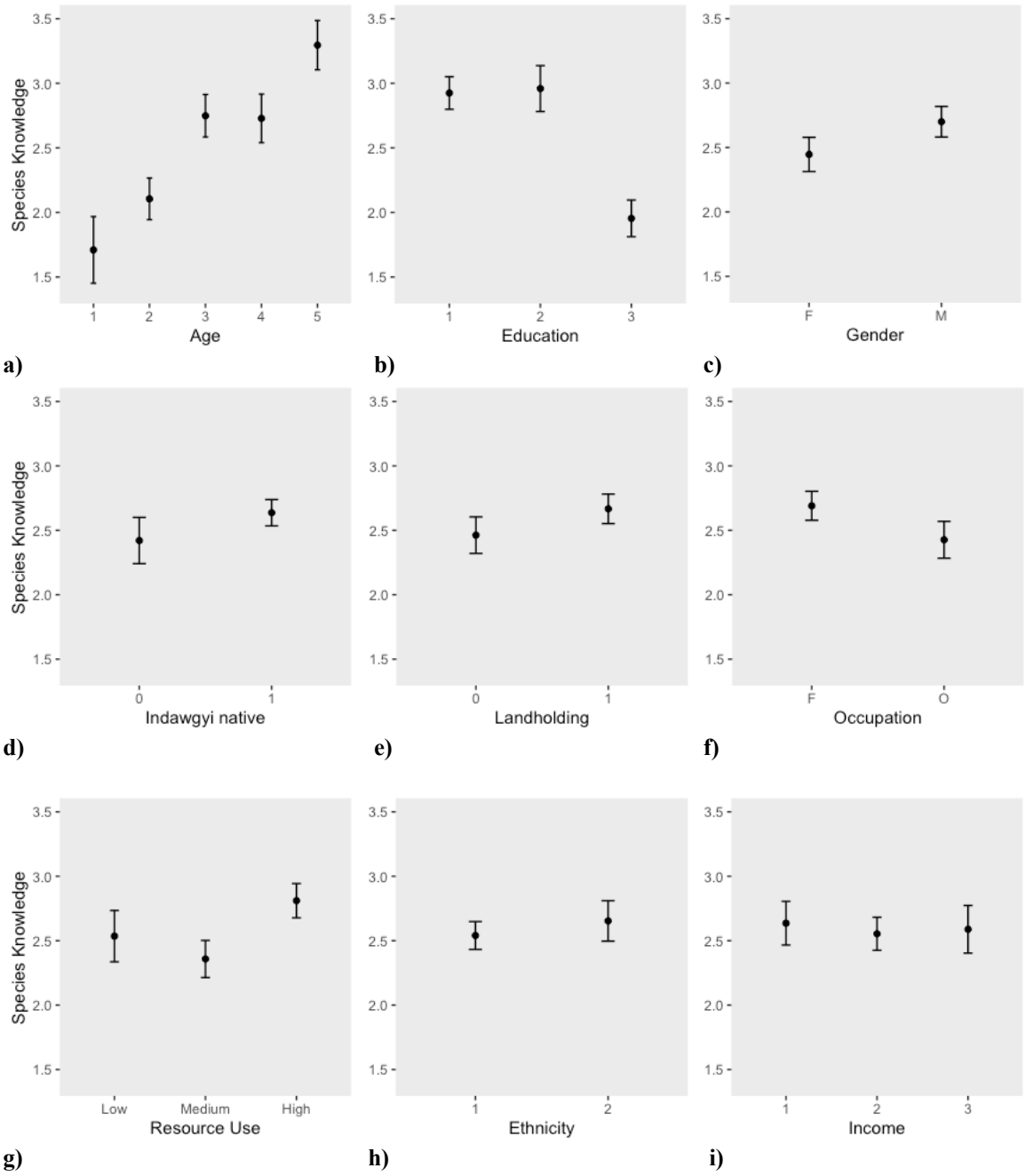

Figure 3. Mean score values (±SE) for the local knowledge of chelonian species at Indawgyi across demographic factors: a) age, b) education (1=no formal education/ primary education, 2=middle school, 3=high school or college/ university), c) gender, d) origin (0=migrant, 1=Indawgyi native), e) landholding status (0=non-landowner, 1=landowner), f) occupation (F=farmers, O=other occupations), g) natural resource use (1=low, 2=medium, 3=high resource use), h) ethnicity (1=Shan-ni, 2=other ethnicities), i) income (1=MMK 0-40,000,-, 2= MMK 40,000-80,000,-, 3= above MMK 80,000,- per month).

Farmers seemed to score higher than other occupations (Figure 3 f), but again, the difference was not significant (χ^2=4.65, df=3, P=0.19). However, due to merging a number of different occupations into one group, some information was inevitably lost. The amount of resources harvested from nature appeared to have some effect on the species knowledge, with the high resource use group scoring highest (Figure 3 g), but the differences were not significant (χ^2=9.97, df=6, P=0.13). The largest ethnic group at Indawgyi (Shan), did not differ much from the other ethnicities (χ^2=4.64, df=3, P=0.20) (Figure 3 h), but, as in the case of occupation, some information was probably lost by merging all the other ethnicities into one group. Finally, the differences in species knowledge between the three income level groups were not significant (χ^2=2.94, df=6, P=0.82), (Figure 3 i).

Linear mixed effects models were used to examine more closely the combined effects of the demographic factors on the local knowledge of species. Using random intercept for village, models of various complexities were fitted with different configurations and interactions of the demographic variables to find the optimal fixed effects structure. The best model for the data, based on the AICc score (Table A1, Appendix), included fixed effects of age (in years), education, respondent's origin (migrant/ Indawgyi native) and income (in MMK 1,000):

$$\text{Species knowledge} \sim \text{Age} + \text{Education} + \text{Origin} + \text{Income} + (1|\ \text{Village}) \quad (1)$$

The next best model (Δ AICc=0.75), in addition to all the fixed effects in the best model, included the effect of ethnicity. However, after analyzing both models, the effect of ethnicity turned out to be non-significant, and the simpler model was selected based on lower AICc value and on the principle of parsimony. The summary of the final model is presented in Table 2 and model assumptions plots can be found in the Appendix.

There was a small positive effect of age on the species knowledge, with each additional year of age being associated with an increase in the knowledge by 0.03 points (±0.007). Higher education had a substantial negative effect on species knowledge. Particularly, moving from the no formal/primary education group (Education 1), to the high school/university group (Education 3), was associated with a decrease of species knowledge by 0.64 points (±0.20), whereas there was no significant difference between the primary and the middle school education groups (95% CI: [-0.26, 0.59]). Respondents that were born at Indawgyi had higher

species knowledge than migrants, with an increase of 0.42 points (±0.18) for Indawgyi natives compared to newcomers. Finally, there was a small positive effect of income on the species knowledge, with an increase of 0.0015 points (±0.001) for each additional MMK 1,000 per month (Table 2).

Table 2. Parameter estimates with 95% confidence intervals from a mixed effects model for local knowledge of turtle species at IWS, across different demographic and socio-economic variables. Estimates for Education 2 (middle school) and Education 3 (high school/college) are given as contrasts to Education 1 (none/primary education); estimate for Indawgyi native is given as difference to migrant.

		Estimate	95% CI, lower	95% CI, upper
Random effects:	SD Village	0.13	0.00	0.36
	SD Residual	1.17	1.06	1.28
Fixed effects:	Intercept	1.27	0.50	2.02
	Age (years)	0.03	0.01	0.04
	Education 2	0.16	-0.26	0.59
	Education 3	-0.64	-1.04	-0.24
	Indawgyi native	0.42	0.06	0.77
	Income	0.0015	0.00001	0.003

Environmental awareness

Only 3% of respondents were classified as having low ecological awareness (scoring 1 point). Most of the respondents, 61%, had average awareness (2 points) and 36% of the respondents were evaluated as having high ecological awareness (3 points).

There was a weak positive correlation between the species knowledge and the general environmental awareness of the respondents ($r = 0.28$, $P<0.0001$). Thus, I wanted to examine whether there were similarities between the demographic factors' effects on species knowledge and environmental awareness.

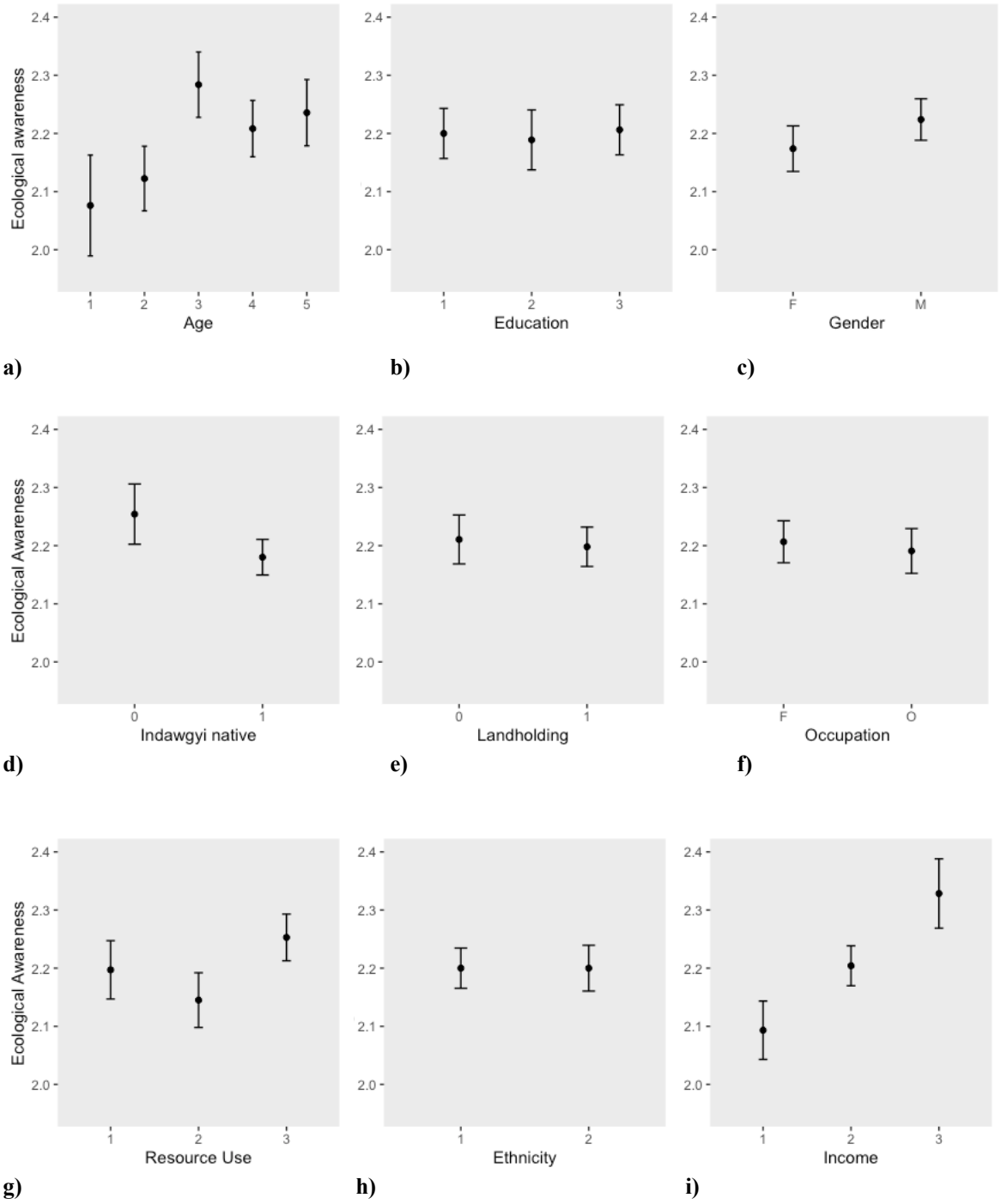

Figure 4. Mean score values (±SE) for general ecological awareness at IWS across demographic factors: a) age, b) education (1=no formal education/ primary education, 2=middle school, 3=high school or college/ university), c) gender, d) origin (0=migrant, 1=Indawgyi native), e) landholding status (0=non-landowner, 1=landowner), f) occupation (F=farmers, O=other occupations), g) natural resource use (1=low, 2=medium, 3=high resource use), h) ethnicity (1=Shan-ni, 2=other ethnicities), i) income (1=MMK 0-40,000,-, 2= MMK 40,000-80,000,-, 3= above MMK 80,000,- per month).

Age appeared to have an effect on the environmental awareness (Figure 4a), with older respondents scoring a little higher than the youngest, but the differences were not significant

(χ^2=10.77, df=8, P=0.21). Moreover, contrary to the species knowledge, there were no differences in ecological awareness related to education (χ^2=1.39, df=4, P=0.85) (Figure 4b). Men scored slightly higher than women (Figure 4c) but the difference was not significant (χ^2=2.12, df=2, P=0.35). Furthermore, there were no significant differences in environmental awareness based on respondents' origin (χ^2=3.37, df=2, P=0.19), (Figure 4d); landholding status (χ^2=2.09, df=2, P=0.35), (Figure 4e); occupation (χ^2=0.72, df=2, P=0.69), (Figure 4f); resource use (χ^2=3.64, df=4, P=0.46), (Figure 4g); or ethnicity (χ^2=1.64, df=2, P=0.44), (Figure 4h). Finally, there were significant differences in environmental awareness between the different income groups (χ^2=14.70, df=4, P=0.005), with higher awareness scores for groups with higher income (Figure 4i).

Mixed effects models with random intercept for village, and different configurations of demographic factors, were fitted to analyze the effects of demographic variables on the general ecological awareness. Model selection process, based on the AICc score (Table A2, Appendix), resulted in the best model including fixed effects of age and income:

$$\text{Environmental awareness} \sim \text{Age} + \text{Income} + (1|\ \text{Village}) \qquad (2)$$

The effect of age, although significant, was small, with an estimated increase in awareness of 0.0004 (± 0.0017) for each additional year of age (Table 3). On the other hand, the effect of income, with an estimated increase of 0.0004 (± 0.0002) for each additional MMK 1,000,- was not significant with 95% CI: [-0.00005, 0.0009].

Table 3. Parameter estimates with 95% confidence intervals from a mixed effects model for ecological awareness against the respondents' age and monthly income.

		Estimate	**95% CI, lower**	**95% CI, upper**
Random effects:	SD Village	0.18	0.10	0.30
	SD Residual	0.34	0.31	0.37
Fixed effects:	Intercept	2.00	1.81	2.19
	Age (years)	0.004	0.0007	0.0074
	Income	0.0004	-0.00005	0.0009

PROTECTED AREA AND LOCAL ATTITUDES TO CONSERVATION WORK AT IWS

PA awareness.

As a UNESCO Biosphere Reserve, IWS consists of three types of zones where different degrees of human activity are regulated. The majority of the respondents (94%) were familiar with the PA and knew about the restrictions. Only 6% of the respondents claimed that they were not aware of the PA around Indawgyi. However, eight of those respondents (out of the total fourteen that did not know about the PA) were from Ma Pyin village, located more than four kilometers away from the PA boundary. The majority of respondents (56%) learned about the PA directly from the park authorities. Others found out about it from neighbors or village headman (35%), notice boards (10%), and via other channels- school, local conservation groups and NGOs, internet and TV (4%). Of those that knew about the PA, 95% answered that fish and timber were restricted within the core zones, 92% mentioned birds, 88% firewood and only 14% named other wild animals (including turtles). Furthermore, 8% mentioned that cultivation of crops was not allowed in the PA, and one person (0.5%) said that harvesting of plants and mushrooms was restricted in the PA (Figure 5).

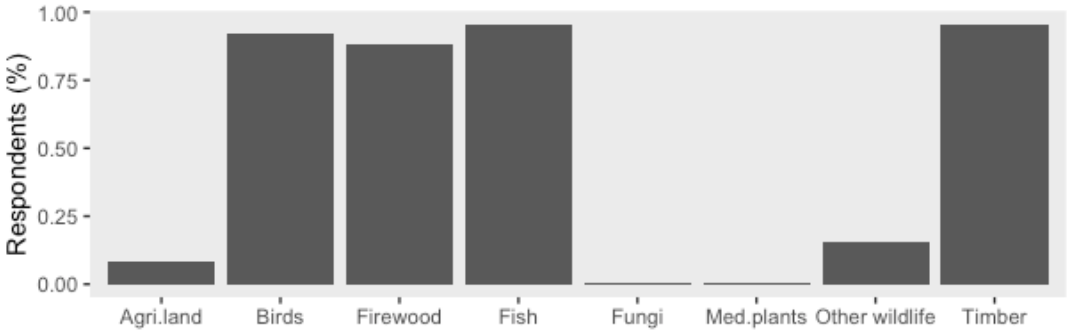

Figure 5. Summary of respondents' answers regarding restricted resources in the PA (N=206).

Reasons for establishing of PA and attitudes to nature conservation.

When asked about the main reasons for the establishing of the PA and the restrictions on the natural resources in the sanctuary, 51% of the respondents answered that biodiversity conservation and nature recovery were the most important factors. 41% thought that the restrictions were introduced in order to halt the overexploitation of natural resources, 6% mentioned preservation of natural resources for future generations, and 1% answered that the

restrictions were imposed because of an outside demand. 19% could not think of any reasons why the PA was established (Figure 6).

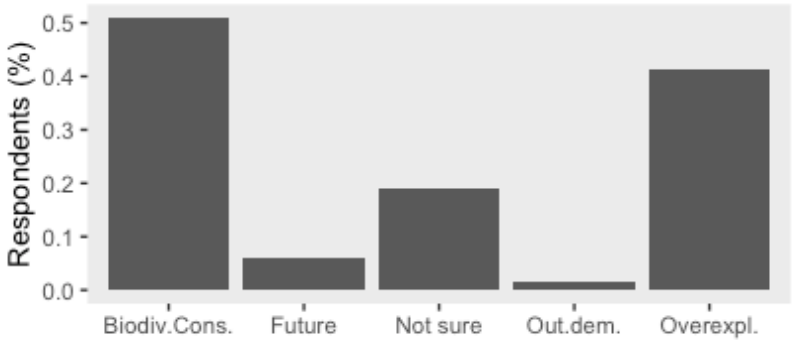

Figure 6. Respondents' (N=220) perceptions of the reasons behind establishing protected area at Indawgyi (Biodiv.Cons.= biodiversity conservation, Future=future generations, Out.dem= outside demand, Overexpl.=overexploitation).

Even though 19% of respondents did not know the reasons for the establishment of PA at Indawgyi, all the respondents acknowledged that nature conservation was necessary. The majority of respondents (56%) declared that conservation was important because of the ecosystem services (nature's benefits) that nature provided to people. The economic benefits people could get from nature, as well as mitigation of climate change were named by 13%. The cultural and spiritual aspects of nature were emphasized by 9% of respondents. Others mentioned preservation of nature for future generations (4.5%) and a sense of responsibility (stewardship) for nature at Indawgyi (3%). There were a few respondents (2%) that could not think any particular reason why conservation was necessary, even though they felt that it was important (Figure 7).

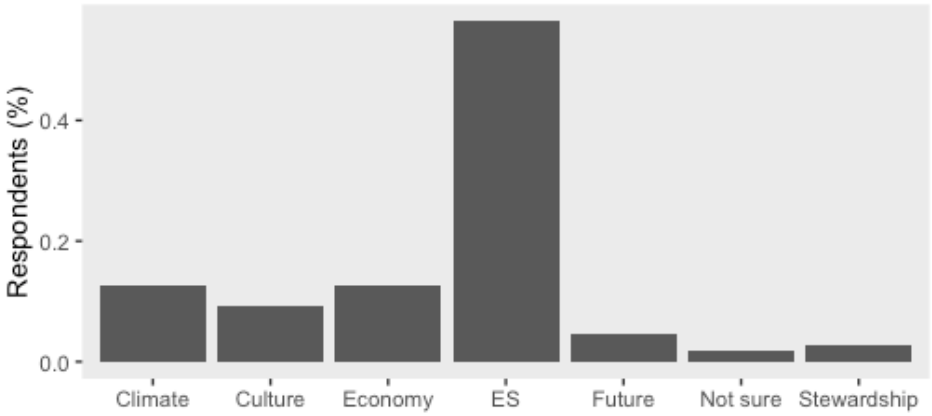

Figure 7. Summary of the respondents' (N=220) perceptions of the most important reasons for nature conservation at IWS (Climate=climate change mitigation, Culture= nature's cultural and spiritual values, Economy=natural resources' economic value, ES=ecosystem services, Future=future generations, Stewardship=feeling of responsibility and care for nature).

Compliance with the PA regulations

Regardless of the positive attitudes to nature conservation, only 10% of the respondents answered that the regulations within the PA were respected by the local community. 14.5% claimed that the restrictions were only respected by those who could afford to buy necessary food, fuel and building materials, whereas the poorest community members had no choice, but to exploit the resources within the PA for subsistence. 70% answered that the restrictions within the PA were not respected at all. 5.5% of respondents did not know (Figure 8).

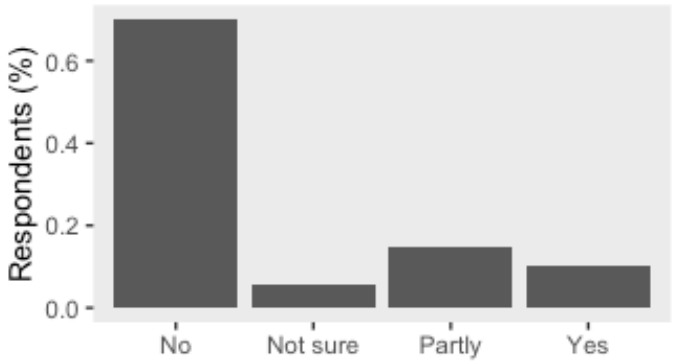

Figure 8. Summary of the respondents' (N=220) assessment of local community's compliance with the PA restrictions.

The responses were similar across the villages in different parts of the lake, with over 50% respondents in each village claiming that the PA rules were not respected, with the exception of the already mentioned Ma Pyin village located outside of the PA, where a larger number of the respondents did not know about the PA and therefore were not sure whether the rules were respected (Table 4).

Generalized mixed effects model was fitted to examine whether there was an association between the demographic variables and the respondents' view on compliance with the PA rules. Respect of PA rules was modelled as a binary response variable, the "not sure" (N=12) answers were removed, and "PA rules are partly respected" answers were treated as "not respected". Models with different configurations of demographic factors (fixed effects) with addition of random intercept for village, were tested. Model selection process resulted in eight essentially equivalent models (Δ AICc<2). All of these models included only one of the considered demographic variables, with the best model (lowest AICc) including the fixed effect of the respondent's origin (Table A3, Appendix). After checking the parameter estimates for the top models, however, neither the respondent origin in the best model, nor any of the other demographic variables in the remaining models, had significant effect on the respondents'

opinion on local compliance with the PA rules. Consequently, further analysis of these models was not pursued.

Table 4. Respondents' assessment of local community's compliance with the PA regulations in ten villages at Indawgyi. The question was: "Are the PA regulations respected by the local people?" and the answers are summarized in the number of respondents and percentage (in the parentheses) for each village.

Village	Yes	No	Partly	Not sure
Chaung Wa	0 (0)	17 (77)	4 (18)	1 (10)
Hepu	2 (10)	12 (55)	8 (36)	0 (0)
Kone Ma Na	5 (23)	15 (68)	2 (10)	0 (0)
Lon Sant	2 (10)	19 (86)	0 (0)	1 (10)
Ma Mon Kaing	3 (14)	16 (73)	3 (14)	0 (0)
Ma Pyin	3 (14)	9 (41)	2 (10)	8 (36)
Nam Mee Laung	0 (0)	20 (91)	2 (10)	0 (0)
Nam Pa Te	0 (0)	15 (68)	5 (23)	2 (10)
Nyaung Bin	3 (14)	18 (82)	1 (10)	0 (0)
Shwe Let Pan	4 (18)	13 (59)	5 (23)	0 (0)
Total:	**22 (10%)**	**154 (70%)**	**32 (14.5%)**	**12 (5.5%)**

At the end of each interview the respondents were asked if there was anything that could be provided to the local community at IWS to ensure local people's respect of the rules within the PA. Improved healthcare was named by 38% of the respondents, claiming that it was expensive and time consuming to get even the most basic medical help, with the most villages lacking medical facilities and staff. Improved infrastructure came next, with 21% claiming that reliable and affordable electricity and improved roads would provide adequate compensation for the restrictions within the PA. Another factor rated as important was education, with 20% of the respondents claiming that it was essential for the whole community and wishing for more support and accessibility to education for the youth at Indawgyi. 13% claimed that creating alternative livelihoods opportunities was needed to ensure that people respected the regulations. Only 11% answered that direct financial compensation or access to cheap loans could provide the solution. 6% of respondents, mostly in villages were farmers lost the right to cultivate crops in areas that they had used traditionally, declared that the only way for the people to respect the PA regulations, was to get their customary tenure rights recognized by authorities. 4% of respondents claimed that access to modern technology for processing of the agricultural

products, as well as irrigation system for the rice paddies, currently completely reliant on rainwater, would help to take the pressure off the natural resources at IWS (Figure 9).

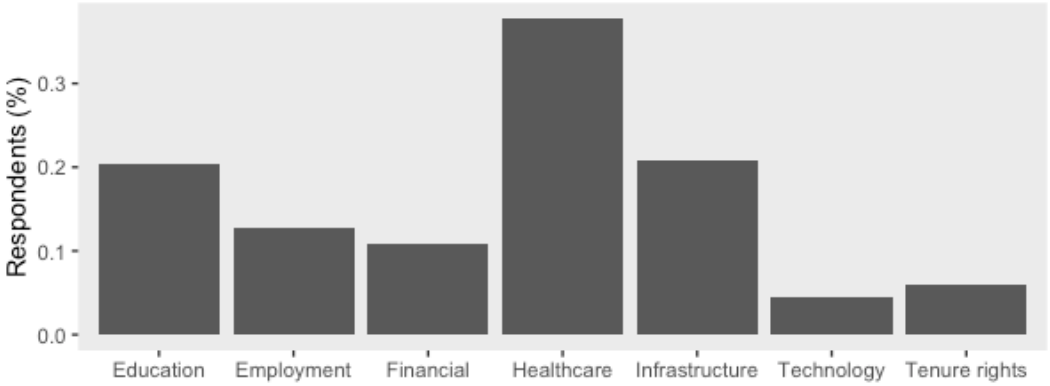

Figure 9. Summary of the respondents' (N=220) views of what could help to improve compliance with the rules and regulations at IWS.

STATUS OF TURTLES AT IWS

An overview of the status of five threatened turtles and tortoises at IWS was compiled, based on the interviews (Table 4). Information collected from the respondents appears to be reflective of the general situation of these species in Southeast Asia.

A. cartilaginea was recognized by 69% of respondents and 99% of them claimed that the lake was the main habitat of the species. According to the majority of respondents the numbers of the turtles were low and decreasing, with the main drivers of decline including local exploitation (claimed by 62%), foreign demand (31%), and bycatch (25%). The turtles are collected (reported by 89% of those familiar with the species) mostly for direct consumption (reported by 77%). The softshell turtle meat was considered a delicacy by many of the respondents. Furthermore, 75% reported that the eggs were collected and consumed as well.

Cuora amboinensis lineata was the least recognized, with 60% respondents reporting they were familiar with the species. However, 96% of those who claimed to have recognized the species, reported forests to be its main habitat, which is incorrect based on the background literature (see species information in methods and references therein), and that was, therefore, evaluated as incorrect for the species knowledge analyses. The only forested areas around Indawgyi today are located on the hills surrounding the lake, and the lowland swamp forests, that once surrounded the lake, have been converted to rice paddies long time ago. It is possible that the images of *C. amboinensis* were confused with a more common, Asian leaf turtle (*Cyclemys*

dentata), that normally inhabits lowland swamps and rivers, but has also been found in hill streams at lower elevations (Das, 2015).

Table 5. Information on turtle species: *Amyda cartilaginea, Cuora amboinensis lineata, Indotestudo elongata, Manouria emys and Nilssonia formosa*, collected using questionnaires at IWS. Recognized indicates the proportion of respondents who claimed they recognized the species from the photographs. Information related to habitat, population trend, drivers of decline and harvesting practices for each species is summarized as proportion (%) of the respondents that had recognized the species.

	SPECIES:	***Amyda cartilaginea***	***Cuora amboinensis***	***Indotestudo elongata***	***Manouria emys***	***Nilssonia formosa***
RECOGNIZED:		69%	60%	73%	67%	65.5%
HABITAT:	**Forest**		96%	98%	100%	0.5%
	Lake, swamp	99%	3%			99.5%
	Rice paddies			1.3%		
	River	1%	1%	0.7%		
FREQUENCY OF OBSERVATIONS	**Every day**					
	Once a week	1%		0.5%		1.5%
	Once a month	5%	2%	2%	2%	5.5%
	Rarely	94%	98%	97.5%	98%	93%
POPULATION TREND:	**Decreasing**	91%	92%	95%	94%	92%
	No change	4.5%	6%	4.5%	5.5%	3%
	Increasing	4.5%	1%	0.5%	0.5%	5%
MAIN DRIVERS OF DECLINE:	**Natural variation**	2.5%	1.5%	2%	2%	3.5%
	Distribution shift	2%	2%	2%	3%	1%
	Bycatch	25%				30%
	Habitat loss	9%	17.5%	19%	20%	10%
	Local Exploitation	62%	60%	66%	67%	60%
	Foreign demand	31%	30%	23%	18%	26%
	Pollution	1.3%	0.5%			1.5%
	Climate change	0.5%				1%
	Pet trade	0.5%		1%		
HARVESTING PRACTICES:	**Animals collected**	89%	85%	88%	89%	91%
	Animals consumed	77%	73%	76%	79%	75%
	Eggs collected	75%	70%	71%	71%	77%

Indotestudo elongata was the most recognized species (73% of respondents). The typical habitat, supported by 98% of those who were familiar with the species, are the deciduous and evergreen forests covering the uplands around the lake. 97.5% claimed that *I. elongata* is rare at Indawgyi, and 95% maintained that the numbers were declining due to local exploitation (66%), foreign demand (23%) and habitat loss (19%). The tortoises are collected (reported by 88%), mostly for food (76%), so are their eggs (71%).

Manouria emys was recognized by 67% of respondents and it was described as typical forest species (by 100% of those who were familiar with the species). Most of the respondents (98%) said the tortoises were rarely encountered and their numbers were decreasing (declared by 94%), mainly as a result of local exploitation (67%), habitat loss (20%) and foreign demand (18%). The tortoises are collected (89%) and consumed locally (79%) and their eggs are collected as food (confirmed by 71%).

The Myanmar endemic *Nilssonia formosa*, recognized by 65.5%, was reported by 99.5% to be an aquatic species, inhabiting the lake. The species was evaluated as rare by 93%, whereas 5.5%, mostly fishers, suggested that they were quite common. Furthermore, 92% of those who recognized it claimed that its numbers were decreasing, with the main culprits including local exploitation (reported by 60%), bycatch (30%), foreign demand (26%) and habitat loss (10%). 91% of those familiar with the species reported that it was collected, and 75% claimed that direct consumption was the main purpose for the harvesting. As in the case of *A. cartilaginea*, *N. formosa* is a softshell turtle, and is considered a delicacy. The eggs were reported to be collected as food by 77%.

Finally, I wanted to examine whether there were differences in abundances of the turtles in different parts of the sanctuary. Based on the number of recognized species in the different zones around the lake (S, W, NW, N and E), the northern and eastern parts appeared to have generally more sightings of turtles compared with the southern, western and north-western parts (Figure 10), and the differences in the total number of the reported sightings between the different parts were significant (χ^2=32.526, df=16, P=0.009). However, looking at the reported sightings of each species individually, the differences in the number of sightings between the zones were only significant for two species, *I. elongata* (χ^2=12.60, df=4, P=0.013) and *N. formosa* (χ^2=16.18, df=4, P=0.003).

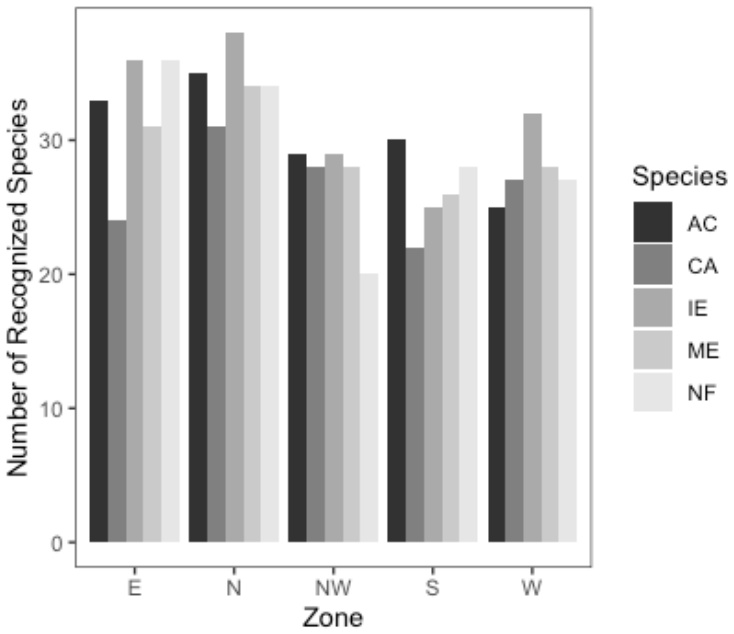

Figure 10. Summary of the sightings of five turtle species (AC= *Amyda cartilaginea*, CA= *Cuora amboinensis*, IE= *Indotestudo elongata*, ME= *Manouria emys*, NF= *Nilssonia formosa*) in different areas of the IWS, based on 44 observers (respondents) in each area.

DISCUSSION

Local ecological knowledge at Indawgyi

The first objective of this study was to evaluate the local ecological knowledge at IWS, based on information collected during the interviews. Two dimensions of LEK were examined- local knowledge of five globally threatened turtles occurring at IWS, and the more general environmental awareness of the respondents. The results indicate that the majority of the local people at Indawgyi have an adequate knowledge of the local species, with nearly 50% of respondents considered to have moderate, and 30% exhibiting good species knowledge. This corresponds to the findings of other studies, that suggested, that local and indigenous communities in different parts of the world tend to have accurate knowledge about the local biota, ecosystems and environmental processes (Huntington, 2000; Riseth et al., 2011; Mmassy & Røskaft, 2013; Padmanaba et al., 2013; Ziembicki, Woinarski & Mackey, 2013; Mmassy & Røskaft, 2014; Turvey et al., 2014). However, most LEK research suggests that there are disparities in the levels of knowledge, not only between individuals, but also between groups with different demographic, socio-economic and resource use characteristics (Voeks & Leony, 2004; Gilchrist, Mallory & Merkel, 2005; Mmassy & Røskaft, 2013; Mmassy & Røskaft, 2014;

Turvey et al., 2014). This has implications for the selection of potential informants, meaning that the most knowledgeable groups in the community should be identified to be able to select the "experts", or that sufficient number of respondents must be interviewed to ensure the reliability of the information collected (Davis & Wagner, 2003; Gilchrist, Mallory & Merkel, 2005; Hamilton, de Mitcheson & Aguilar-Perera, 2012). Species knowledge at Indawgyi increased with age, decreased for people with high school and university education, people born at Indawgyi had better knowledge compared to immigrants, and the there was also a tiny positive influence of income. I did not find any effects of gender, ethnicity, occupation, natural resource use or landholding status on the species knowledge. Education was an important predictor of species knowledge, with respondents that attended high school and college education exhibiting the poorest knowledge of the turtles. This is consistent with the findings of other studies, that found significant differences in species knowledge for different levels of education. For example, Voeks & Leony (2004) found that higher education was associated with an evident decrease in the local knowledge of medicinal plants in Brazil, and Wester and Yongvanit (1995) found the same to be true for food plants in Thailand. However, studies investigating local knowledge of birds in Tanzania (Mmassy & Røskaft, 2013; Mmassy & Røskaft, 2014), did not detect any differences between people with varying levels of education, indicating an efficient transfer of species knowledge within the community, which was likely a result of a high traditional or subsistence importance of these birds for local communities. This is clearly not the case with the turtles at IWS, where they are more likely just a supplementary addition to the local diets or an opportunity to earn extra money by selling the animals at local markets, or to a trader. It does not appear that the turtles have particularly high cultural value to the local people, except an occasional religious release into temple ponds during Buddhist ceremonies (van Dijk et al., 2000; Kuchling et al., 2004). All things considered, it can be expected that people who spend long time at school, often requiring to leave home for extended periods, would have less time to involve in farming, hunting or gathering and consequently, their knowledge of the local species would be deficient.

Age was another factor that had a significant effect on species knowledge. This is not surprising, as given a longer time at a particular place, there are more opportunities for exploring the area and encounters with local species. The effect of age was also found for the knowledge of different bird species in Tanzania (Mmassy and Røskaft, 2013), LEK of the giant salamanders in China (Pan et al., 2016), LEK of plants in Thailand (Wester & Yongvanit, 1995), as well as for LEK in tropical fisheries (Hamilton, de Mitcheson & Aguilar-Perera; 2012). However,

Mmassy and Røskaft (2014), who evaluated LEK based on one species of bird in Tanzania, did not find association between the age of the respondents and their knowledge of the species. Moreover, Davis & Wagner (2003), who based their assessment of local fish experts in Nova Scotia on a peer-referenced identification process, found that retired fishers were not considered to be the most knowledgeable within their communities. Thus, even though age was positively associated with species knowledge at IWS, the effect of age should be considered individually for different regions, species, and resource user groups, instead of simply assuming that the elders are the local knowledge repositories in all communities. The differences in species knowledge between older and younger respondents, with people over 56 exhibiting largely a good knowledge of the turtles, whereas very few younger respondents had any species knowledge at all, could also be an important indicator of substantial declines of the turtle populations at Indawgyi in recent decades, resulting in decreasing opportunities for encounters with the species by younger people.

People who were born at Indawgyi were shown to have better species knowledge compared to the newcomers. As in the case of the age, longer time of residence at Indawgyi could certainly be expected to increase the knowledge of the local species. Additionally, since some of the internal migrants in the area came from distant parts of Myanmar (e.g. Inle Lake), which are likely to have different chelonian fauna, their knowledge of the local turtles would naturally be limited. This corroborates the results of Turvey et al. (2014) who found differences in species knowledge between native residents and newcomers, and to some extent, the results of Wester & Yongvanit (1995), who found that the degree of mobility of a person had a significant impact on the knowledge of local plant species- with the knowledge decreasing for people who travelled most.

Income, determined as the total household earnings divided by the number of people living in the household (but without establishing more general wealth of the household, including standard of the house, appliances, or vehicles), was found to have a small positive effect on the species knowledge. It is difficult to explain this association. It could be speculated, that those who are most involved in the exploitation of the wild species, can gain economic benefits by selling the animals to traders. Thus, the knowledge of the species gained by their harvesting could be linked with higher income. However, it may well be that the most knowledgeable and resourceful individuals could simply be more capable of earning a living. All the same, my results are in contrast to other research, that found increasing wealth, usually associated with

decreasing dependence on the natural resources, to have a negative impact on the ecological knowledge (Wester & Yongvanit, 1995; Pilgrim et al., 2008), or that income had no effect on the local knowledge at all (Voeks & Leony, 2004). Thus, the marginal effect of income, suggested by my results, could probably be disregarded.

I did not find any significant differences in the knowledge of species between men and women, which contradicts much of the LEK research. For instance, the knowledge of food- and medicinal plants was found to be clearly women's domain by studies conducted in Asia (Wester & Yongvanit, 1995) and South America (Voeks & Leony, 2004), whereas in the African savannah, men had much better knowledge of birds than women, as men had traditionally hunted the birds in that region (Mmassy and Røskaft, 2013; Mmassy and Røskaft, 2014). Although several respondents mentioned that the forest turtles at IWS are hunted by men with specially trained dogs, which is widely practiced both in Myanmar and other places in Southeast Asia (Platt et al., 2000; van Dijk et al., 2000), a lot of the harvesting is probably opportunistic, done by both men and women, for example, while gathering NTFP. Consequently, all those using the forest have equal chances of encountering the species, rendering the gender related differences in species knowledge non-significant. That should be considered in the potential turtle protection and other conservation projects at IWS, to ensure equal involvement of men and women.

There was no effect of ethnicity on the species knowledge at IWS, contradicting other studies (Mmassy and Røskaft, 2013; Mmassy and Røskaft, 2014; Turvey et al., 2014), that detected significant differences in LEK based on ethnicity, largely related to different ways of living and using nature. The random sampling design of my study, even though helpful in acquiring the representative proportions of the ethnicities present in the surveyed villages, was not suitable to obtain sufficient number of representatives from the different ethnicities for the analyses. In particular, the Kachin people were hugely underrepresented with only one respondent. Consequently, combining the different ethnic groups for the analyses may have obscured the differences linked to ethnicity.

Studies of LEK often emphasize the significance of local practices and dependence on natural resources for the quality of local knowledge (Gilchrist, Mallory & Merkel, 2005; Hamilton, de Mitcheson & Aguilar-Perera, 2012). However, the methods I used did not detect any significant effects of occupation, resource use level, or landholding status on the knowledge of turtles. In the case of occupation, such effects were probably disguised due to the merging of many

different occupation groups into one, due to small sample sizes- as was the case for ethnicity. Furthermore, the accuracy of the resource use level variable is somewhat uncertain, as some of the respondents may have not given completely honest answers as to how many natural resources they extracted. Particularly, the number of people that admitted to hunting and collecting wild animals was low. With this kind of surveys, however, especially considering people admitting to involvement in potentially illicit practices, it cannot be excluded that some respondents might provide misleading information (Hamilton, de Mitcheson & Aguilar-Perera, 2012). Consequently, the actual differences in species knowledge between people with differing resource use levels could not be detected by the analyses.

Environmental awareness, which is crucial for understanding the importance of healthy ecosystems to human wellbeing, was shown to be fairly good at IWS. Only 3% of the respondents were considered to have low environmental awareness, whereas 36% had high awareness scores. Since there was some positive correlation between the species knowledge and the general environmental awareness, it was interesting to compare the most important factors that influenced these two aspects of LEK. As shown, the demographic factors did not have much influence on the environmental awareness. Significant differences between people with different income levels were only detected when analyzing the demographic factors individually and again, in contrast to the findings of other studies (Wester & Yongvanit, 1995; Pilgrim et al., 2008), there was a positive effect of income. However, by analyzing the combined effects of different demographic factors on environmental awareness, using linear mixed effects models, only a minimal positive effect of age was detected, whereas the effect of income was non-significant. Thus, there was not much disparity in environmental awareness between the different demographic groups at Indawgyi, in contrast to the knowledge of species, that was associated with a number of significant differences. It is therefore conceivable, that formal education, with strong negative effect on the species knowledge, helps to balance out the differences in the level of environmental awareness between people with high versus those with low education. Environmental awareness may then be achieved both by traditional use of nature and by formal education. This is clearly not the case for species knowledge, due to the very practical nature of this type of knowledge, that is not only not being taught at school, but also requires a longer experience in exploring and using nature. However, introducing elements of local fauna and flora into formal education at Indawgyi, and involving local youth in the monitoring activities, could help to improve the species knowledge for those who dedicate more time to education. That could be advantageous for boosting the awareness of the local

environment and developing a sense of place, ultimately contributing to improved protection of the local species (Danielsen et al., 2007; Ballard, Dixon & Harris, 2017; McKinley et al., 2017).

All things considered, the overall level of LEK at IWS presents an opportunity for local participation in various conservation activities, such as monitoring or providing species information via surveys. Hopefully, the results of this study can provide some guidance with regard to identifying the most knowledgeable groups of the community that could be involved in such conservation projects.

Local views on biodiversity conservation at IWS

It appears that most people at IWS are aware of the PA and the restrictions, with only a small percentage of respondents who claimed that they had never heard of the PA. Park authorities seemed to be the main provider of the information regarding the PA, as almost 60 % of respondents claimed that this was how they had found out about it. Thus, even with limited manpower, consisting of only eighteen employees (McInnes et al., 2016), the park staff at IWS manage to reach many local people directly.

The majority of respondents understood that the restrictions on the natural resources were enforced in order to protect the biodiversity and to mitigate the continuing overexploitation. However, almost 20% answered they did not know the reasons behind the restrictions. Furthermore, only a few respondents mentioned that hunting and collecting wild animals was restricted within the PA (except fish and birds that were mentioned by the majority). This could indicate that animals other than birds and fish have not been traditionally targeted by hunters in this area. Alternatively, since a lot of the original fauna at Indawgyi has likely been extirpated, there may be so few wild animals left, that it is no longer lucrative to hunt them. Consequently, the respondents may have assumed, that it was unnecessary to mention restrictions on harvesting animals that no longer were there.

Local attitudes to biodiversity conservation at IWS were very positive, with 100% of respondents acknowledging the necessity of conservation work. Maintaining nature's benefits to people (ecosystem services) appeared to be the most important reason for conservation, followed by climate change mitigation and economic benefits from selling natural products. Certainly, positive views on conservation alone are not enough to guarantee sustainable practices, but stewardship attitudes could be an important step in the right direction. However,

a number of respondents reported troubled relationship between the villagers and the PA staff. We were told about unfair treatment by the park authorities, with unequitable consequences for different groups of people, confiscation of fishing gear needed for subsistence, or lack of proper compensation for lost access to agricultural land. Additionally, many respondents felt that they were being excluded from important decision-making processes linked tightly to their livelihoods. Such dynamics in the relations between park employees and local community are a common issue in many PAs, but improved relations could surely benefit both the local community and the PA (Allendorf et al., 2006; Stern, 2008; Kubo & Supriyanto, 2010). Furthermore, some respondents mentioned large scale logging activities they had observed during the dry season, with the PA staff allegedly selling access to illegal loggers. However, the corruption and the illegal logging at IWS may now be a thing of the past, as suggested in a conservation news article by Crane (2016).

Local compliance with the PA rules

Regardless of the overall positive attitudes to conservation at Indawgyi, the majority of the respondents declared that the rules of the PA were not respected, with 70% claiming that the rules were not respected at all, and 14.5% claiming that the rules were only respected by wealthier people. I wanted to find out if the demographic factors could help explaining the lacking compliance at IWS. It was particularly interesting to examine whether there was an association between the respondents' income and resource use, and their views on compliance. I used generalized linear mixed effects model, with the compliance modelled as a binary response variable. Different configurations of the demographic factors were analyzed to find the best models. However, the results of the analysis were rather inconclusive, pointing to eight equivalent models, none of which included significant effects of any of the demographic variables. The way the question about compliance was formulated may have been partly responsible for these results. Trying to avoid misleading answers, I asked whether the PA rules were respected, instead of asking the respondents directly whether they respected the rules. Thus, the answers may have not been entirely reflective of the respondents' practices within the PA, leading to ambiguous results. It is also possible that the aforementioned issues with establishing the actual resource use and income of the respondents contributed to misleading results. Nevertheless, other factors might be equally, or even more important for the local compliance than the demographic factors (Allendorf et al., 2006). Studies investigating the effectiveness of the PAs usually emphasize the importance of relationship between local people and park authorities. Local compliance is to a high degree dependent on local people perceiving

the PA management decisions and regulations as credible. Good park-people relations might help to achieve more compliance, by improving people's perceptions of legitimacy of the PA rules (Viteri & Chávez, 2007; Stern, 2008; Kubo & Supriyanto, 2010; Andrade & Rhodes, 2012). Thus, again, the problematic relationship between the local people and the park staff at IWS, combined with high proportion of respondents claiming that the PA rules are not respected, are worrying and require urgent attention. The PA authorities should strive to improve the dialogue with the local community, find ways of communicating the benefits of conservation to local livelihoods and try to involve the local people in the decision-making processes. As long as the ownership to the conservation work is lacking and people do not perceive the PA officials and their decisions as legitimate, the effectiveness of the PA management could be destined for failure.

At the end of each interview, the respondents were asked if there was anything that could be provided to the local community to improve the compliance with the PA regulations. Accessible and affordable healthcare appeared to be the most desirable, followed by education and improved infrastructure. Poor access to healthcare applies to all the residents at Indawgyi. Most villages have only small clinics with rudimental facilities, limited opening hours and hardly any medical staff. Some villages have better facilities than others, and the distances are not long between the villages. However, the bad condition of the roads, especially during the wet season, can make it logistically and economically challenging in terms of transporting sick individuals, and for the doctors to get to the patients. Access to healthcare is a serious issue in most of the developing world and providing affordable healthcare to residents adjacent to PAs might help improving local compliance (Chapman et al., 2015). Education was another important issue for the people at Indawgyi. With 30% of respondents that completed high school, only 7% with university education, and 12% without any formal education, it is understandable that the people at Indawgyi wish for accessible and cheap education, in order to improve young people's outlooks for the future. Finally, improved standard of the roads and more stable power supply, would surely help to make the everyday lives of the whole community around IWS much easier.

Status of turtles at IWS

The final objective of this study was to assess the status of five threatened turtle species that have been recorded in the sanctuary. I gathered the information on the turtles provided by all respondents, including information on habitat, abundance, population trends, threats and local harvesting practices. For each species, over 90% of those who recognized the animals

acknowledged that they were rare, and that their numbers were decreasing. Other studies that assessed the status of turtles in Myanmar, also concluded that the turtle populations in the country had declined substantially in recent years (Kuchling et al., 2004; Platt et al., 2017). Moreover, the main causes of declines identified by these studies were echoed in the answers of my respondents. Local exploitation was named as the main driver of the declines for all the species. Foreign demand, mostly from China, was the second most mentioned threat to the turtles, followed by habitat loss, as well as bycatch- for the aquatic species. For all the species, the majority (around 90%) of those who recognized them reported that the animals were collected, as well as consumed locally (confirmed by around 75%). The eggs of all species were also reported to be collected by the majority of the respondents. Thus, the results, based solely on the local knowledge, are consistent with a number of other studies investigating the turtle populations in Myanmar and other parts of Southeast Asia. These studies have been consistent in implicating a number of recurrent drivers of turtle populations declines, including subsistence harvesting to supply the local demand for meat and eggs; wildlife trade to supply the food markets in China, traditional medicine and pet markets; hunting of tortoises using specially trained dogs (mentioned by a number of the respondents at IWS); and loss of habitat, due to logging, wildfires, mining and human settlements around the turtles' nesting sites (McCord & Philippen, 1998; van Dijk et al., 2000; Kuchling et al., 2004; Min, 2012; Platt et al., 2012; Shwe & Grindley, 2012; Stanford et al., 2015; Auliya et al., 2016; Ihlow et al., 2016; Platt et al., 2017; Rahman et al., 2019). Thus, the information collected at Indawgyi, even though not delimited to the most knowledgeable community members, should not be ignored, as it seems to accurately reflect the situation of the turtles in the region described by other studies.

The fact that the northern and eastern parts at IWS had more reported sightings suggests that there could be more turtles in these areas. There are some differences in topography, but mainly, substantial differences in infrastructure between the southern and western part compared to north and east. There are no paved roads north and east of the lake and in the wet season the access to the villages in these areas is difficult. Less road traffic for extended periods, may have a positive effect on wildlife, making the animals more abundant in these areas. Additionally, the areas west and south of the lake are more densely populated, which certainly has a higher impact on wild species, and the gold mines located in the south inevitably impact the natural habitat of many species, including turtles. All this is largely supported by Shwe & Grindley (2012), who also found that the turtles were mostly found in the undisturbed habitats in the eastern part of the lake.

Limitations of the study

Much of the research on local and traditional knowledge suggests that it is a reliable source of information, and in most cases comparable in quality to scientific data (Johannes, Freeman, & Hamilton, 2000; Davis & Wagner, 2003; Robertson & McGee, 2003; Haggan, Neis, & Baird, 2007; Anadón et al., 2009; Hamilton, de Mitcheson & Aguilar-Perera, 2012; Turvey et al., 2013; Ziembicki, Woinarski & Mackey, 2013; Turvey et al., 2014; Pan et al., 2016; Lyver et al., 2018). However, to ensure the credibility of the information, it is important to validate it (Huntington, 2000; Gilchrist, Mallory & Merkel, 2005). The best thing would be to compare the respondents' information with transect data. However, with the limited time and budget for this study, that was not possible. Additionally, the main idea for the study was to explore cheap and quick methods of collecting the necessary data, as an alternative to the time consuming and expensive traditional scientific methods (Meijaard et al., 2011; Padmanaba et al., 2013). An earlier turtle inventory from Indawgyi by Shwe & Grindley (2012) corroborates much of my results. Given that it was also largely based on the interviews with local stakeholders, it is surely not as optimal for validating my results as using transect data, but it does provide, to some extent, a test of reliability.

The accuracy of the status of the turtles at Indawgyi, which was based on the information from all the respondents, can be also debated, as part of the information came from individuals that did not have good species knowledge. However, as already mentioned, this information corresponded with the findings of other chelonian research in the region, and it was also very consistent across the respondents in the different parts of Indawgyi. Thus, it is likely to provide important basic predictions about the situation of chelonians at Indawgyi.

In the case of one species, however, the least recognized *Cuora amboinensis*, the information is highly uncertain, with a possibility of misidentification by most respondents, as already mentioned in the results. The fact, that there was so much consistence in reporting of incorrect habitat for the species (hill forests), may suggest that another turtle species, similar to *C. amboinensis*, occurs in the habitats reported by the respondents. *Cyclemys dentata*, that was also recorded at IWS (Shwe & Grindley, 2012), inhabits both plains and lower hills (Das, 2015), and having some similarities to *C. amboinensis,* it could have been the source of the mix-up. Alternatively, the respondents might have been familiar with *C. amboinensis* from local markets and simply assumed the habitat to be forest. Another possibility is that the turtles do occur up to certain elevations in the hill forests, and that the species information should be

updated- but that would require records from transect surveys for support. Thus, in the evaluation of the species knowledge, the information provided on *C. amboinensis* habitat was assessed as incorrect for most respondents, lowering the overall species knowledge score.

The most important flaw of the study was a result of miscommunication with my field-assistant regarding the recognition of the species. I found out halfway through the field work, that a positive answer to recognized species was recorded when the respondent confirmed being familiar with the species, without actually naming the species. Thus, an important indicator of species knowledge- the species' name, was not considered in the evaluation of the respondent's species knowledge. In the remaining surveys, the species names were included, but I was not able to use this information in the analyses, with data for half of the respondents missing. However, based on one hundred and ten interviews, only a few of respondents were able to name the species, which may indicate that the majority did not know the names of the turtles. Thus, including the name information in the evaluation of LEK would have most likely reduced the proportion of respondents with good species knowledge. That being said, most of the respondents, even though they did understand and spoke Burmese well, used Shan dialect as their first language. Thus, it is not unlikely that they had their own vernacular names for the animals, that may have been lost in translation, as my assistant did not understand the Shan dialect. This kind of challenges are often the case for LEK research (Ziembicki, Woinarski & Mackey, 2013), and could have been avoided by better preparation ahead of the field work, being clearer in communication with my field assistant, and ultimately could be solved by recording and comparing the different local names of the animals. All the same, I hope that the background information that I used to evaluate the species knowledge, was adequate to assure the reliability of the rest of the species data.

CONCLUSIONS

The rapid economic growth in Myanmar, combined with surging human population, high rates of poverty and unsustainable use of natural resources, pose huge challenges for biodiversity conservation. Protected areas can help mitigating some of the negative effects on natural ecosystems, but to be effective, the PA managers need updated species inventories, data on abundances and distributions, evaluation of conservation status and threats. However, scientific data for many of Myanmar's species are often inadequate, due to limited resources earmarked for environmental protection. Furthermore, some of the PAs are located in remote parts of the country, with difficult accessibility and civil unrest. Given this situation, it is necessary to

consider alternative ways of resource management and obtaining information necessary for conservation decisions. Involving local communities in the management, and use of local and traditional knowledge, have been consistently shown to be effective in addressing many of the challenges related to biodiversity protection in developing world. Local ecological knowledge can provide a cheap, quick and reliable means of gathering basic data, needed for resource management and conservation. Resource users in rural communities around the world spend considerable parts of their lives in nature- farming, hunting and harvesting local plants and animals, and can be very knowledgeable about local species and ecosystems. This was confirmed by the results of this study. Most of the people had a decent knowledge of the local turtle fauna and were able to provide information on the habitat, population trends and the main threats to the turtles at IWS. Based on the information provided by the respondents, the turtle populations at Indawgyi appear to be low and are declining, as the unsustainable harvesting continues. Thus, effective conservation measures are needed to protect the turtles and the many important ecological roles they have in the ecosystems of Indawgyi. The levels of species knowledge differed significantly between certain demographic groups. The elders (people over 50), people without high school and university education, and people who were born at Indawgyi, were the ones who possessed the best species knowledge. This is an important information for any further use of community surveys at Indawgyi aimed at collecting species data, since the quality of the data depends on selecting the most knowledgeable individuals for the surveys. Most of the people were aware of the PA regulations and had positive attitudes to conservation, suggesting that biodiversity protection in the sanctuary should not be complicated. However, this is currently not the case, and there are a few important issues that need addressing. The majority of the people claimed that the PA rules are not respected, indicating that improving local compliance should be prioritized. The respondents pointed out a few measures that could help compensating the opportunity losses related to the PA restrictions, that could help with compliance, including accessible healthcare, support for education and improved infrastructure. Furthermore, the compliance issues could, to some extent, be related to the problematic relations between the park staff and the local people. Park authorities must be perceived as credible in order for the locals to see the management decisions as legitimate. Improved dialogue with local community and local participation in the resource management could provide the people with a sense of control over the most important aspects of their livelihoods. This kind of empowerment could help to improve local acceptance and ownership of the rules, hopefully leading to more sustainable resource use. Finally, the local dependence on the natural resources must be addressed. The growing pressure on the local

fauna and flora, driven by local and foreign demand, is devastating for the integrity of the ecosystems. Thus, alternative sources of income are critical to reduce people's involvement in illicit practices, such as logging and hunting. Moreover, local people must feel that they get tangible benefits from the PA, including both direct and indirect benefits of the conservation work. Below, I present some suggestions that could be relevant for the management of IWS:

1) To replace the reliance of people on harmful harvesting practices it is necessary to develop alternative livelihoods programmes, including sustainable fuel alternatives (e.g. locally produced rice husk briquettes), support sustainable local businesses and initiatives that help creating new jobs, as well as improve access to external markets for the sustainable local products. For the local community forestry, locally managed fisheries and any future (eco)tourism projects, it is important that all revenues from these activities (e.g. selling fishing licenses to outsiders) go directly to the local community.
2) Improving the relations between the PA staff and the local community is going to require involving people more in the conservation and management processes. Local platforms for communication on current environmental issues should be developed to facilitate the flow of information. Community outreach projects and environmental education programmes at schools and in monasteries should be initiated. The emphasis should be on the benefits of biodiversity conservation for the human well-being, the uniqueness of various species and their roles in providing ecosystem services, as well as the consequences of overexploitation. Photos and posters of threatened local fauna and flora, with information regarding their conservation status, should be made available in schools, monasteries and community centers, to raise the awareness and appreciation for the species. Local people should participate in regular monitoring of species and safeguarding the nesting sites of birds and turtles. These activities should be validated, e.g. using photos or phone application, and preferably compensated, but voluntary reporting should be encouraged as well. School children could also be involved in similar activities, promoted as voluntary citizen science projects.
3) Conduct more community surveys, investigating the status of local fauna and flora. I would suggest including villages located in the hills in such surveys, as that could provide some additional information based on the LEK of other ethnicities (particularly, the Kachin people). Investigating the vernacular names in the local dialects should be done to help validating the information. Also, focusing on the demographic groups that

were found to have the best knowledge by this study, could help to ensure the quality of information. These surveys could be done as cooperation projects of the park authorities and local universities. I think it is important to involve the park employees, in order to show that they are not only there to impose restrictions, but also to learn from the locals and use their knowledge in management decisions.

4) Accessible healthcare, support for education and improved quality of the roads, were highly requested by the respondents, who thought these would improve local compliance with PA rules. It is understandable that these measures require substantial investment. However, even small improvements initiated and advertised by the park authorities would certainly help to boost the credibility of the PA staff.

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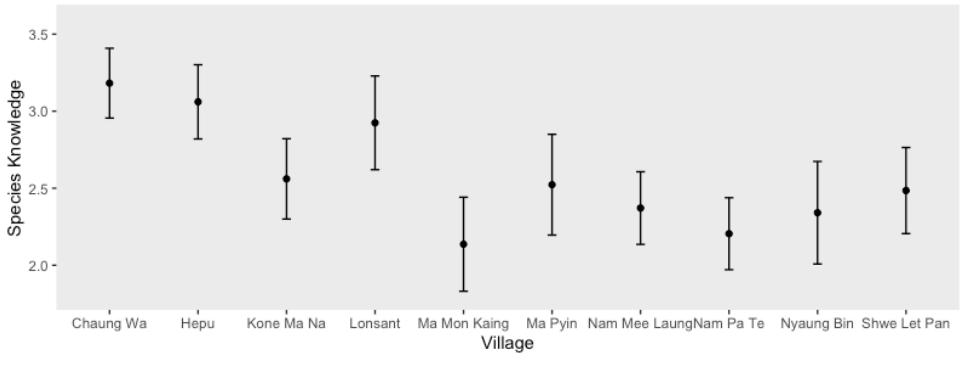
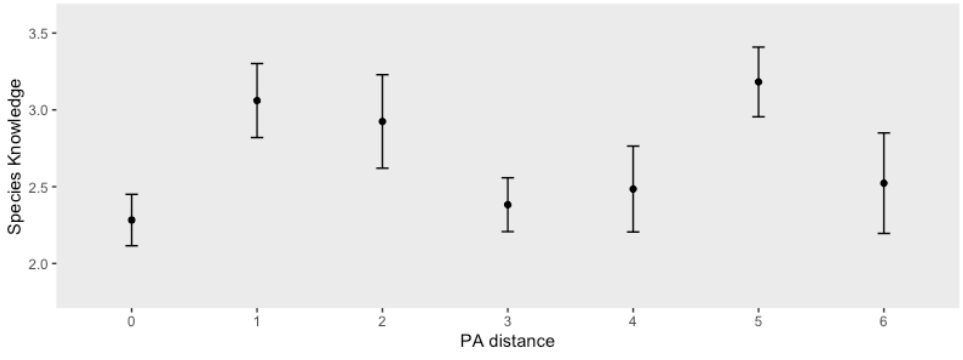
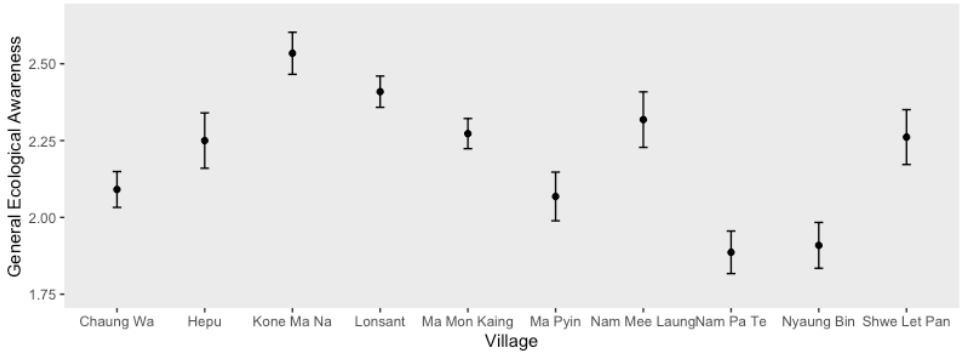
APPENDIX



a)



b)



c)

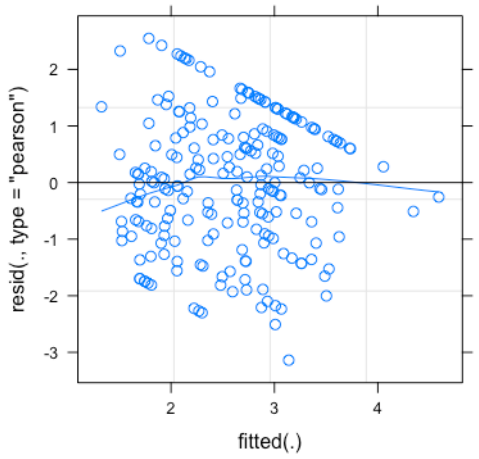
d)

Figure A1. Variation of the mean score values (±SE) for: a) species knowledge at IWS across different villages, b) species knowledge in different distances to the PA (0 indicates a village adjacent to PA and 6 is a distance of 4.6 km between the village and the PA), c) ecological awareness in different villages, d) ecological awareness in different distances to the PA.

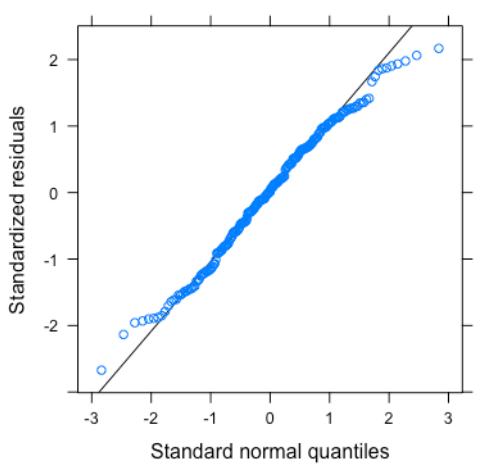
Table A1. Model selection table listing the best seven models for the analysis of demographic factors' effects on species knowledge at IWS. *Df* indicates the number of parameters, Δ AICc is the difference in AICc between the best model with the lowest AIC value and the consecutive models, w_i indicates the Akaike weight of the model. All models included random effect of village in addition to the fixed effects (Sp. knowledge = local species knowledge, Orig = respondent's origin, Edu = education, Inc = monthly income, Ethn = ethnicity, Occ = occupation, Land = landholding status, RsUse = natural resource use level).

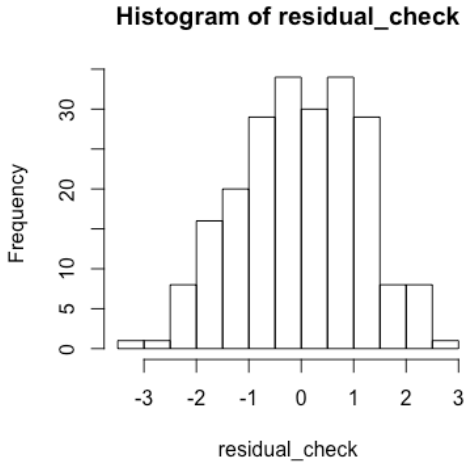
Model	*Df*	ΔAICc	w_i
Sp. knowledge ~ Age + Orig + Edu + Inc	8	0.00	0.287
Sp. knowledge ~ Age + Orig + Edu + Ethn + Inc	9	0.10	0.273
Sp. knowledge ~ Age + Orig + Edu + Ethn + Inc + Occ	10	2.25	0.093
Sp. knowledge ~ Age + Orig + Edu + Ethn + Gender + Inc + Occ	11	2.55	0.080
Sp. knowledge ~ Age + Orig + Edu + Ethn + Inc + Land + Occ	11	4.13	0.036
Sp. knowledge ~ Age + Orig + Edu + Gender + Inc + Land + Occ	11	4.32	0.033
Sp. knowledge ~ Age + Orig + Edu + Ethn + Gender + Income + Land + RsUse	13	4.35	0.033

MODEL ASSUMPTIONS (species knowledge)

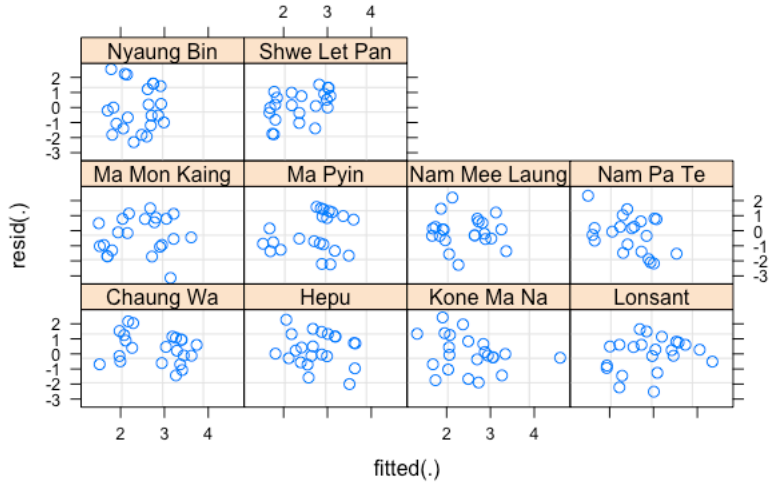


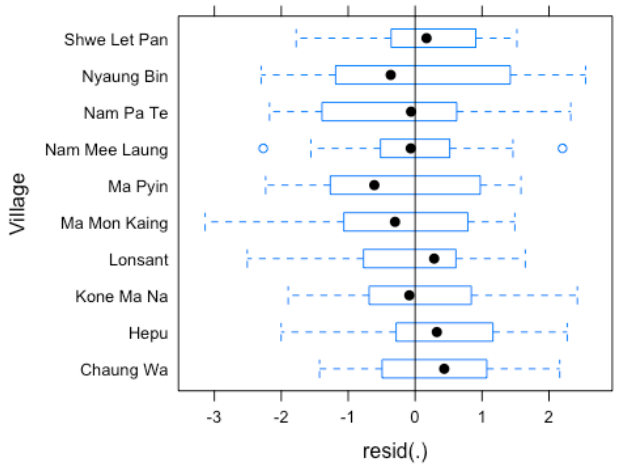
There is some structure in the residuals, a result of the discrete nature of the response variable, that was here modelled as a continuous variable. Distribution of residuals look normal.



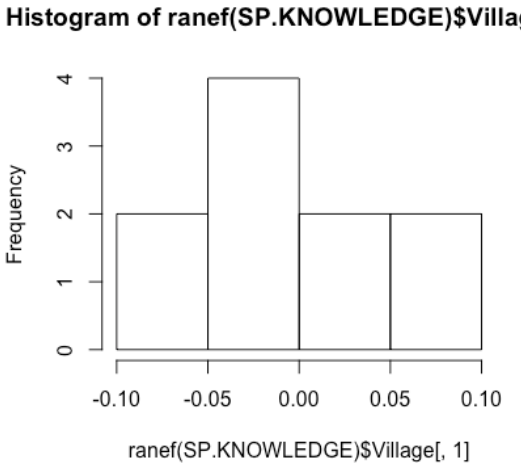


The weighted residuals look reasonably normal, with only slightly heavy tails as indicated by the quantile plot.





Within-group errors are independent and normally distributed with the same variance, mean = 0, and they are independent of the random effects.

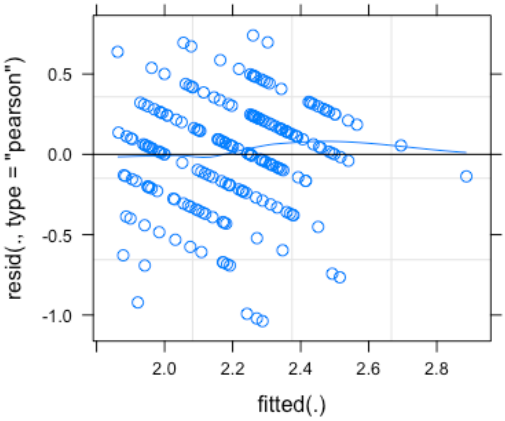


Random effects are approximately normally distributed, with mean = 0.

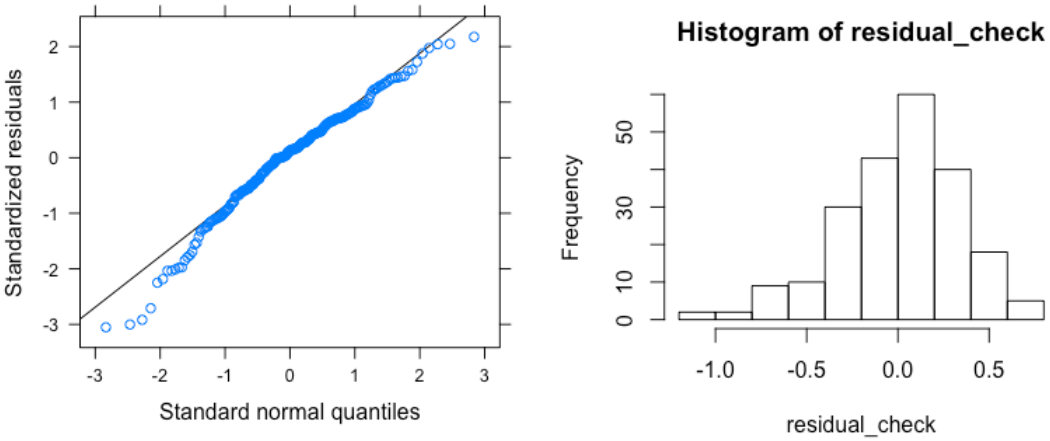
Table A2. Model selection table showing the top seven models for the analysis of demographic factors' effects on general ecological awareness. *Df* indicates the number of parameters, Δ AICc is the difference in AICc between the best model and the consecutive models and w_i indicates the Akaike weight of the model. All models included also the random effect of village.

Model	Df	ΔAICc	w_i
Eco awareness ~ Age + Income	5	0.00	0.433
Eco awareness ~ Age + Origin + Income	6	2.11	0.151
Eco awareness ~ Age + Resource Use + Income	7	2.17	0.147
Eco awareness ~ Age	4	3.47	0.076
Eco awareness ~ Age + Origin + Education+ Income	8	4.51	0.045
Eco awareness ~ 1	3	5.57	0.027
Eco awareness ~ Landholding status	4	6.22	0.019

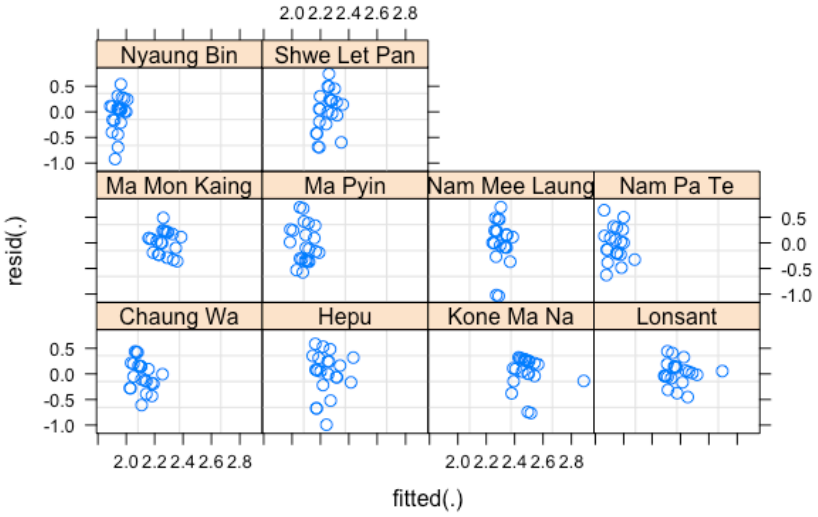
MODEL ASSUMPTIONS (environmental awareness)

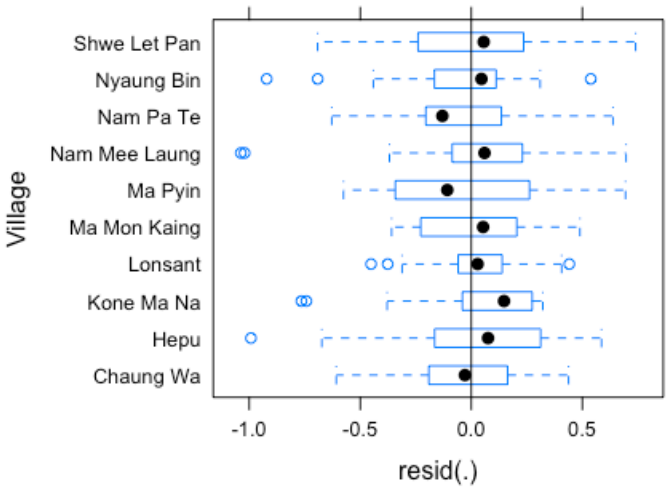


As in the case of species knowledge, the bands in the homoscedasticity check plot are a result of the discrete nature of the response variable.

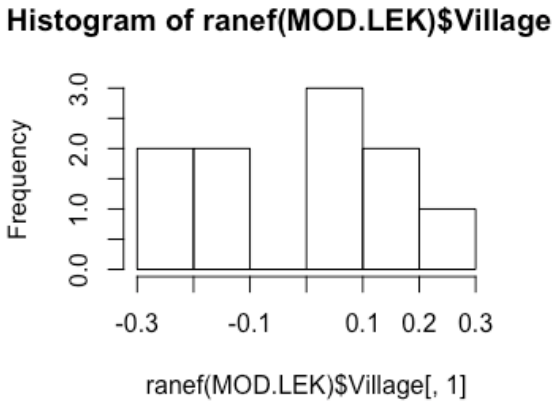


The residuals are approximately normally distributed, with slightly heavy tails.





Within-group errors are independent and normally distributed with mean = 0 and the same variance, and they are independent of the random effects.



Random effects are approximately normally distributed, with mean = 0.

Table A3. Model selection table for the generalized mixed effects models for the analysis of demographic factors' effects on the respondents' assessment of compliance with PA regulations at IWS. Only models with ΔAICc<2 are presented. *Df* indicates the number of parameters, Δ AICc is the difference in AICc between the best model and the consecutive models, and w_i indicates the Akaike weight of the model. All models included the random effect of village.

Model	Df	ΔAICc	w_i
PA respected ~ Origin	3	0.00	0.212
PA respected ~ Landholding status	3	1.00	0.128
PA respected ~ Income	3	1.33	0.109
PA respected ~ Gender	3	1.52	0.099
PA respected ~ Ethnicity	3	1.82	0.085
PA respected ~ Age	3	1.83	0.085
PA respected ~ Education	3	1.85	0.084
PA respected ~ Occupation	3	1.85	0.084

Questionnaire

General Information

Questionnaire No: … Date: … Area/ Zone: …

House/Respondent No: Village Name: …

I. Demographic Information

1. Age:

2. Gender:
   Male Female

3. Ethnicity:
   a) Bamar b) Kachin c) Shan d) Other

4. Religion
   a) Buddhist b) Christian c) Muslim d) Other

5. Education
   a) None b) Primary School c) Middle School d) High School
   e) University f) Other, e.g. monastery education

6. Occupation / main source of income: …

7. Family Size: …

8. Estimated household income: …

9. Landowner? Yes / No

10. Were you born here? Yes / No

II. Local Knowledge of Species

Show photographs of the turtles:

*Manouria emys (**ME**), Indotestudo elongata (**IE**), Nilssonia formosa (**NF**), Amyda cartilaginea (**AC**), Cuora amboinensis lineata (**CA**)*. Ask if the respondent can recognize the species.

For each recognized species:

11. Where can these animals be found?

a) Rice paddies: **(ME) (IE) (NF) (AC) (CA)**

b) Lake shore: **(ME) (IE) (NF) (AC) (CA)**

c) In the lake/ water: **(ME) (IE) (NF) (AC) (CA)**

d) Forest: **(ME) (IE) (NF) (AC) (CA)**

12. How often do you see them?

a) Every day: **(ME) (IE) (NF) (AC) (CA)**

b) Once a week: **(ME) (IE) (NF) (AC) (CA)**

c) Once a month: **(ME) (IE) (NF) (AC) (CA)**

d) Rarely: **(ME) (IE) (NF) (AC) (CA)**

13. Do you see as many of them as before, or have you noticed any changes over time?

a) The numbers have not changed: **(ME) (IE) (NF) (AC) (CA)**

b) The numbers have decreased: **(ME) (IE) (NF) (AC) (CA)**

c) The numbers have increased: **(ME) (IE) (NF) (AC) (CA)**

d) Not sure: **(ME) (IE) (NF) (AC) (CA)**

14. If answered b) in 13 → What are the reasons for the change?

a) Natural variation:

(ME) (IE) (NF) (AC) (CA)

b) The animals have moved somewhere else:

(ME) (IE) (NF) (AC) (CA)

c) Climate change:

(ME) (IE) (NF) (AC) (CA)

d) Habitat loss caused by expanding agriculture, conversion of wetland into rice fields, deforestation/logging.:

(ME) (IE) (NF) (AC) (CA)

e) Bycatch of fishing activities:

(ME) (IE) (NF) (AC) (CA)

f) Excessive harvesting for local consumption:

(ME) (IE) (NF) (AC) (CA)

g) High demand from foreigners:

(ME) (IE) (NF) (AC) (CA)

h) Pet-trade:

(ME) (IE) (NF) (AC) (CA)

i) I don't know

(ME) (IE) (NF) (AC) (CA)

15. Is the animal collected by local people? Yes / No → If yes, what is the purpose?

a) Direct consumption/ food: **(ME) (IE) (NF) (AC) (CA)**

b) Sold at the market: **(ME) (IE) (NF) (AC) (CA)**

c) Sold to foreigners: **(ME) (IE) (NF) (AC) (CA)**

16. Are the eggs collected? Yes / No → If yes, what is the purpose?

a) Direct consumption**:** **ME) (IE) (NF) (AC) (CA)**

b) To be sold at the market: **(ME) (IE) (NF) (AC) (CA)**

c) Sold to foreigners: **(ME) (IE) (NF) (AC) (CA)**

III. General questions regarding protected area (PA) and ecosystem services:

17. Do you know about the PA around Indawgyi and the park boundaries? Yes / No

18. How did you find out about it? …

19. Do you use any of these resources within the PA (or from the lake/forest, for those who don't know about the PA)?

a) Fish b) Fuel-wood c) Timber d) Medicinal plants e) Fruit

f) Mushrooms g) Birds h) Wild animals i) Other

20. Are any of the following natural resources restricted?

a) Fish b) Fuel-wood c) Timber d) Medicinal plants e) Fruit

f) Mushrooms g) Birds h) Wild Animals i) Other

21. Do you know why the authorities are restricting the use of natural resources?

a) Because somebody else wants to use them

b) Because excessive harvesting is harming nature

c) To conserve the biodiversity and allow nature recovery

d) To preserve nature for future generations

e) I don't know

22. Have you noticed declines of any of the following natural resources over time?

a) Fish b) Fuel-wood c) Timber d) Medicinal plants e) Fruit

f) Mushrooms g) Birds h) Wild Animals i) Other

23. Do you think nature conservation is necessary? Yes / No

→ If yes, why? …

24. Can you think of 3 examples of nature's benefits to people (ES), that are most valuable to you? …

25. Do you think that the natural ecosystems at Indawgyi, and consequently the ability of nature to provide the necessary ES, are threatened? Yes / No

→ If, yes- what are the biggest threats? …

26. Are the PA rules and respected? Yes / No

27. Has the traditional use of natural resources changed due to the PA regulations?

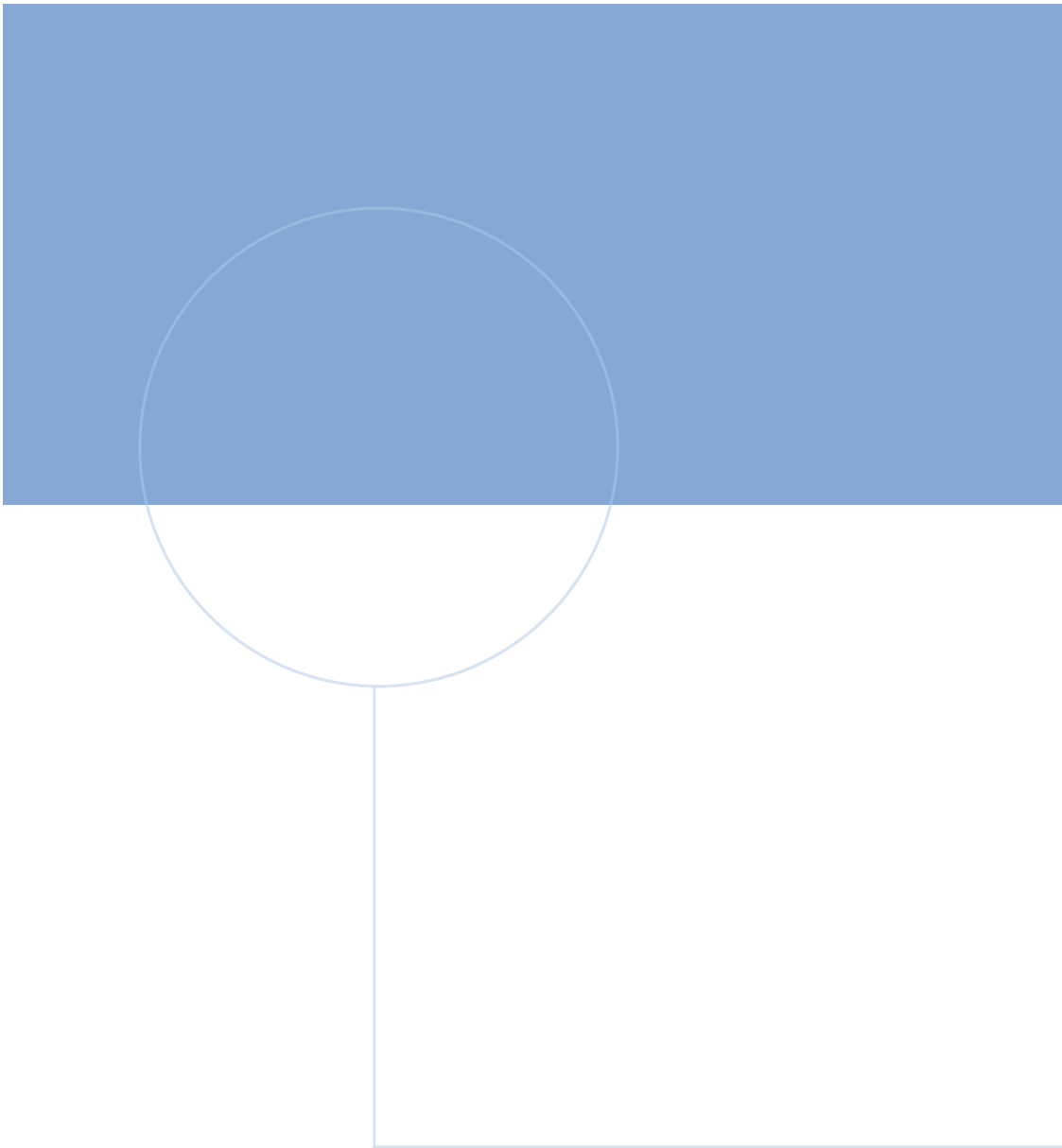
Yes / No → If yes, the PA regulations restrict access to:

a) Food b) Fuelwood c) Building materials d) Medicinal plants e) Other

28. Do you have a suggestion what could be done to compensate local people for the opportunity losses related to the PA restrictions? Can you think of one important thing that could be provided to the local community, you and your family, to compensate for the restrictions on the use of nature?

29. Do you have any household items made of turtle shell/ parts of turtles? May I see it / take a photo?

Thank you!



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