05

Putting Food Needs First

HOW ALTERNATIVE PROTEINS COULD SAVE MADAGASCAR'S ENDANGERED BIODIVERSITY

This anthology is a project of the Planetary Health Alliance (planetaryhealthalliance.org). The Planetary Health Alliance is a consortium of over 200 partners from around the world committed to understanding and addressing the human health impacts of global environmental change.

Case studies were written and photographed by Hilary Duff with editing and support from Amalia Almada, Christopher Golden, and Sam Myers. Teaching guides were written by Carlos A. Faerron Guzmán.

Please cite this case study as "Duff H., Faerron Guzmán, C., Almada, A., Golden, C., and Myers, S. "Putting Food Needs First: How Alternative Proteins Could Save Madagascar's Endangered Biodiversity." Planetary Health Case Studies: An Anthology of Solutions. 2020; https://doi.org/10.5822/phanth9678_5"

To access the full Planetary Health Case Studies: An Anthology of Solutions, please visit https://www.planetaryhealthalliance.org/case-studies

Executive Summary

For further detail on themes covered in this case study, see the land use section of chapter 4 and chapter 5 on nutrition in ↘ Planetary Health: Protecting Nature to Protect Ourselves.

Learning Objectives

After examining this case, students should be able to:

① Understand the roles of policy, governance, culture, health access, malnutrition, and poverty in relation to Malagasy biodiversity and forests.

② Analyze the risks associated with bushmeat consumption.

③ Describe the role of health systems in response to zoonotic diseases.

④ Assess the opportunities and challenges associated with the community-based poultry intervention applied in this region of Madagascar.

Madagascar is one of the most biodiverse countries on Earth, and is home to a variety of endemic animal and plant species, including more than 100 species of lemur. Traditional conservation policies and laws have attempted to safeguard this wildlife for more than a century, but haven't always thoughtfully addressed the needs and motivations of people living in these environments.

Today, humans are impacting wildlife in Madagascar including its charismatic lemurs in two key ways: through land use change driven by agriculture and energy needs, and through the hunting of wildlife for subsistence needs. Both land use change and hunting can have positive and negative public health implications. For example, while the latter provides a critical source of nutrition, particularly for poor rural communities, hunted wildlife also increases the risk of exposure to zoonotic disease

Set in the Maroantsetra region of northeastern Madagascar, this case looks at interventions that could dually support wildlife conservation and promote human health. These interventions include the possibility of sustainable wildlife harvest as well as domestic animal rearing. Chickens are one of the desired domestic animals, and this case explores efforts to make the switch to domestic animal rearing possible and sustainable.

This case study was drafted based on interviews conducted in northeastern Madagascar and Antananarivo, Madagascar, in March 2019.

Most people are still asleep as Zandrilahy leaves Antaravato to check his lemur snare. Walking along the narrow dirt track that constitutes the main road of the village, the path continues through knee-deep mud in rice paddy fields and up a 45 degree incline where only a machete can slash some semblance of a trail through the brush. After a half hour of bushwhacking, Zandrilahy reaches his destination: a clearing called a *fira* where he's constructed the snare.

If this do-it-yourself assemblage of twigs, grass, and cord works as planned, it will be used to snare one of the 12 species of lemurs[1] hunted for food around Makira Natural Park, the largest protected rainforest area in Madagascar. Now, in the middle of the rainforest, Zandrilahy demonstrates the snare's effectiveness. Reaching for a fallen leaf the length of his arm, he skirts it down the branch that juts into the *fira* like a diving board over a swimming pool. A bunch of bananas sit at the end of the branch; in between is a mechanism constructed of grass and a delicate braid of orange cord. That cord is attached to another thinner branch that arches over the *fira*, creating what's called laly totoko—a baited bridge. As Zandrilahy brings the leaf towards the snare, its movements are eerily similar to the swaying of a lemur's tail. Into the trap the leaf goes and snap! It triggers the snare and the leaf is yanked out of Zandrilahy's hand and left to dangle above the *fira*—an imaginary lemur caught in a tight noose. Zandrilahy smiles.

Scenes like this are a nightmare for conservationists. Hunting lemurs has been illegal in Madagascar since 1960, and current consumption rates of the animal in the Makira forest point towards local extinction.[2] Seen through this lens, a complete ban on hunting would be a logical decision. But a shortcoming of such an all-or-nothing policy is that it fails to consider the growing body of research into the complex reasons why men like Zandrilahy hunt terrestrial wildlife in the first place.

Food security is a basic human right,[i] and Zandrilahy and his family depend on the forest's wildlife to survive. They're not alone—hundreds of millions of people worldwide rely on terrestrial wildlife for food.[3] As a result, an estimated 301 mammal species globally are threatened by human hunting pressure. Meat consumption is the primary purpose of that hunt.[4][ii]

[i] The right to food was first recognized in the 1948 Universal Declaration of Human Rights, and later ratified in the 1966 International Covenant on Economic, Social and Cultural Rights. What else is considered a basic human right?

[ii] Beyond mammals, what other species are hunted for meat consumption?

Although satisfying a family's food needs is essential, hunting wildlife can have negative public health implications. Around the world, terrestrial wildlife hunting has led to transmission of pathogens from their original animal hosts to humans—Ebola and HIV in the Congo-Cameroon Basin in continental Africa; Nipah virus, SARS, and Swine influenza in Malaysia.[5] In all cases, scientists and public health officials have connected each outbreak to the hunting, butchering, and eating of terrestrial wildlife. In Madagascar, where bubonic plague has recently made a resurgence, the World Health Organization has said hunting or other contact with rodents could lead to increased risk of contracting the disease.[6][iii]

[iii] Deforestation and an expanding agricultural frontier can also be a risk factor for zoonotic diseases. Has this happened in your country?

Zandrilahy constructs a snare across a forest clearing in Makira Natural Park in northeastern Madagascar.

In northeastern Madagascar, or in any place where people rely on terrestrial wildlife as a food source, wildlife conservation and public health efforts must account for the needs of the people living in those environments. If governments and organizations are going to demand an end to hunting and, in turn, curb the possible spread of zoonotic disease, they also need to ask what other food sources can be offered as nutritional, sustainable, and accessible alternatives. Plus, those options need to be culturally appropriate and desirable—because as Zandrilahy says, lemur meat makes for a delicious dinner.

Madagascar: Old World Biodiversity Meets New World Challenges

It was approximately 88 million years ago that the island nation of Madagascar shifted away from all other landmasses. Now part of the African continent, Madagascar spent more of its geographic past attached to India, before tectonic plate activity isolated the country in the middle of the West Indian Ocean, hundreds of kilometers off the coast of mainland Africa. More than twice the size of the United Kingdom, Madagascar is the world's fourth largest island.[iv]

[iv] Behind Greenland, New Guinea, and Borneo, Madagascar is almost as big as Texas!

The country's geographic marooning had a remarkable impact on its biodiversity. More than 90% of Madagascar's mammal and reptile species can only be found in that country.[7] That includes 59 species of chameleons, more than two dozen species of small, hedgehog-like tenrecs, and what is perhaps Madagascar's most famous resident: the lemur.

Scientists believe lemurs crossed the Mozambique Channel from mainland Africa on floating mats of vegetation. Encountering Madagascar some 62 to 65 million years ago, the species evolved free of aggressive primates such as monkeys and chimpanzees, as well as the large predators that roam the savannas of mainland Africa. Lacking the predator-prey dynamic faced by other primates, lemurs evolved into a small-bodied, docile species that eat primarily fruits, insects, and leaves. Today, Madagascar is home to more than 100 endemic species and sub-species of lemurs, from the pocket-sized Madame Berthe's mouse lemur to the 9.5 kilogram indri.[v]

[v] Around the size of an adult beagle.

Though they historically lacked predation, lemur populations today face many threats. In fact, 94% of species "are under some level of threat, making lemurs the single most imperiled group of mammals on Earth."[8] Though different for each species, lemurs generally reproduce later in life and have longer intervals between births, two biological factors that affect the ability for healthy population growth. Then there are the pressures posed by another predatory primate: humans.

Humans are one of the more recent mammals to reach Madagascar.[9][vi] Just as the country's endemic species rely on the natural resources of the island nation, so too do the 25.5 million people who now share that home.

[vi] Islands were some of the last places to be populated by humans. Which do you think was the last region of the world to be populated by humans?

The History of Malagasy Conservation

Colonial notions of conservation have often prevailed since the first settlers "discovered" new land and established authority over areas traditionally managed by Indigenous groups. This is true worldwide, but especially in Africa where all of the continent's wildlife reserves were established during European colonialism.

Colonial conservation, also known as fortress colonialism, was characterized by the expulsion of local populations from the land in order to protect wildlife and other biodiversity. The expectation was that local people would destroy environments and that the only way to protect valuable ecosystems was to exclude all human presence other than for tourism and scientific research.[10]

In Madagascar, colonial conservation policies started after 1894 when the country became a French colony. That style of governance continued following Madagascar's independence in 1960. Between 1927 and 1997, 46 protected areas were created across the country. Protection of species and enhancing opportunities for research were the primary motivations, similar interests to those held by colonial conservationists. The establishment of these protected areas did little to consider the communities living on the land—people who were reliant on the food, livelihoods, and spiritual sanctuary it provided.

The indri, known in Malagasy as the babakoto, is one of Madagascar's most iconic lemur species. Critically endangered, the Indri is one of more than 20 species of lemurs hunted in northeastern Madagascar.

Traditional Malagasy Governance

Long before these written laws and European colonialism, however, there was the presence of *fady*—the Malagasy taboo system that influences social, moral, and cultural behavior. While *fady* vary by individual, household, community or ethno-linguistic group, there are many instances of taboos related to the avoidance[vii] of certain animal species. These are generally motivated by self-preservation and not by conservation.. Similar to Western conservation laws that have legal implications enforcing morality and action, so too does *dina*, the Malagasy system of community law. Neither *fady* nor *dina* were reflected in the French administration's conservation system.

[vii] Avoidance includes staying away, not hunting, and not eating these species.

"Ignoring that was a major flaw in getting people to believe in the value of conservation," says Dr. Christopher Golden, whose multi-decade research in northeastern Madagascar sits at the intersection of conservation, nutrition, and human health. "If you are excluding people from land that they have had de facto control over for generations and then not providing an incentive to conserve that land, it's going to create a mixed message where conservation is seen as exclusionary and not benefiting them."

[viii] These targets are expected to be 25% of all land and water protected by 2025 and 30% by 2030.

Which countries do you think are protecting more of their terrestrial and marine territories? Which are protecting less? ↘ Use this map to narrow down your assumptions.

The expansion of protected areas has continued in recent years. In 2003, Madagascar's President Marc Ravalomanana pledged to triple the country's protected area over the following six years. The bold plan put Madagascar on the path to achieving a *UN Convention on Biological Diversity* target: that each nation protect 17% of its land and freshwater and 10% of its marine and coastal ecosystems by the end of 2020.[11][viii]

[ix] It should be noted that while Madagascar's protected areas did grow substantially post-2003, the World Bank estimates that only 5.9% of terrestrial land in the country is protected today.

Madagascar's protected areas quadrupled between 2003 and 2016.[12][ix] Managed under the newly-created Madagascar Protected Area System (SAPM), governance of these areas shifted in an effort to better account for the needs of rural communities. "[SAPM management] parallels global trends in protected area policy, and reflects the realization that most priority sites were home to significant populations of rural people that depended to varying extents on natural resources for their subsistence and income," write the authors of one report.[13]

[x] How is the concept of governance different to the concept of government?

Certain areas protected under SAPM have a shared governance model[x] where the central government mandates management to another body. This is often a Malagasy or international non-governmental organization that works closely with local communities to create protected area management plans.

SAPM also saw the creation of Communautés de Base (COBAs), federations of community members that jointly manage the expanded protected areas. COBAs formalize the process of land management and formerly transfer control of the area into the hands of the communities that have held traditional claims to the land. COBAs are then responsible for making their own land management plans that balance their livelihood and natural resource needs with conservation objectives. These groups also create and enforce *dina* (local customs and social norms) in these areas.

Conservation practitioners in Madagascar say the shift towards community management is the start in making biodiversity protection more inclusive and attractive to local communities. However, they admit that enhancing participation from rural communities, ensuring financial sustainability of the management programs, securing law enforcement, and alleviating poverty are among the principle challenges for Madagascar's protected areas going forward.[14]

Human Needs of the Forest

While an expanding network of protected areas is seen as aiding conservation efforts, it doesn't bring immediate economic benefit to most Malagasy. Madagascar is one of the poorest countries in the world, and three quarters of the population live in extreme poverty, surviving on less than $1.90 a day.[15] Over 60% of the country's population lives in remote, rural regions, further limiting access to food markets, healthcare, education, and other basic services.

Four out of five Malagasy rely on agriculture as their main livelihood,[16] the majority of whom are small-scale rice farmers who grow the country's staple food. Population pressure contributing to agricultural expansion is the leading cause of land use change in the country, as forest is cleared or burned to create space for agriculture, including rice fields.[17] The burning of land and forest for agriculture is called tavy, and it is significant as both an ancestral practice[xi] and as the most efficient and inexpensive way to prepare land for new growth.[xii]

Energy demands also contribute to deforestation rates. Only 13% of Madagascar's population has access to electricity,[18] one of the lowest rates worldwide. This furthers the reliance on forests, and up to 99% of the population uses either firewood or charcoal as their cooking

[xi] Slash and burn is a practice used in many parts of the world. What are some pros and cons of this practice?

[xii] Chapter 1 in this anthology looks at the prevalence, cultural relevance, and economic necessity of slash-and-burn agriculture in Indonesia. There, the practice has increased the risk of fires on peatland ecosystems. This has led to annual haze events that have significant public health implications.

[xiii] What are some health consequences from using charcoal or wood as cooking fuel source?

In 2012 alone, 63% of the 8000 child deaths due to acute lower respiratory tract infections were attributable to household air pollution. ↘ WHO 2012

[xiii] Make sure to visit Global Forest Watch to understand the extent of the deforestation process in Madagascar over the last 20 years.

fuel source.[xiii] More than 90% of Madagascar's original forests have been lost since humans first came to the island thousands of years ago.[19] Almost half of that deforestation has occurred in the last 70 years.[20]

Deforestation and forest fragmentation have long been considered the main drivers of habitat and subsequent species loss for Madagascar's wildlife.[21] But a recent body of evidence points to subsistence hunting as an equally pressing anthropogenic threat, both in Madagascar and other parts of sub-Saharan Africa. In Madagascar, regions in the northeast have been a focal point of research into hunting, health, and conservation.*

A rice paddy field outside of Antaravato, northeastern Madagascar.

A Visit to MaMaBay

Communities in northeastern Madagascar are illustrative of the intersectional nature of Madagascar's environmental, social, and economic challenges. Reaching these communities is also revealing of the isolation faced by many of the country's rural regions.

Twice a week, a plane flies between Antananarivo, Madagascar's capital city, and Maroantsetra, a small market town in the country's northeast. Despite its position on Antongil Bay which connects to the ocean, Maroantsetra is described as landlocked because of the difficulty residents have in accessing goods and services from other parts of the country. The single road heading south from the town is little more than a mud track, and the 500-kilometer stretch is impassable at worst and can take days to navigate even during the dry season.

And so, most visitors arrive by plane, a landing that offers clear views of Nosy Mangabe, the island reserve that is part of nearby Masoala National Park. Mainland hillsides are fringed with dark rainforest canopy stretching as far as the eye can see, the landscapes of Masoala National Park to the east and Makira Natural Park in the west. Encapsulating the bay and the two protected areas, the region is often referred to as MaMaBay. While Masoala National Park was first created in 1997 and remains governed by Madagascar National Parks, Makira forest was protected as part of the post-2003 expansion under the Madagascar Protected Area System. Management of the park has been mandated to the Wildlife Conservation Society (WCS), an international NGO with a regional field office in Maroantsetra.

"Makira Natural Park is the largest protected block of terrestrial humid rainforest in Madagascar," explains Andrew Kirkby, MaMaBay Landscape Coor*dina*tor with WCS. "Access to get from one side to the other can be three to four days. There are approximately 90,000 people living around the park, many of whom have very limited access to basic needs. This makes it quite a complicated landscape to address many of the problems."

The Limitations in Accessing Healthcare

Traditional ethnomedicine[xiv] is the first level of healthcare accessed by people living in the Maroantsetra region in northeastern Madagascar. Here, 241 species of plants have been identified as providing ethnomedical treatment to 82 categories of illness, demonstrating that traditional medicine is a well-established practice. Not limited to this region or Madagascar alone, the World Health Organization estimates traditional medicine is used by 80% of Africa's population as a way to address a gap in healthcare needs.

A survey looking at medical access and barriers in the Maroantsetra region found that the majority of adolescent men and women rely first on traditional medicine as a way to address illness.[xv] This is because of three key barriers in accessing healthcare in the region:

- Geography: People in Maroantsetra region need to travel between one and eight hours by foot to reach the nearest Centres de Santé de Base (CSB) I or II clinic, both of which provide different levels of service. River or sea travel would reduce that time, though safety and the logistics of finding and renting a boat can be complicated and cost-restrictive.
- Financial: Despite certain healthcare costs covered or subsidized by the government, CSB or hospital visits involve additional expenses, including transportation to facilities, loss of wages for the patient and the family member who likely needs to accompany that person, and the cost of any prescribed medication or treatment.
- Expertise: Madagascar has 1 physician per 7,000 people, with most professionals concentrated in urban centers. While[xvi] CSB I facilities have a healthcare professional, they provide only basic primary care and vaccinations. Physicians are limited to CSB II facilities. Allopathic (conventional pharmaceutical) medication is available at the village level in epiceries, pharmacies, and is commonly sold by traveling salespeople with no specific health-related training.

↘ Watch: MAHERY video on the barriers to healthcare access in Madagascar

Gathered from the forest and distributed by a traditional healer or self-administered, ethnomedicines are lower cost and more geographically accessible. The value of these plant-based medicines has been compared to that of local allopathic medications, and are estimated to bring household value equivalent of 43% to 63% of median household income.[22] Dependent on the health of the surrounding environment, ethnomedicine is just one further illustration of the important ecosystem services provided by the forest.

[xiv] Often referring to indigenous practices, ethnomedicine describes the use of plants and animal species for medical purposes.

[xv] Reliance on traditional medicine was lower for more vulnerable populations, including children and elderly.

[xvi] How about in your country or region of origin? What is the recommended rate of doctors per population?

Sources: Bustamante, N.D., et al. 2018. A qualitative evaluation of health care in the Maroantsetra region of Madagascar. International Health. https://doi.org/10.1093/inthealth/ihy070; Golden C.D., et al. 2012. Rainforest Pharmacopeia in Madagascar Provides High Value for Current Local and Prospective Global Uses. PLoS ONE 7 (7): e41221.

An area of forest on Nosy Mangabe, a small island reserve in northeastern Madagascar that is part of Masoala National Park.

Park Director Hervé Andrianjara Amavatra outside the office of Masoala National Park. He says that while the park does not condone hunting, they can understand why it's a necessity for some families.

Reaching the villages where those people live requires a trip via a combination of either motor vehicle, boat, or foot, a journey that can take from a few hours to days. Scarcity of food, finances, and healthcare pose an acute threat to these communities, and this reality has led to an increased dependence on the forest and its wildlife species.

Across Madagascar, including in the northeast, terrestrial mammals are commonly hunted as a subsistence food source.[23] Also known as bushmeat hunting, terrestrial wildlife hunting has not always been well studied in Madagascar. Part of the reason, experts say, was that it was never considered a significant threat when compared to other causes of species decline such as deforestation and forest fragmentation.

Another reason bushmeat hunting was not recognized as a threat was because of its low public visibility. Unlike in West and Central Africa where wildlife ranging from antelopes to chimpanzees to forest elephants can appear at local markets, the comparatively small size of Madagascar's mammals mean hunts are often surreptitiously transported from forest to home and consumed wholly by a single family. While other threats, including the short and long-term ownership of lemurs as pets[24] and the sale of certain types of bushmeat as a luxury food item,[25] are present in Madagascar, they're much less common than in other regions of Africa. For example, in the Congo Basin, a hotspot for illegal wildlife hunting, an estimated 4.5 million tons of bushmeat enters the market annually, often for luxury consumption.[xvii]

Lack of bushmeat visibility in Madagascar is also driven by the illegality of the action and by stigma. "[Bushmeat] is considered poor people's food, and so you're not broadcasting to people that you're eating it," says Dr. Christopher Golden, who in 2009 published one of the first papers looking at subsistence wildlife hunting in the Makira forest. The use of bushmeat as a subsistence food source is also reflected in some central African countries, including Cameroon where bushmeat can be purchased from the market. Similar to Madagascar, bushmeat consumption is generally limited to the poorest of households as opposed to being a luxury product.[26]

In Masoala National Park, Park Director Hervé Andrianjara Amavatra says there were 13 lawsuits against lemur hunters in

[xvii] Read more on the global bushmeat from ↘ this document of the Convention on Biological Diversity and Center for International Forestry Research (CIFOR)

2018, and nine the previous year—though he notes the greater number was due to an increase in patrols, and not necessarily in hunting activity. "I know the sanctions of the penalty are a little bit tough, but there are some awareness raising activities that we have done so people should not commit infractions," says Amavatra. He says the park staff doesn't explicitly see hunters as "bad" people, though.

Former bushmeat hunters are often aware of the consequences of their actions. "Almost all the animals have disappeared," says Laurent, who lives in the northeastern village of Antaravato. "We can't hear the voice of the babakoto[xviii] from our home anymore. I realized that if all the lemurs would disappear there would be no stories for the future generations."

Moratombo, another former hunter, learned to catch wildlife when he was a child, a skill he attributes to his ancestors. "The meat of lemur was so tasty, and that's the reason I ate it. It made me strong," he explains. "I would bring the meat back to my family, normally three times a week. Now the lemurs and the forest are very far away because people are cutting the trees and others are hunting with guns."

[xviii] Babakoto is the Malagasy name for the indri, the largest lemur species.

The Effects of Social Discounting

A concept called social discounting can further the understanding of why people in northeast Madagascar hunt, despite seeing the decline of their surrounding natural environment. Social discount rates are the element of cost-benefit analysis used to "put a present value on costs and benefits that will occur at a later date."[27] For example, someone with a 5% annual social discount rate may perceive a service offered by an ecosystem as worth $1 today, but just $0.95 a year from now—a 5% loss in value. The higher the social discount rate, the more a group of people is likely to use a resource today in fear that it will diminish in value in the future.

Social discount rates differ greatly based on context, but range in developing countries between 8-15% annually, with developed nations averaging 3-7% each year.[28] Early results from studies conducted in the Makira forest show that discount rates are incredibly high, perhaps approaching 50%. When it comes to wildlife hunting, this translates to an urgency of 'hunt this animal today because there's a high likelihood that it will not be there later.'

Bushmeat hunting still commonly occurs in northeastern Madagascar. A 2009 survey conducted by Dr. Christopher Golden and his team found that 95% of households had consumed some type of terrestrial mammal in the past year, including 23 species of lemur, bats, tenrecs, and bush pigs. Additionally, over half of households had eaten a lemur species even under a hunting ban. Bushmeat hunting can be a crucial food source, but also have negative implications for human health. Examining the risks requires a trip across the Mozambique Channel to mainland Africa.

Zoonoses in the Anthropocene

Zoonotic disease may not be a mainstream term, but its epidemics are. The global shutdown caused by the COVID-19 pandemic in 2020. Ebola in Sierra Leone, Guinea, Liberia, and the Democratic Republic of Congo. The original emergence of HIV. All are examples of zoonotic disease—infectious diseases spread from animals to humans. Worldwide, 75% of emerging infectious diseases originate from this breaching of the animal-human barrier.[29] Patient zero—the first human infected by a disease—often comes from a location where there are unique or intensified interactions between humans and animals.

Though transmission varies depending on the infectious disease, the spread of pathogens generally happens through a few key steps. First, the zoonotic virus or bacterium is transmitted from a wild animal to humans or domestic animals. In his TED talk about the global emergence of zoonotic disease, virologist Dr. Nathan Wolfe illustrates this first step with photos of hunters in central Africa. The images show men with wild game hoisted over their shoulders—a source of either food or income for their families. In many cases these animals are bloody.

Wolfe says the intimate interaction between hunter and catch is an ideal scenario for people to come in contact with the fluids and tissues of infected wildlife, exposing them to disease as a result. Cuts and bites from infected animals also present an opportunity for disease exposure. Hunters and butchers of wildlife are at greatest risk, though risks affect any person overseeing the transportation, sale, or cooking of an infected animal. In many cases it's not possible to know whether an animal is infected in the first place.

↘ *Appendix: Nathan Wolfe's TED talk – The jungle search for viruses*

Larger-scale anthropogenic activities can exacerbate the spread of zoonotic disease. That includes the consumption demands of a growing human population and the globalization of trade. The first has led to rapid land use change to make way for human settlements and food production. Deforestation is a major cause of land use change in both Madagascar and across sub-Saharan Africa. With a population that is expected to double in the next three decades, the region's forests are a valuable source of fuel for firewood and land for agricultural expansion.

Madagascar is just one testament to this trend. A lower income country that is rich in national resources, strong evidence has drawn the connection between greater economic prosperity and a reduction in forest cover.[30] The scale of this threat is substantial—in pursuit of traditional economic development and a desire to improve qualities of life, the motivations behind deforestation in low and middle income countries are difficult to contest.

Increased risk of disease transmission, zoonotic and otherwise,[xix] is an unintended consequence of deforestation. Interestingly, if looking solely through the lens of preventing zoonoses, a complete clear-cutting of forest would be better for human health, particularly when compared to the selective logging that happens in many parts of central Africa and Madagascar. Selective logging is the practice of cutting certain high-value hardwood species while choosing to leave the rest—this means wild animal habitat remains, though in a more concentrated area. There is as a result greater opportunity for humans to come in contact with wild animals and the diseases they may carry.[31]

Even anthropogenic activities meant to improve human health—the construction of a road into a rural village in order to provide improved health services, for example—can increase disease transmission. Those roads link previously isolated communities with urban centers, exposing people to diseases from other parts of the world and vice versa. Making previously inaccessible tracts of forest reachable by road can also increase the ease and appeal of bushmeat hunting in those locations. Finally, roads contribute to the globalization of trade, meaning that diseases once isolated to small pockets of the world now have greater potential to spread through traveling products and people.

[xix] The case studies in chapter 3 and 6 of this anthology examine the effect deforestation has on water quality and the spread of diarrheal and water-borne diseases in Indonesia and Fiji.

In Madagascar specifically, there isn't yet evidence of the spread of zoonotic disease due to bushmeat hunting. General awareness campaigns do, however, aim to educate people about the real possibility of the emergence of zoonoses like has been witnessed in many regions around the world. "There are lots of national communications on the radio to say that people who eat wild animals, especially bats, need to be careful because they could bring viruses," says Johnnah Ranariniaina, Manager of Livelihoods with the Wildlife Conservation Society in Madagascar. Though discussed, Ranariniaina says people only have a basic awareness at best. "It's still minor because people have not seen a tangible case in their village that shows someone died because of a [zoonotic disease] outbreak."

However, research from northeastern Madagascar indicates many people have a deeper traditional knowledge of how animal and plant species affect their health. A study found that more than three-quarters of social taboos (*fady*) held by Malagasy households were linked to spiritual immunity, physical health, and personal security—all elements of human health and well-being.[32] These taboos have been orally passed down through empirical observation, and govern behavior through the prohibition of certain actions. Says the study: "The local Malagasy stories often illustrate a sophisticated understanding of germ theory, whereby microorganisms, too small to be seen by the eye, are believed to be the root of contagion and disease."

A critically endangered bamboo lemur in Madagascar's Andasibe-Mantadia National Park.

People living in Antaravato village talk outside their homes after a morning health survey. While some families live in houses with corrugated metal roofing and multiple rooms, most people live in these raised, one-room homes constructed of reeds and raffia.

The Role of Food Taboos on Health and Well-being

Be it for reasons of health, economics, religion, or simply what tastes best, everyone has motivations for why they eat what they eat. Food taboos are another factor—cultural practices that dictate what people should and should not hunt and, as a result, eat. “You can’t truly understand why people are hunting or not hunting certain species without understanding the social system in which hunting behaviors are embedded,” says Dr. Christopher Golden, who co-authored a study on the potential implication of Malagasy food taboos on human health and species conservation.

The study documented 1,119 taboo stories in 819 households, with 65% of households having an origin story for at least one food taboo. While taboos have sometimes been reduced to superstition, the study found certain taboos were consistent with findings of modern science and medicine. Based more on observation versus empirical “hard science,” taboos were found to be an invaluable form of Indigenous knowledge that could be used to advise against the consumption of certain animals that pose a potential threat to a person's health. A notable 21% of food taboos related to physical health in the form of zoonotic disease, toxins, or allergic reactions.

The hedgehog tenrec is an interesting example of how a food taboo could potentially safeguard human health. The small ground mammal is an effective reservoir of the bubonic plague,[xx] a medieval zoonotic disease that has caused epidemics in Madagascar since 2012. The most common food taboo in the Makira forest region relates to hedgehog tenrecs and “according to local stories, ancestors would bleed, vomit, and have foamy mouths following hedgehog tenrec consumption, similar to symptoms of bubonic plague.” While 45% of households had a food taboo for the hedgehog tenrec, just 3% had a similar taboo for the common tenrec, a species similar in physical appearance, and yet not an effective host for the plague. In this case, the research concludes that traditional knowledge of plague and its link to hedgehog tenrecs could have informed the creation of this food taboo.

Conservation-wise, a quarter of the population has a food taboo related to lemurs. The study hypothesized as to whether this taboo could have conservation-related impact in a region where nearly half (49%) of the population hunts lemurs. It found that nearly all households with a lemur taboo abide by that taboo, whereas 42% of the population complies with local conservation policies. The conclusion was that, while not 100% effective in accomplishing conservation purposes, food taboos should be understood by conservation-focused organizations in order to thoughtfully couple these beliefs with more conventional forms of environmental policy-making.[xix]

Source: Golden, C. D., and J. Comaroff. 2015. The human health and conservation relevance of food taboos in northeastern Madagascar. Ecology and Society 20(2): 42. http://dx.doi.org/10.5751/ES-07590-200242

[xx] Curious about the bubonic plague? ↘ Read here.

[xxi] What are some food taboos from your place of origin or current place of living?

While taboos are present in Malagasy households, subsistence food needs can contradict these beliefs and lead to bushmeant hunting—a more affordable action families take to improve nutrition and provide other essential health benefits.

A tenrec and a sifaka lemur (photos courtesy of Dr. Benjamin Rice)

Bushmeat Hunting: The Need for Nutritious Diets

It's smoky in the kitchen and the light streaming through the wood slat walls is suspended in the haze. Maman'i Aimé is preparing lunch. Crouching over the cooking hearth, she adjusts the burning branches and the fire radiates warmly into the small room.

Picking up an old condensed milk can, Maman'i Aimé measures portions of rice—enough for the nine people who will be joining her table today. Next to the fire hearth is a metal bowl of cassava leaves that have been pounded into a coarse grind. With the rice cooking, Maman'i Aimé calls out to her son who quickly clambers up a palm tree to retrieve a coconut. Her husband, Laurent, chops it in half with a machete and Maman'i Aimé extracts the milk by squeezing the meaty coconut flesh through the coarse weave of a cloth satchel. Combine these ingredients and you have a dish called ravimbazaha sy voanio—cassava leaves and coconut served over rice. Maman'i Aimé tosses the remaining coconut fibers to her chickens who squawk excitedly around the sandy yard.

The family's average meal is usually a bit more basic: moringa leaves stewed in salty water, perhaps with dried fish. Other staples include plantain, breadfruit, and ovy dia, a wild yam foraged from the surrounding Makira forest. Whatever the accompaniment, it's always served alongside a heaping plate of white rice, the likes of which is grown in the family's nearby paddy or hillside field. Rice is the foundation of Malagasy meals, and paddy field production is particularly high in this part of the country where consistent rain provides plenty of access to surface water. Eaten for breakfast, lunch, and dinner, Madagascar has one of the highest rates of rice consumption worldwide.

Maman'i Aimé's family is not unique in their meal selection. A nutritional analysis of diets in rainforest communities in northeastern Madagascar—including Antaravato, the village where Maman'i Aimé and her family live—tracked the 250 types of foods eaten over a nine-month period. Research was gathered and analyzed by Madagascar Health and Environmental Research (MAHERY), an organization founded by Dr. Christopher Golden.

The study found that cereals like rice, root vegetables, and starchy tubers,[xxii] constitute nearly 80% of the Malagasy diet by weight. That translates to a diet that is very high in carbohydrates, has sufficient protein (primarily from rice), and not very much fat. Many of these foods are low in micronutrients,[xxiii] and diets were found to be severely lacking in calcium and vitamins A, B12, and D. Overall, households were found to be consuming an acceptable amount of food[xxiv] for just over half of the year, though distribution of food among family members is inconsistent.

Micronutrient deficiencies are difficult to visually diagnose, which has led to the public health community penning the term 'hidden hunger.' The term describes the chronic micronutrient deficiency faced by more than two billion people worldwide—more than twice the number who are malnourished due to a lack of calories.[33] Hidden hunger[xxv] can lead to a compromised immune system and predisposition to certain diseases, affecting the health of individuals, families, and countries for years to come. Economic growth is a major determinant in reducing this burden.[34]

While conventional and higher yield crops like carrots, onions, and tomatoes can be grown in other parts of Madagascar, year-round rain and a likelihood of cyclones means farmers in the northeast region are limited to growing rice and a variety of valuable cash crops like vanilla, coffee, and cloves.[35] Even though vegetables and other packaged products are shipped to Maroantsetra, the nearest market town, those products are expensive and geographically far. Maman'i Aimé makes the multi-hour trip to Maroantsetra just four times a year. For most people in Antaravato, they're reliant on what they can grow, gather, and hunt in their surrounding environment.

Chickens in Antaravato

[xxii] Including cassava, yams, taro, and sweet potato.

[xxiii] Why are micro-nutrients important? How about others like iodine, iron, or magnesium?

[xxiv] The study used the World Food Programme's Food Consumption Score (FCS) index to determine whether a household was eating an acceptable, borderline, or poor consumption of food. The index outlines the frequency in which eight food groups should be eaten over the course of a week. Food groups include main staples, vegetables, fruit, meat/fish, and milk. More information about the FCS index ↘ can be found here.

[xxv] Is there hidden hunger in your part of the world? How is it being addressed? Check out ↘ this map to understand where the problem is worst.

Maman'i Aimé uses a famiaham-banio to extract the milk from coconut shavings. She's preparing ravimbazaha sy voanio, a delicious dish of cassava leaves and coconut served over white rice.

Pounded cassava leaves are a common green in Malagasy cooking

Why the World Can't be Vegetarian

What would happen if the world were vegetarian or vegan? It's a question that's been posed by various popular media articles and pondered on global platforms like the World Economic Forum. Research supports the shift. Respected nutritionist and epidemiologist Dr. Walter Willett from the Harvard Chan School of Public Health recently advocated for the benefits of a plant-based diet, including its role in reducing the risk of non-communicable diseases like diabetes and heart disease.[36] Worldwide, red meat consumption is 288% higher than the planetary boundary (or 638% higher in North America).[37][xxvi]

Decreasing consumption of animal-based protein is thought to be one of the most effective individual ways of lessening the effects of climate change. The agricultural industry is the largest producer of methane and nitrous oxide, which, in addition to carbon dioxide, are two of the most damaging greenhouse gases.[38] In fact, recent studies estimate the livestock sector (both the rearing of animals and the land use conversion to make space for domestication) could consume between 37% and 49% of the greenhouse gas budget created in order to limit global warming between 2°Celsius and 1.5°Celsius by 2030.[39]

With evidence mounting, it seems like a moral imperative to become vegetarian. But as the recent EAT-Lancet Commission on Food, Planet, Health found, pressing vegetarianism on the world is not feasible for many communities and cultures worldwide, especially in sub-Saharan Africa. The region has the highest burden of stunting, a condition that prevents the proper growth and cognitive development of children within the first 1,000 days of their life.[40] Chronic under- or malnutrition is commonly blamed for stunting, and can be linked to a lack of the protein and key micronutrients that are particularly rich in animal-source foods. Despite too-high red meat consumption trends worldwide, access to animal-based protein in sub-Saharan Africa is projected to be lower than the healthy reference diet developed by the EAT-Lancet team.[xxvii] Additionally, there is the need to consider the taste and cultural preferences of local communities who may be accustomed to eating fish and livestock as part of indigenous diets.

The conclusion drawn by the EAT-Lancet Commission is contrary to ideas of total vegetarianism: people living in sub-Saharan Africa could benefit from an increase rather than a decrease in animal-source protein, while still eating within planetary health boundaries. The commission advocates that, as with other categories of food, consumption needs to be considerate of the regional and socioeconomic realities of the people doing the dining.

More context on this topic is offered in a case study looking the need to restructure the present-day food system.

[xxvi] ↘ Here are the countries that consume the most meat in the world.

[xxvii] The healthy reference diet recommends the consumption of 84 grams of animal-source protein per day, while the availability of animal-source protein in sub-Saharan Africa is projected to be just 13 grams per day by 2050, given current population estimates.

Animal-source foods, rich in micronutrients, make up around 5% of the diet by weight in northeast villages with wildlife contributing 40% of the total. Up to three quarters of hunted terrestrial wildlife species are classified as endangered[41] or critically endangered. Another option for animal-source food is domestic livestock such as chickens and zebu, though ownership of these animals is often limited to wealthier households. Studies from eastern Madagascar have shown that domestic animals and fish are the preferred food among people, demonstrating that bushmeat hunting often occurs out of necessity as opposed to preference.[42]

A family's bushmeat consumption habits change throughout the year. People generally have a higher macro and micronutrient intake during the hot season of September to January, months that correspond with peak fishing and rice harvest season. On the contrary, surveys show a drop in protein, vitamins A and B12, zinc, and fat between February and September when fishing and rice aren't as readily available.[43] During these periods, families who cannot afford domestic meat supplement their nutritional intake by hunting lemurs, tenrecs, and other terrestrial mammals. This bushmeat is an essential part of diets, especially for children whose growth and development are seriously impacted by a lack of iron and other micronutrients.

↘ *Appendix: Seasons in Madagascar recognized by the local Malagasy in the Maroantsetra region (from Golden et al 2019)*

Iron-deficient anemia (IDA) is the most common cause of anemia worldwide,[xxviii] and is a hidden hunger that occurs primarily when a person isn't eating enough iron-rich foods. It's further exacerbated by infectious disease burden, intestinal parasites, or excessive blood loss.[xxix] West and Central parts of sub-Saharan Africa, as well as Madagascar, made little progress when it came to reducing anemia rates between 1990 and 2010.[44] IDA can lead to longer term health effects, including cognitive, motor, and emotional development issues.

Removing access to wildlife is estimated to lead to a 29% increase in the number of children suffering from anemia in northeastern Madagascar. In the poorest households where reliance on hunted wildlife is highest, anemia cases in children would triple.[45]

[xxviii] Anemia is described as a low hematocrit. That is your body lacks enough properly functioning red blood cells, and that usually limits the capacity to carry adequate oxygen to your body's tissues. What then could be some signs and symptoms of anemias?

[xxix] What other conditions can cause iron-deficiency anemia?

Monitoring Malagasy Health

The health of families in Antaravato is well monitored by an organization called Madagascar Health and Environmental Research (MAHERY). Staff with the organization measure the growth and weight patterns of kids aged 12 and under quarterly and conduct dietary intake surveys three times a year.

Data is logged using a small offline tablet powered by the Dharma Platform, a health surveillance tool. The measurements help the MAHERY team track the long-term development and diets of families in northeastern Madagascar.

MAHERY is working in collaboration with the national Ministry of Public Health, Catholic Relief Services, and the Dharma Platform to pilot a community-based health surveillance platform. Currently, the main source of epidemiological data in the country is gathered by the ministry's Centres Santé de Bases when patients visit the clinic, says Hervet Randriamady, MAHERY's National Research Director. However, Randriamady says access to these clinics is often restrictive—and as a result, the data they can collect is limited and doesn't always record the full reality of people living in rural regions. For example, the ministry may never hear about community illnesses or outbreaks, and as such are unable to appropriately allocate resources or send in medical staff to address epidemics.

The health surveillance system being trialed by Randriamady and the MAHERY team could bridge the gap between community and ministry. The paperless platform reduces human error and allows for the faster transfer of data. If the pilot proves successful, community health workers across Madagascar could be equipped with a tablet and the health surveillance platform. Not only that, but the health data that's collected could be paired with climate and habitat mapping data to get a big picture look at how the health of communities is affected by changes to the natural environment.

A young boy in Antaravato village stops snacking on rice in order for Rivo, an employee with Madagascar Health and Environmental Research (MAHERY), to measure his head circumference. These anthropometric measurements happen every three months.

Maman'i Aimé and Laurent outside their home in Antaravato.

Back in her kitchen in Antaravato, Maman'i Aimé says her family was one of those households. "We were struggling to find food because of the difficulty getting money, especially for our first child," she says. At the time, the family didn't have a plantation of their own to grow crops, and performed small jobs for other people to make enough income to purchase food.

"When I was working in the faraway field plantations I started to build some [wildlife] traps so I could eat," explains Laurent, Maman'i Aimé's husband. Flipping over a piece of paper, he sketches his passive snaring method, identical to the trap set in the forest by Zandrilahy and similar to the majority of traps set up in the region.[46]

The family's meals were soon supplemented by bushmeat. "In 1992 our second son was born. Since then when I caught lemurs I would bring them home for all of my family. That was to feed them, and it related to the fact that I had two young children," Laurent explains. "If I did not bring home that lemur we wouldn't eat meat and we would just eat greens."

Laurent stopped hunting in 2005, persuaded by awareness programs conducted by the Wildlife Conservation Society and the prompting of a catchy tune from Malagasy artist Clément Mily. The musical ode to encourage people to protect their natural environment was widely popular in the nineties, and is called Mandrora mantsilany. This translates loosely to "if you spit lying down then your spit will come back to you." Laurent smiles and hums a few bars outside of his home.

↘ *Appendix: Mandrora Mantsilany on YouTube*

Laurent and Maman'i Aimé say it's easier to put food on the table today. They started their own agricultural plantation in 2000 and can now grow more crops. Maman'i Aimé says they eat meat about once a week—sometimes zebu, but more commonly the scrawny chickens scurrying around their yard. Still, limitations exist. "We can eat every day but sometimes we cannot afford expensive meat," Maman'i Aimé says. "My favorite meal is freshwater fish from this area with some greens. I do love lemurs, but they're very rare today."

Sustainable Wildlife Hunting: A Possibility in Madagascar?

Hunted wildlife remains an important part of diets for many in northeastern Madagascar. As research has shown, reducing a reliance on wildlife and conserving biodiversity demands more than hunting bans or creating protected areas. Instead, it requires a conservation and development intervention that will transition people away from bushmeat without taking a toll on their nutritional needs or limited financial resources.

That intervention could take different forms. One option is the continued hunting of certain wildlife, though done in a way that is sustainable and allows for the reproduction and growth of those populations. But is that possible in Madagascar and other parts of the world?

A 2013 review of 750 harvest sustainability evaluations worldwide found 65% of harvests had been deemed sustainable,[47] suggesting that sustainable hunting could be a possible strategy. However, the authors of the review noted that these evaluations may be challenged because they relied on indicators gathered once as opposed to over time. As a result, the data may not capture the wildlife population trends that could increase or decrease due to factors such as habitat and climate change.

In Madagascar, a new global program is taking on this question of whether hunting can be done sustainably. The European Commission-funded Sustainable Wildlife Management Programme was launched in July 2018 and is led in Madagascar by the Wildlife Conservation Society (WCS) in collaboration with various national and international partners. One of the programme's approaches in Madagascar is to see if there are "resilient wildlife and domestic species" that could be used to transition people away from a reliance on bushmeat[48] to achieve interlinked objectives of promoting wildlife, conserving the ecosystem, and improving livelihoods and food security.

Lemurs and many other terrestrial mammals are protected by law. However, "there are other [wildlife] species that are not protected, which, if hunted sustainably, could provide a sustainable and healthy source of wild meat for people," says Charlotte Spira, the Ecological and Social Research and Monitoring Manager with WCS. Possible legal, sustainable wildlife, she says, could be wild pigs, which are not a conservation priority as they are an introduced species, and certain species of rodents and tenrecs. "One of the activities planned in the SWM Programme is conducting wildlife surveys to estimate the population sizes of these species to inform decision-making at the community level, for them to adopt more environmentally friendly hunting practices," says Andrew Kirkby, WCS' MaMaBay Landscape Coordinator.[xxx]

xxx What are some places in which "sustainable hunting" is allowed and working well?

Ecologist and founder of MAHERY, Dr. Christopher Golden, agrees that wild pigs could be a sustainable hunting option, but says they're an exception. Overall, he's less certain the terms 'sustainable' and 'wildlife hunting' can go together in Madagascar. This is because of the types of species in the country, their reproductive behavior, and the size of the human population that relies on them.

For example, lemur species that reproduce at a later age and have longer intervals between births are more susceptible to overharvesting.[49] Research indicates that the season in which people hunt has the ability to both positively and negatively influence the sustainability of lemur populations.[50] Bushmeat hunting in northeastern Madagascar is especially common between March 15 and June 15 because these months correspond with off-peak fish and rice harvest season. It is also the wet season when fruit-laden trees attract lemurs which increases the likelihood of hunting success.

Dr. Christopher Golden says he can't foresee a solution that is a triple win for the sustainable hunting of bushmeat, lemur populations, and food security. That's why he and the MAHERY team have introduced a solution that involves alternative foods such as chickens. Studies from eastern Madagascar have found that people prefer many kinds of domesticated livestock (e.g. pig, chicken, zebu, goose, turkey, and duck) over the common brown lemur, the most desired illegally hunted wildlife.[51] This suggests people would be willing to eat chicken as an alternative to bushmeat—if it were an affordable and viable option.

On Poultry and Planetary Health

"If there was no disease many people would become rich," says Jerome, shaking his head. Another resident of Antaravato, the village at the edge of Makira forest in northeastern Madagascar, Jerome's face is barely visible in the little light radiating from his storefront. His 20 chickens have been brought inside for the night. Jerome has been rearing poultry for more than three decades. Like many people in Antaravato and villages across Madagascar, he and his chickens have faced their fair share of problems.

Over the years, Jerome estimates he's lost more than a thousand chickens to an infectious bird fever called Newcastle disease. [xxxi] He isn't alone—a Madagascar-based study found the disease causes up to 40% mortality in non-vaccinated flock.[52] While people consider chicken a delicious food source, viability and consistency of flock has been an issue because of this disease. Currently, bushmeat presents a cheaper and more reliable source of much-needed micronutrients.

There is a vaccine against Newcastle disease, but it can only be injected by a trained veterinarian.[xxxii] In a context where people rarely leave the village for pressing health concerns, the likelihood of traveling for a chicken vaccine is slim. This injectable vaccine also needs to be refrigerated, a barrier in rural villages where the nearest fridge may be a day's walk away.

In 2014, MAHERY approached Dr. Ando Miharifetra, head of the Department of Vaccine Production at the Institut Malgache des Vaccins Vétérinaires (Malagasy Institute of Veterinary Vaccines, referred to in short as IMVAVET) in Antananarivo, Madagascar's capital city. With intellectual and financial support from MAHERY and the Wildlife Health Network, the IMVAVET team developed a thermostable[xxxiii] vaccine that could withstand the challenging conditions of Malagasy villages like Antaravato.

The newly developed vaccine comes in an inconspicuous eye dropper bottle. With a handful of rice tossed to the ground as a diversion, a man quickly scoops up one of the chickens dashing around the yard. Josiane brandishes a small eye dropper bottle and tenderly holds the chicken's head between her index finger and thumb. A droplet lands in its eye and seconds later the bird is released, left to continue its rice pecking.

[xxxi] Care to read more on Newcastle Virus? ↘ Click here

[xxxii] All these are challenges of many types of vaccines administered to humans.

[xxxiii] Which is to say it doesn't require refrigeration

This is the scene that plays out in certain households across Antaravato and five other villages every four months. The small eye dropper bottle means the vaccine can be administered by community vaccinators like Josiane. Trial vaccination has been ongoing since May 2016, and Josiane is one of the volunteers who was trained by the IMVAVET and MAHERY teams.[xxxiv]

These trials have shown promising results in six rural villages in northeastern Madagascar. Data gathered between 2011 and 2018 found that village chicken populations could stabilize and grow with moderate, consistent vaccination. However, complete herd immunity[xxxv] against Newcastle disease would require at least 85% of all village chickens be vaccinated, something that is unlikely with community vaccination alone.

Even with a thermostable vaccine that can be administered by community members, challenges in raising village chickens remain. For one, vaccination needs to happen every four months, otherwise chickens remain at risk of contracting the disease. While relatively inexpensive per individual dose—100 Ariary, about USD $0.03—Josiane says the cost can add up for large flocks, and is compounded by the fact that people are skeptical of the vaccine's effectiveness.

"They say that their chickens will go blind, or that their chicken died due to vaccination," says IMVAVET's Dr. Miharifetra of some of the reasons why people are resistant to the vaccination. "When they say something like that we're trained to convince them otherwise, but it's very hard. As of right now we have failed 100% of the time." Increasing acceptability of the vaccine through community education and outreach is an important next step for MAHERY and IMVAVET.

For Jerome, the long-time poultry farmer, the cost of the vaccine is a worthwhile investment. "Even if I raised hundreds of chickens I'd still get the vaccine because the cost of one chicken that stays alive could cover the cost of the vaccine for me. Since I've been part of the vaccination program no chicken has died. It's been very effective," he says.

[xxxiv] In recent years, and thanks to the work of the GAVI Alliance, vaccination rates for children have actually almost doubled! ↘ Read more here.

[xxxv] What is herd immunity?

Josiane administers the vaccine against Newcastle disease. While administration of this eyedropper fluid is easier than the previous injectable vaccine (which could only be administered by trained veterinarians), Josiane still faces other challenges in convincing community members to vaccinate their flock.

Dr. Ando Miharifetra from IMVAVET inspects one of the insulated bags used to transport the I-2 vaccine to northeastern Madagascar. The vaccine must first be transported by plane from the capital city of Antananarivo to Maroantsetra, where it is then driven, boated, or walked into rural communities.

The Wildlife Conservation Society is looking to chickens and fish farming as an alternative meat source to wean people from bushmeat, though their approach differs from that of MAHERY. WCS plans to establish 150 demonstration farms in the 10 Communautés de Base (COBA) where its Sustainable Wildlife Management Programme operates. The organization will provide these households with the start-up materials, training, and vaccines they need to either maintain a chicken population or start a fish farm. WCS also plans to train local veterinarians to help provide and administer a thermostable chicken vaccine in collaboration with the Ministry of Agriculture, Livestock and Fisheries.

This poultry program is the next iteration of the agricultural livelihood projects WCS has already been operating around Makira forest. Only now, MaMaBay Landscape Coordinator Andrew Kirkby says WCS is framing its programme slightly differently: "In these 10 selected sites, we want to carry out a very targeted combination of activities including forest management through good natural resource governance, livestock keeping, and sustainable hunting while improving access to veterinary and human health services. We hope that these sites could serve as an example of what is possible and provide guidance and lessons learned to expand to other sites around the park."

There are co-benefits for conservation and human health if MAHERY and WCS' poultry and alternative protein programs are successful and sustainable. For example, chicken survival would mean families have access to a valuable and preferred source of micronutrients in their own backyard, which could reduce their reliance on wild bushmeat. In addition to curbing hunting rates for lemurs and other wildlife, chickens are raised in small areas near a family's home, reducing the amount of forested land that may need to be cleared to raise livestock or grow crops.

From a human health perspective, healthy chicken flocks could improve food security, address the challenge of 'hidden hunger' in children and adults, and limit the contact people make with wildlife that could be carrying disease.

There are also socio-economic benefits to be gained. Chickens are one of the most culturally-appropriate food sources for people. Unlike lemurs which can be taboo to eat, there are few Malagasy cultural taboos that exist against chicken.[53] Finally, both WCS and MAHERY see the potential of poultry not only as a food source, but also as an income generating opportunity for families who want to sell surplus chickens and eggs.

Back in Antaravato, it's time for another meal with Maman'i Aimé and Laurent. This time, it's perhaps fitting that chicken is being served. Laurent has owned chickens since he was 10-years-old, and has had a similar experience to Jerome, raising the birds only to see them die with Newcastle disease. "Sometimes you think you don't want to do that anymore, but when you see the chickens of your neighbor you say, oh I'm going to do that again because you get inspired," he says.

The family eats meat once a week when the chickens are healthy. Laurent joined the vaccination program at inception and says his chickens have not been killed by the disease since. He says that today many people in the village have poultry, and that there are few people who still hunt lemurs. But it's hard to know, and local dietary intake surveys certainly reflect that wildlife is still making it onto people's plates. Until an alternative can be successfully introduced across the entire village, that's likely to remain true. But today, in this moment, the family has nutritious food on the table. And with that, Maman'i Aimé says a prayer and it's time to eat.

Keeping Track of Who's Who

Maman'i Aimé

Resident of Antaravato, wife of Laurent

Andrew Kirkby

RMaMaBay Landscape Coordinator, Wildlife Conservation Society (Madagascar)

Charlotte Spira

Ecological and Social Research and Monitoring Manager, Wildlife Conservation Society (Madagascar)

Hervé Andrianjara Amavatra

Park Director, Masoala National Park

Laurent

Resident of Antaravato, husband of Maman'i Aimé

Zandrilahy

Former bushmeat hunter and resident of Antaravato

Dr. Christopher Golden

Ecologist and epidemiologist; Assistant Professor of Nutrition and Planetary Health with the Harvard T.H. Chan School of Public Health; Director and Founder of Madagascar Environmental Health and Research (MAHERY)

Dr. Ando Miharifetra

Head of the Department of Vaccine Production at the Institut Malgache des Vaccins Vétérinaires (Malagasy Institute of Veterinary Vaccines, IMVAVET)

Jerome

Resident of Antaravato and chicken owner

Moratombo

Former bushmeat hunter and resident of Antaravato

Josiane

Volunteer community chicken vaccinator; resident of Antaravato

Johnnah Ranariniaina

Manager of Livelihoods, Wildlife Conservation Society (Madagascar)

Acknowledgements

Thank you, first, to Dr. Christopher Golden for his support and guidance around this case. In Madagascar, this case study would not have been possible without the help and leadership of Hervet Randriamady and the entire Madagascar Health and Environmental Research Team. A special thanks to Tata and Dalia for hosting me in Maroantsetra, and to Maman'i Aimé and Laurent for doing the same in Antaravato. This case benefited from the expertise of the Wildlife Conservation Society Madagascar team in Maroantsetra.

A curious brown lemur in Andasibe-Mantadia National Park in eastern Madagascar. Despite being a protected species, the brown lemur is commonly eaten in parts of the country.

Bibliography

[1] Golden, Christopher D. "Bushmeat hunting and use in the Makira Forest, north-eastern Madagascar: a conservation and livelihoods issue." The International Journal of Conservation. July 1, 2009; https://doi.org/10.1017/S0030605309000131

[2] Brook, Cara E., et al. "Population viability and harvest sustainability for Madagascar lemurs." Conservation Biology. June 13, 2018; https://doi.org/10.1111/cobi.13151

[3] Ripple, William J., et al. "Bushmeat hunting and extinction risk to the world's mammals." Royal Society Open Science. October 1, 2016; https://doi.org/10.1098/rsos.160498

[4] Ripple, William J., et al. 2016.

[5] Cantlay, Jennifer Caroline, et al. "A Review of Zoonotic Infection Risks Associated with the Wild Meat Trade in Malaysia." Ecohealth. March 22, 2017; https://doi.org/10.1007/s10393-017-1229-x

[6] "Plague: Madagascar." World Health Organization. October 2, 2017; https://www.who.int/csr/don/02-october-2017-plague-madagascar/en/

[7] "Madagascar – Country Profile." Convention on Biological Diversity. 2019; https://www.cbd.int/countries/profile/default.shtml?country=mg

[8] Brook, Cara E., et al. 2018.

[9] Hansford, James, et al. "Early Holocene human presence in Madagascar evidenced by exploitation of avian megafauna." Science Advances. September 2018; https://doi.org/10.1126/sciadv.aat6925

[10] Doolittle, Amity A. "Fortress Conservation." Encyclopedia of Environment and Society. 2007; http://dx.doi.org/10.4135/9781412953924.n432

[11] "Aichi Biodiversity Targets." Convention on Biological Diversity. May 11, 2018; https://www.cbd.int/sp/targets/

[12] Gardner, Charlie J., et al. "The rapid expansion of Madagascar's protected area system." Biological Conservation. February 2018; https://doi.org/10.1016/j.biocon.2018.02.011

[13] Gardner, Charlie. J, et al. 2018.

[14] Gardner, Charlie J., et al. 2018.

[15] "The World Bank in Madagascar: Overview." The World Bank. March 4, 2019; https://www.worldbank.org/en/country/madagascar/overview

[16] "Economic Outlook for Madagascar: Sustained Growth Needs to be More Inclusive to Benefit the Poorest." World Bank. July 31, 2018; https://www.worldbank.org/en/country/madagascar/publication/madagascar-economic-update-fostering-financial-inclusion

[17] Waeber, Patrick O., et al. 2019.

[18] "The World Bank in Madagascar: Overview." 2019.

[19] NASA. "Deforestation in Madagascar." Land-Cover / Land-Use Change Program. https://lcluc.umd.edu/hotspot/deforestation-madagascar

[20] Harper, Grady J., et al. "Fifty Years of Deforestation and Forest Fragmentation in Madagascar." Environmental Conservation. December 1, 2007; https://doi.org/10.1017/S0376892907004262

[21] Golden, Christopher D. 2009.

[22] Golden, Christopher D., et al. "Rainforest pharmacopeia in Madagascar provides high value for current local and prospective global uses." PLoS One. July 27, 2012; https://doi.org/10.1371/journal.pone.0041221

[23] Golden, Christopher D., et al. "Economic Valuation of Subsistence Harvest of Wildlife in Madagascar." Conservation Biology. January 9, 2014; https://doi.org/10.1111/cobi.12174

[24] Reuter, Kim E., et al. "Live capture and ownership of lemurs in Madagascar: extent and conservation implications." Oryx. January 2015; https://doi.org/10.1017/S003060531400074X

[25] Barrett, Meredith A. and Ratsimbazafy, Jonah. "Luxury bushmeat trade threatens lemur conservation." Nature. September 24, 2009; https://www.nature.com/articles/461470a

[26] Wolfe, Nathan D., et al. "Bushmeat Hunting, Deforestation, and Prediction of Zoonotic Disease Emergence." Emerging Infectious Disease. November 2005; https://doi.org/10.3201/eid1112.040789

[27] "What are social discount rates?" The London School of Economics and Political Science. May 1, 2018; http://www.lse.ac.uk/GranthamInstitute/faqs/what-are-social-discount-rates/

[28] Zhuang, Juzhong, et al. "Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis: A Survey." Economic and Research Department Working Series, Asian Development Bank. May 2007; https://www.adb.org/sites/default/files/publication/28360/wp094.pdf

[29] Wolfe, Nathan D., et al. 2005.

[30] Cuaresma, Jesús Crespo, et al. "Economic Development and Forest Cover: Evidence from Satellite Data." Scientific Reports. January 16, 2017; https://doi.org/10.1038/srep40678

[31] Wolfe, Nathan D., et al. 2005.

[32] Golden, C. D., and J. Comaroff. 2015. The human health and conservation relevance of food taboos in northeastern Madagascar. Ecology and Society 20(2): 42. http://dx.doi.org/10.5751/ES-07590-200242

[33] Gödecke, Theda, et al. "The global burden of chronic and hidden hunger: Trends and determinants." Global Food Security. June 2018; https://doi.org/10.1016/j.gfs.2018.03.004

[34] Gödecke, Theda, et al. 2018.

[35] Golden, Christopher D., et al. "Seasonal trends of nutrient intake in rainforest communities of northeastern Madagascar." Public Health Nutrition. May 21, 2019; https://doi.org/10.1017/S1368980019001083

[36] "Vegan diet can benefit both health and the environment." Harvard Chan School of Public Health. https://www.hsph.harvard.edu/news/hsph-in-the-news/vegan-diet-health-environment/

[37] Willett, Walter, et al. "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems." The Lancet. February 2, 2019; https://doi.org/10.1016/S0140-6736(18)31788-4

[38] Ritchie, Hannah and Roser, Max. "CO_2 and other Greenhouse Gas Emissions." Our World in Data. May 2017; https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

[39] Harwatt, Helen. "Including animal to plant protein shifts in climate change mitigation policy: a proposed three-step strategy." Climate Policy. November 26, 2018; https://doi.org/10.1080/14693062.2018.1528965

[40] "Stunting in a nutshell." World Health Organization. https://www.who.int/nutrition/healthygrowthproj_stunted_videos/en/

[41] Golden, Christopher D., et al. 2014.

[42] Jenkins, Richard K.B., et al. "Analysis of Patterns of Bushmeat Consumption Reveals Extensive Exploitation of Protected Species in Eastern Madagascar." PLoS One. December 14, 2011; https://doi.org/10.1371/journal.pone.0027570

[43] Golden, Christopher D., et al. 2019

[44] Kassebaum, Nicholas J. "A systematic analysis of global anemia burden from 1990 to 2010." Blood. January 30, 2014; https://doi.org/10.1182/blood-2013-06-508325

[45] Golden, Christopher D., et al. "Benefits of wildlife consumption to child nutrition in a biodiversity hotspot." PNAS. December 6, 2011; https://doi.org/10.1073/pnas.1112586108

[46] Golden, Christopher D. 2009.

[47] Weinbaum, Karen Z., et al. "Searching for sustainability: are assessments of wildlife harvests behind the times?." Ecology Letters. October 15, 2012; https://doi.org/10.1111/ele.12008

[48] "Sustainable Wildlife Management Programme. Madagascar: Executive Summary." Wildlife Conservation Society.

[49] Brook, Cara E., et al. 2018

[50] Brook, Cara E., et al. 2018

[51] Jenkins, Richard K.B., et al. 2011.

[52] Maminiaina, Oliver F., et al. "Newcastle Disease Virus in Madagascar: Identification of an Original Genotype Possibly Deriving from a Died Out Ancestor of Genotype IV." PLos One. November 15, 2010; https://doi.org/10.1371/journal.pone.0013987

[53] Golden, Christopher D. and Comaroff, Jean. "The human health and conservation relevance of food taboos in northeastern Madagascar." Ecology and Society. 2015; http://dx.doi.org/10.5751/ES-07590-200242

Resources from Learning Notes

IUCN and UNEP-CMC. The World Database on Protected Areas (WDPA). April 2016. https://wdpa.s3.amazonaws.com/Files_pp_net/Global_PAs_April_2016_w_logos.png

Convention on Biological Diversity. Accessed May 1, 2020. https://www.cbd.int/

WHO and UNFCCC. Climate and Health Country Proile-2015: Madagascar. World Health Organization, 2015. https://apps.who.int/iris/bitstream/handle/10665/246140/WHO-FWC-PHE-EPE-15.40-eng.pdf?sequence=1&isAllowed=y

Global Forest Watch. 2014. World Resources Institute. Accessed on May 1, 2020. www.globalforestwatch.org.

Nasi, R., D. Brown, D. Wilkie, E. Bennett, C. Tutin, G. Van Tol, and T. Christophersen. "Conservation and use of wildlife-based resources: the bushmeat crisis." Secretariat of the Convention on Biological Diversity and Center for International Forestry Research (CIFOR. Technical Series 50 (2008). http://re.indiaenvironmentportal.org.in/files/Conservation%20and%20use%20of%20wildlife-based%20resources.pdf

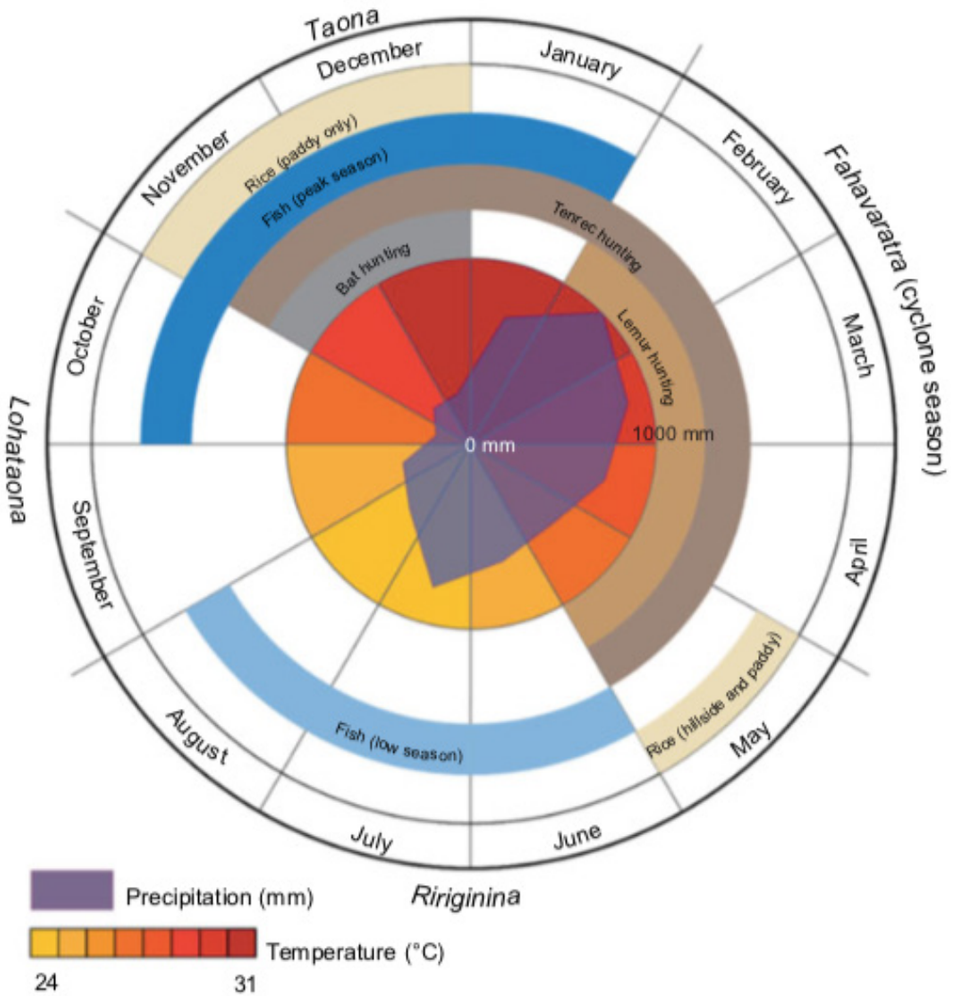
Muthayya, Sumithra, Jee Hyun Rah, Jonathan D. Sugimoto, Franz F. Roos, Klaus Kraemer, and Robert E. Black. "The global hidden hunger indices and maps: an advocacy tool for action." PLoS One 8, no. 6 (2013). https://journals.plos.org/plosone/article/figure?id=10.1371/journal.pone.0067860.g002

"Newcastle Disease." OIE: World Organistion for Animal Health. Accessed on May 1, 2020. https://www.oie.int/en/animal-health-in-the-world/animal-diseases/Newcastle-disease/

"Madagascar." Gavi. Accessed on May 1, 2020 https://www.gavi.org/programmes-impact/country-hub/africa/madagascar

Smith, Rob. "These are the countries that eat the most meat." World Economic Forum, August 29, 2018. https://www.weforum.org/agenda/2018/08/these-countries-eat-the-most-meat-03bdf469-f40a-41e3-ade7-fe4ddb2a709a/

"Plague." CDC. Last updated November 26, 2019. https://www.cdc.gov/plague/index.html


Taona
December
January
February
Fahavaratra (cyclone season)
March
April
May
June
July
August
September
Lohataona
October
November
Rice (paddy only)
Fish (peak season)
Bat hunting
Terrec hunting
Lemur hunting
0 mm
1000 mm
Fish (low season)
Rice (hillside and paddy)
Precipitation (mm)
Ririginina
Temperature (°C)
24
31