Exposure to UV radiation, oxygen, high temperatures, and microbial activity for an optimal duration can biodegrade some types of plastic. Those made from polymers such as aliphatic polyesters, bacterial biopolymers, and some bio-derived polymers can be biodegradable in the natural environment. However, many plastics labelled as biodegradable—including single-use plastic shopping bags and take-away food containers—will breakdown completely only when subjected to prolonged temperatures above 50°C. These are the conditions produced in an industrial composter. Such conditions are rarely met in the marine environment.\(^5\)

**Biodegradable**

Capable of being degraded by microorganisms such as bacteria and fungi. Biodegradation refers to a biological process of organic matter being completely or partially converted to water, carbon dioxide, methane, energy, and new biomass by microorganisms (UNEP 2015).
Chemical additives are often included during plastic manufacturing to generate or enhance certain properties. These properties often make the material more durable by introducing anti-microbial, flame retardant, UV resistance, rigidity, malleability, or waterproofing characteristics. Such enhanced plastic products include packaging materials, containers and bins, fishing nets, bottles, pipes, and furniture. After the product becomes waste, the chemical additives can potentially leach into marine organisms when they ingest the plastic and their systems attempt to digest. Potential adverse effects, at high enough concentrations, may include immunotoxicological responses, reproductive disruption, anomalous embryonic development, endocrine disruption, and altered gene expression.13-17
Common sources of microplastics

In the late 1990s, cosmetic and personal care manufacturers began to market ‘microbeads’ as abrasives in skin cleansers, toothpaste, shaving cream, and similar products. Researchers monitoring water quality began to find microbeads in public water reservoirs and natural environments by the mid 2000s. Investigators were able to trace the particles to the personal hygiene use in communities upstream of rivers, lakes, and seas. Following public awareness campaigns widely supported by consumers, some producers responded by agreeing to remove the material from their goods. The microbead issue has attracted considerable international attention and generated significant actions to address the pollution, particularly in Europe and North America. However, similar particles are still being introduced into water systems in other regions. Without appropriate wastewater treatment to capture particles of that size, microplastic will remain an important pollutant given extensive use of primary microplastics in industry and the generation of secondary microplastics in many sectors.

For instance, an abrasive application was designed as an alternative to stripping paint with toxic chemicals: primary microplastics are commonly used for surface blasting to remove rust, paint, and other unwanted surface coverings on buildings, cars, ships, and aircraft. While the abrasives are used repeatedly, they eventually break down to unsuitable size and are discarded. During their useful life, these plastic materials can become highly contaminated with heavy metals from the surface covering, such as cadmium, chromium, and lead.

Growing evidence suggests that fibres from synthetic fabrics are a significant source of secondary microplastics commonly found in wastewater and in the aquatic environment. The world’s consumption of synthetic fibres as clothing and textiles for domestic and industrial uses exceeded 55 million tonnes in 2013, or 61 per cent of the global consumption of all fibres. This reveals a sharp increase from 35.8 million tonnes
Plastic fibres—polyester, acrylic, and polyamides—are shed from garments through mechanical abrasion in washing machines and then drained with the effluent water.

The Norwegian Environment Agency found that emission of microplastic in wastewater from washing synthetic clothing is an order of magnitude higher than that from the personal care products and cosmetics. Experiments show that more than 1,900 microplastic fibres are released from a single synthetic garment in just one wash by a laundry machine. Their microscopic size and buoyancy allows these microplastic pollutants to pass through both the coarse (larger than 6 millimetre) and fine (1.5-6 millimetre) screen filters that are most commonly used in wastewater treatment facilities. They then end up in sludge or in natural water bodies that receive the effluent. Researchers estimate that about 10 per cent of synthetic fibres present in the wastewater can pass undetected through the treatment facility.

Another source of microplastic pollution is the plastic debris from mechanical abrasion of car tyres on pavement that is washed by rain, snow melt, and street cleaning into natural and municipal drainage systems. On-going research focuses on potential sources of microplastics. One monitoring and sampling investigation, conducted over many months of 2014 and 2015, suggests that atmospheric fallout delivers microplastics to whole landscapes, and to any closely associated marine environments. The study sampled an urban site and a suburban site in the region of Paris, France, and found fibres made up most of the microplastic deposition, that deposition at the urban site notably exceeded the suburban site, and that nearly 30 per cent of the fibres were synthetic, specifically made from hydrocarbons.
Plasticized food chains

Numerous studies in recent years have provided more evidence on the presence, distribution, and starting sources of microplastic. However, the current stage of knowledge does not provide a definitive explanation of how microplastic contaminants interact chemically and physiologically with various organisms at different trophic levels. Ultimately, the risks microplastics pose to human health through consumption of contaminated food need to be considered, but these are still difficult to determine. Researchers are attempting to answer these questions with focus on specific areas. First is the level of exposure.

In a recent study, a quarter of the marine fish sampled from markets in Indonesia and California, USA, were found to have plastic debris and fibres from textiles in their guts.33 Besides seafood, emerging evidence shows that the microplastics, especially synthetic fibres, have been detected in a variety of foods, including drinking water, beer, honey, sugar, and table salt.34-36 The presence of microplastic in foodstuffs could potentially increase direct exposure of plastic-associated chemicals to humans and may present an attributable risk to human health. However, on the basis of current evidence, the risk to human health appears to be no more significant than via other exposure routes.6

Many chemicals of concern, such as heavy metals and persistent organic pollutants (POPs) are present in the marine environment, and are taken up by marine organisms. Research has shown that harmful and persistent substances both bioaccumulate over time and biomagnify as predators eat prey, especially in species high in lipids (oils and fats). Depending on how much an organism consumes and how high it is on the food chain, each assumes some of the chemical burden of the prey and of the environment.37 In this manner seafood can become contaminated, particularly in higher-level predators such as tuna and swordfish, causing concern for human health, in some circumstances.38

Many POPs are hydrophobic, meaning they are repelled by water. When these chemicals encounter plastics in lakes and oceans, they are absorbed into the plastic surface. The degree of adsorption varies widely depending on different characteristics of the POP and its host, as well as other environmental variables. However, plastic resin pellets collected from the oceans and beaches have been found to contain POPs at orders of magnitude higher concentrations than the water.39

**Heavy metals**

Heavy metals normally occur in nature and are essential to life, but can become toxic through accumulation in organisms. Arsenic, cadmium, chromium, copper, nickel, lead and mercury are the most common heavy metals which can pollute the environment. Sources of heavy metals include mining, industrial production, untreated sewage sludge and diffuse sources.

**Persistent organic pollutants**

Persistent organic pollutants (POPs) are chemical substances that remain in the environment, are transported over large distances, bioaccumulate through the food web, and pose a risk of causing adverse effects to the environment and human health. POPs include pesticides such as DDT, industrial chemicals such as polychlorinated biphenyls (PCB) and unintentionally generated chemicals such as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).

**Bioaccumulate**

The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism. Bioaccumulation takes place within an organism when the rate of intake of a substance is greater than the rate of excretion or metabolic transformation of that substance.
Usually, when microplastics and the contaminants they sequester are detected in seafood, they are in the animal’s stomach. Except for shellfish, humans tend to remove and discard the stomach of the seafood they consume. The risk of chemical contaminants being transferred to humans would then depend on: i) the retention time of the particles in the fish gut, ii) the rate and degree to which contaminants are released from the plastic and cross the gut wall, iii) the degree to which fine particles might be translocated from stomach to other tissues of animals, and iv) the degree to which chemical contaminants can transfer from the consumed seafood to human body. At present scientists only have results from laboratory feeding studies using non-commercial fish species to examine contaminant transfer and accumulation in the tissues and that note any altered predatory behaviour. A number of these experiments with a range of marine species show that microplastics are able to translocate from stomach to other organs such as liver and hepatopancreas. Currently there is insufficient evidence to assess the potential for transfer of these contaminants to the fish flesh, and hence be made available to predators, including humans.

Different types of microplastics found in the Francisco Bay

**PCBs**

- Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants
- Endocrine disrupting chemicals

**DDTs**

- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

**HCH**

- Insecticide

**Nonylphenol (NP)**

- Antioxidant (TNP)
- Raw material of plastic additives
- Endocrine disrupting chemicals

**Plastic resin pellets**

Plastic resin pellets are the raw material for the manufacturing process of plastic items

**Video: Are microplastics in our water becoming a macroproblem?**

Video Link: https://www.youtube.com/watch?v=ZHCgA-nSwRW

Photo Credit: Coprid/ Shutterstock.com

**Microplastics typically found along the Rhine River**

Opaque spherules, fragments and fibres: (a/b) transparent spherules with gas bubbles, polymethylmethacrylate; (c/d) opaque spherules, polystyrene

Source: Mani *et al.* (2015)
Addressing the issue at the source

While more research to investigate the physiological, biological, and chemical interactions between microplastic and organisms is underway, it is imperative to continue with the effort by all stakeholders to reduce new influx of plastic into the environment. Concerted efforts have been made by various stakeholders to tackle the issue of microplastics at the source including governments, private sector and NGOs. The Netherlands intends to become the first country to be free of microbeads in cosmetics by the end of 2016. Member companies of the Dutch Cosmetics Association are working towards removing microbeads from their products. By 2017, 80 per cent of the companies are expected to have completed the transition to a microbead-free product line. In December 2015, the United States passed a law that prohibits the sale and distribution of cosmetic products containing plastic microbeads with a phase-out period until 1 July 2017 when the bead manufacturing will be completely banned. The legislation also preempts state laws and regulations related to microbeads, which helps close some loopholes, such as banning only non-biodegradable plastic microbeads. Other countries such as Australia, Canada, and the United Kingdom are following suit.

As a front runner in raising awareness of the issue and campaigning against the use of microbeads, the Beat the Microbead initiative has so far attracted more than 79 NGOs from 35 countries and 59 companies in the cosmetic industry to join the effort. A smartphone App developed by the initiative has been used by consumers around the world to scan the bar code to check for the presence of microbeads in personal care products available in the market.

The European Union through its project, MERMAIDS, works to address the issue of microplastic fibres released through textile washing processes into the European waters. The project is investigating different technologies that can capture released fibres in the washing process, or prevent the breakage of fibres from garments through innovative textile or detergent additives.

Starting in 1992, with the goal to minimise the impact of pellet leakage into the environment, the Operation Clean Sweep initiative has become even more relevant as the issue of microplastic has become a global challenge. It is an example of industry-driven effort with the aim to prevent raw plastic materials such as plastic pellets, flakes, and powder from entering the waste stream. Targeting different segments of the plastic industry including supplier, manufacturer, and transport operators, the initiative aims to achieve a zero loss of these materials through better containment, reclamation, and proper disposal.

Further engagement of other relevant industries that use primary microplastics in their industrial processes or indirectly generate secondary microplastics is crucial. Textile industries may have an important role to play in research and development for synthetic textiles that shed fewer fibres, or simply minimise the use of synthetic material in their products. Involvement of the producers of washing machines

Video: Operation Clean Sweep

© Operation Clean Sweep/American Chemistry

Video Link: https://www.youtube.com/watch?v=54QQ8t8TePY

Photo Credit: XXLPhoto/ Shutterstock.com
is necessary for the enhancement of filtering capacity to effectively capture microscopic fibres from drain water. The shipyard, aviation, and automobile industries are key in the reduction of microplastic leakage through the effective containment and appropriate disposal of spent abrasive blasting materials and generated dust.

Recognizing the environmental and economic impacts of plastics in the marine environment, in June 2014 the United Nations Environment Assembly, represented by over 163 countries, adopted a resolution on marine plastic debris and microplastics to address the issue through legislation, improved waste management, efficient use and sound management of plastics, enforcement of international agreements, and education. The G7 summit in June 2015 expressed their commitment to address the land-based and sea-based sources of marine litter by improving waste management, searching for sustainable solutions to reduce or prevent microplastic pollution, and promoting best practices throughout the plastic value chain. In September 2015, world leaders agreed on a specific target to “prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution” by 2025 (SDG Target 14.1) of the Sustainable Development Goals (SDGs). However, indicators to be used for monitoring progress towards the target are currently under development among governments and stakeholders.

Concentration of PCBs in plastic resin pellets collected from beaches around the world

Concentration of DDTs in plastic resin pellets collected from beaches around the world

Photo Credit: UN Photo/Martine Perret

© International Pellet Watch

© International Pellet Watch
References


Loss and Damage: Unavoidable Impacts of Climate Change on Ecosystems

What is Loss and Damage?

Anthropogenic climate change is underway and will continue for the foreseeable future. It is manifesting more rapidly and more intensely than many expected.\textsuperscript{1,2} The most recent global assessment by the Intergovernmental Panel on Climate Change indicates that the world has become 0.85°C warmer than in the late nineteenth century and extreme weather events are likely to become more frequent. Increase in the frequency, intensity and/or amount of heavy precipitation is to be expected; drought is to become more intense and prolonged in many regions; and incidence and/or magnitude of extreme high sea level is likely to increase.\textsuperscript{1} These climatic changes and extreme events pose an unprecedented threat to people, ecosystems, assets, and economies.

Mitigation and adaptation—described as avoiding the unmanageable and managing the unavoidable, respectively—remain the most important paths to reduce the adverse effects of a changing climate.\textsuperscript{3,4} However, given the delays over the last 25 years in accomplishing mitigation and the late start on tackling adaptation, scientific evidence indicates that limits to adaptation are clear and that losses and damages from climate change in human and natural systems are inevitable.\textsuperscript{5-8}

While there is no universally agreed definition to date,\textsuperscript{8-11} the term ‘loss and damage’ may be used to describe the adverse effects of climate change that cannot be avoided through mitigation measures or managed through adaptation.
Loss and damage become evident when adaptation measures are unsuccessful, insufficient, not implemented, or impossible to implement; or when adaptation measures incur unrecoverable costs or turn out to be measures that increase vulnerabilities, called maladaptations. Loss and damage can occur from a spectrum of climate change impacts, ranging from sudden onset events such as cyclones, hurricanes, flash floods, and landslides to slow-onset processes such as increasing average temperature, sea level rise, drought, soil salinization, and ocean acidification. Extreme events alter ecosystems. As a result, they disrupt food production, water supply, infrastructure and settlements, and human lives and livelihoods. With more than 60 per cent of the ecosystems and their services already degraded or exploited unsustainably. Climate change will cause further changes and adverse consequences, including alterations in the efficiency of ecosystem services. Understanding the serious implications of loss and damage should motivate policy makers, governments, communities, and individuals to minimize, and ultimately prevent, losses and damages.

**Video:** Interview with Frans Berkhout, King’s College London

---

Global patterns of observed climate change impacts reported since AR4. Each filled symbol in the top panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the bars. Regional-scale impacts where climate change has played a minor role are shown by outlined symbols in a box in the respective region. Sub-regional impacts are indicated with symbols on the map, placed in the approximate area of their occurrence. The impacted area can vary from specific locations to broad areas such as a major river basin. Impacts on physical (blue), biological (green), and human (red) systems are differentiated by color. This map represents a graphical synthesis of Tables 18-5, 18-6, 18-7, 18-8, and 18-9. Absence of climate change impacts from this figure does not imply that such impacts have not occurred.

---

**Video Link:** https://www.youtube.com/watch?v=Pp8WEhG2UHs
Expected loss of ecosystems and their services

There are a number of sudden- and slow-onset events in recent years that may be attributable to climate change and have caused losses and damages to human systems and ecosystems. Since 1950 heat wave frequency has increased in large parts of Europe, Asia, and Australia.\(^1\) The European heat wave of 2003 is seen as the shape of things to come, reflecting temperature that are extreme now, but projected as normal summers in the later 21st century.\(^{20,21}\) To some degree this event can be attributed to climate change. Recent studies suggest that severe heat waves, formerly occurring twice a century, are now expected to occur twice a decade.\(^22\) Direct and indirect consequences of the 2003 heat wave on human and ecosystems were devastating. At least 30,000 people died as a consequence of the high temperatures and their persistence over a period of three months.\(^23\) The economic losses in the European Union’s agricultural sector amounted to US$14.7 billion.\(^{24}\) It caused a significant decrease in glacier volumes across the continent and damaged montane permafrost through increased thawing. Alpine glacier mass reduced by 10 per cent in that year.\(^{25}\) Water resources, already stressed from high temperatures and precipitation deficit, were put under further pressure from substantially increased demand for water supply and electricity generation.\(^{23,26-29}\)

Examples of sudden-onset events include the powerful typhoon Haiyan (Yolanda) in 2013 that killed 6,300 and left nearly 800,000 people displaced.\(^{30}\) Aside from this direct harm to people, both agriculture and ecosystems were affected, especially in coastal zones.\(^{31}\) An estimate of 260,000 tons of rice production was lost due to strong winds and continuous inundation.\(^{32}\) Haiyan’s storm surges were exceptionally high.\(^{33,34}\) The sea level rise associated with climate change can increase the height of storm surges.\(^{35}\) For the Philippines, the sea level was already 30 centimetres higher than that in 1993.\(^{36}\) A storm surge in Tacloban was found to reach a maximum inundation height of 7 metres above sea level.\(^{34}\) Along Samar Island, the surge contaminated surface water and deeper aquifers that supply water to local communities. It will take many years to recover.\(^{37}\)

The Sahel and the semi-arid drylands of East Africa are in many ways emblems of climate change vulnerability. The regions have faced challenges such as crop and livestock losses, food insecurity, displacement, cultural losses including traditional livelihood systems, and conflict. Many of these challenges are caused by climate variability and exacerbated by climate change. At the beginning of 2015 an estimated 20.4 million people were food insecure as a result of ongoing drought mostly in Niger, Nigeria, Mali, and Chad where conflict and poverty compound food insecurity.\(^{38}\) The Sahel seesaws between drought and flood events, and increased drying temperatures have partially offset the recovery of rainfall since...
the great drought of the 1980s. During the same period in much of East Africa, rainfall trends have declined.39-42

From 2012 through 2015, California experienced the most severe drought in the last 1,200 years.43 A range of scientific research has suggested a link between anthropogenic warming and an increase in the occurrence, strength, and length of high impact droughts in this region of the U.S. The economic impacts of drought on California agriculture in 2015 alone were estimated at US$2.7 billion.44 About 60 per cent of water supply to California comes from groundwater.45 The groundwater storage has been overdrawn for many decades. The long period of drought drastically increased groundwater withdrawal and, as a result, lowered the groundwater level and storage capacity.46 Reduced rainfall also means less replenishment for the underground aquifer. This has led to an irreversible aquifer-system compaction, causing the land to subside. In 2014 a large area measured 96 kilometres long subsided further by 33 centimetres as a result of this recent drought.47
Reducing risks associated with climate change

The Sendai Framework for Disaster Risk Reduction 2015-2030 is an internationally agreed framework that guides the risk management of multiple hazards including those associated with climate change. A number of risk management strategies and instruments described in the framework can be considered as transitional through mitigation and adaptation to loss and damage. These include: risk reduction, risk retention, risk transfer, and approaches to specifically deal with slow-onset events. Applying these strategies, and following through, could reduce loss and damage by enabling management through adaptation.

Risk reduction measures are implemented before the advent of a weather event or climatic process to prevent loss and damage and can be structural or non-structural. For example, sea level rise is considered a slow-onset threat and often not apparent until a convergence of circumstances delivers an extreme event. Most recent projections of sea level suggest a global average rise of up to 1.30 metres by 2100. Further research suggests that global average sea level will continue to rise for at least 5,000 years. These projections of rise in sea level may seem gradual and in a distant future. However, when extreme low pressure, high tides, an unobstructed angle of approach, strong winds, and a long fetch converge to produce extreme storm surges, ever rising sea level becomes a more relevant part of coastal life. This is what happened in the case of Typhoon Haiyan and also when Hurricane Sandy hit the Greater New York City region in 2012. New York City had been implementing an adaptation strategy before the event, since 2008, so when Sandy arrived decision makers could reduce risks through strategic actions during the event.

Risk transfer is a practice of formally or informally redistributing the risk of financial consequences for particular negative events from one party to another. The variety of risk transfer mechanisms, such as insurance, form an essential part of disaster risk management strategies. Insurance tools play a role in preventing and managing loss and damage caused by events which cannot be foreseen when and where they occur. Insurance is used to address the consequences of extreme weather events but is not generally feasible for slowly developing and foreseeable events that happen with high certainty under different climate change scenario. Insurance is not optimal for events that occur with very high frequency, such as recurrent inundation of flood plains.

Risk retention refers to approaches that allow country to “self-insure” against climate stressors by means of its own social, economic, cultural, and other resources. For example, social protection measures can help societies to bounce back from the onset of unexpected severe weather events, and build resilience of the population to slow onset climatic processes. Establishing financial reserves to cushion the unexpected financial consequences from climate change impacts help repair the damage, and help societies recover from losses. Risk retention works more effectively when implemented together with other risk management approaches.

Video: Interview with Koko Warner, United Nations University

Video Link: https://www.youtube.com/watch?v=gSQCb3WwMCc
Progress on addressing Loss and Damage

In 2013 the UNFCCC specifically addressed loss and damage associated with the adverse effects of climate change by establishing the Warsaw International Mechanism on Loss and Damage. The Paris Agreement that emerged from the 2015 UNFCCC Conference of the Parties strongly recognised loss and damage by making the Warsaw International Mechanism a permanent institution. The Agreement calls on Parties to recognise “the importance of averting, minimising and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage”.

The Paris Agreement proposes several areas for international cooperation and facilitation to enhance understanding, action, and support including early warning systems; emergency preparedness; slow onset events; events that may involve irreversible and permanent loss and damage; comprehensive risk assessment and management; risk insurance facilities, climate risk pooling, and other insurance solutions; non-economic losses; and resilience of communities, livelihoods, and ecosystems.

Increasing international efforts to support developing countries to avert, minimise, and address loss and damage including through the Warsaw International Mechanism will be important. The UNFCCC, the 2030 Agenda for Sustainable Development, and the Sendai Framework for Disaster Risk Reduction provide a framework through which loss and damage can be addressed. Institutional and legal frameworks that are applicable at various scales will also be essential.

To implement comprehensive risk management strategies that reduce and avert loss and damage, decision makers will need a better understanding of the potential range, magnitude, and location of future climate change impacts. Enhancing understanding of the role of ecosystem services to human well-being is crucial to informing policy responses.

When ecosystems are not functioning at optimal standards, their provisioning capacity becomes unstable and their regulating of Earth systems can fail. Averting loss and damage must include ways to safeguard ecosystems and their services that underpin human abilities to protect against loss and damage. The research community has a critical role to play in developing innovative tools and measures to address loss and damage. But the most important role is to deliver capacity to communities at the frontline of ecosystem destruction who need substantial investment and incentive to avert damage to and loss of ecosystems and their services.

With the growing scientific knowledge on the residual impacts of climate change, it is imperative that societies anticipate loss and damage, and are prepared well enough to avert it.

Video: Interview with Saleemul Huq at COP 21 in Paris

© Acclimatise

Video Link: https://www.youtube.com/watch?v=kJI8F_6mGmY
References


Climate changes trigger accumulation of toxins in crops

Climate change is already underway, with shifting weather patterns that will present serious challenges to agricultural productivity. Each of the past several decades has been significantly warmer than the previous one. The period 2011–2015 was the hottest on record, and 2015 was the hottest year since modern observations began in the late 1800s. The 2013 global assessment released by the Intergovernmental Panel on Climate Change reports that since 1950 the frequency of heat waves has increased in large parts of Europe, Asia, and Australia; that the frequency and intensity of droughts have increased in the Mediterranean and West Africa; and that the frequency and intensity of heavy precipitation events are likely to increase in North America and Europe.

Given that more than 70 per cent of agricultural production relies on rainfall, increasing climate variability poses an unprecedented challenge to agriculture and to food production systems around the world. Climate threats to food security are expected to be worse in countries at subtropical and tropical latitudes. For instance, the frequency, severity, and range of droughts in the entire African continent have significantly increased between 1900 and 2013. Specifically in East Africa, the well-documented 2010–2011 drought greatly affected agricultural yield and increased food insecurity in the region. In 2015-2016, El Niño-related dry conditions reduced crop production in parts of Asia, Central America, the Caribbean, and Oceania, while drought conditions in East and Southern Africa resulted in decreased cereal production. Analysis of detailed crop
statistics time series suggests that between 32-39 per cent of the fluctuations in observed global crop yield is a direct result of climate variability, particularly for maize, rice, wheat, and soybean.⁹

Extreme climatic conditions reduce yields and increase postharvest losses. They also trigger biophysical reactions in plants in response to environmental stresses. These reactions include concentrating chemical compounds that are harmful to animal and human health. Despite a plant’s various protective responses, in prolonged unfavourable conditions stress can overwhelm its ability to thrive, and can weaken the plant further, leading to increased disease susceptibility. In such cases, either the plant itself or invading microbes can produce specific chemical compounds at levels toxic to human health.

SPEI Global drought map

© SPEI Global Drought Monitoring
http://sac.csic.es/spei/map/maps.html

Video Link: https://www.youtube.com/watch?v=IbpuvI5-s4c

Photo Credit: Earl D. Walker / Shutterstock.com
Contamination pathways—implications for crops, animals, and people

Worldwide, over 80 plant species are known to cause poisoning from accumulation of nitrates. Under normal growing condition, plants convert nitrate into amino acids and protein. Drought conditions slow or prevent the conversion, causing nitrate to accumulate indefinitely to the level that becomes toxic to animals. Common crop plants most susceptible to nitrate accumulation are barley, maize, millet, sorghum, soybean, sudangrass, and wheat. When cattle, sheep, and goats consume large quantities of high nitrate plants, their ruminant digestive processes cannot break down the nitrate fast enough to avoid poisoning. Acute nitrate poisoning in animals can lead to miscarriage, asphyxiation, and death. Nitrate poisoning in livestock can ruin the livelihoods of smallholder farmers and herders.

Sufficient rain can revitalize plant growth and help reduce nitrate accumulation. However, after a drought-breaking rainfall or irrigation inflow, rapid growth in water-stressed plants could result in dangerous accumulation of another toxic compound called hydrogen cyanide or prussic acid. Examples of plants that can accumulate prussic acid are cassava, flax, maize, sorghum, sudangrass, arrow grass, velvet grass, apricot, peach, cherry, elderberry, and apple. Another important category of toxin associated with changing climate is mycotoxins, chemical by-products of fungal growth. Mycotoxins can cause severe damage to the health of animals and humans even at small concentration. Mycotoxin-producing fungi infect many crops such as coffee, groundnut, maize, oilseeds, peanut, sorghum, tree nuts, and wheat. An estimate in 1998 suggested that mycotoxins contaminated at least 25 per cent of cereals worldwide.

Aflatoxins are a type of mycotoxin produced by a species of Aspergillus fungi. About 4.5 billion people in developing countries are exposed to uncontrolled and unmonitored amounts of aflatoxins. Acute exposure can be lethal, while chronic exposure can lead to cancer. Evidence further suggests it may also stunt foetal and infant development, block nutrient uptake, and suppress immunity. Poorer farmers may feed mouldy grains to livestock, but this is not a safe option. Aflatoxins and other mycotoxin contaminants can reduce animal productivity and increase mortality, and they can persist in animal-sourced food products such as milk to impair human health and nutritional status.
A study of aflatoxin occurrence in Serbian maize confirms that the contamination detected in the 2012 maize harvest resulted from that year’s prolonged warm weather and extreme drought conditions. Normally, environmental and climatic conditions in Serbia and other temperate regions do not favour the growth of aflatoxins, in contrast to tropical and sub-tropical zones where aflatoxin contamination is more evident. However, the risk of aflatoxin contamination, particularly in maize, is expected to increase in higher latitudes due to rising temperature. A recent model study predicts that aflatoxin in maize will become a food safety issue for Europe, especially in the most likely scenario of a 2°C increase in global temperature. Areas at high risk of aflatoxin outbreaks include Eastern Europe, the Balkan Peninsula, and the Mediterranean.

Risk maps for aflatoxin contamination in maize at harvest in 3 different climate scenarios, present, +2 °C, +5 °C

![Risk maps for aflatoxin contamination in maize at harvest in 3 different climate scenarios, present, +2 °C, +5 °C](image)

Source: Battilani et al. (2016)
Material available under Public License, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4828719/
Remediating toxic contamination in plants and animals

We are just beginning to recognize the magnitude of toxin-related issues confronting farmers in developing countries of the tropics and sub-tropics. As warmer climate zones expand towards the poles, countries in more temperate regions are facing new threats. Deteriorating climatic conditions combine with enhanced capacities of diagnostic surveys for toxin detection to reveal that more and more global food stocks appear to be at risk of contamination. The effects of other environmental cues on plant-pathogen interactions or on a plant’s own biochemical responses have yet to be resolved. However, it is clear that more extreme environmental conditions can trigger toxin accumulation in crops. The ability to detect these toxins is becoming less expensive and more mobile, which will help ensure that the food being produced and consumed is safe.

Growing recognition of these challenges has prompted a range of efforts to understand, prioritize, and respond. In at-risk regions, an important start has been made on programmes to increase productivity and reliability of crops that are less susceptible to toxin contamination. These are combined with drought and disease surveillance programs and warning systems. Such mutually reinforcing efforts can help deploy effective strategies and targeted rapid responses to outbreaks when climatic conditions become severe.

At the global and regional level, relevant programmes are underway: the Comprehensive African Agricultural Development Program; the African Union Commission’s Partnership for Aflatoxin Control in Africa (PACA); food safety and regulation efforts by the UN Food and Agriculture Organisation (FAO), the World Food Programme, and the World Health Organization; and the 2030 global agenda for sustainable development with a specific sustainable development goal seeking to “end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.” Some research focuses on strategies to develop more varied drought-tolerant or disease-resistant crops, including genome editing to eliminate genetic elements underlying susceptibility to risky diseases or toxins; transformation with disease resistance, drought tolerance, or toxin-degrading genes; and characterization of available agro-biodiversity options for on-farm production, for both the crop itself and the microbial communities influencing productivity and stress tolerance.

A growing number of projects are applying science-based solutions to address these health and development challenges. Examples include accelerating the international network of National Agricultural Research Systems (NARS)—supported by FAO, the Consultative Group for International Agricultural Research (CGIAR), and their constituent agencies—as well as international plant breeding efforts and technologies; bio-control strategies to apply natural antagonists of toxin-producing fungi in farmers’ fields, proper postharvest drying and storage; and development of mobile diagnostics and decontamination. Risk assessment and mapping is a powerful tool for decision making based on an understanding of various aspects of contamination risk. Some research focuses on strategies to develop more varied drought-tolerant or disease-resistant crops, including genome editing to eliminate genetic elements underlying susceptibility to risky diseases or toxins; transformation with disease resistance, drought tolerance, or toxin-degrading genes; and characterization of available agro-biodiversity options for on-farm production, for both the crop itself and the microbial communities influencing productivity and stress tolerance.
Persistent high levels of aflatoxins—naturally occurring carcinogenic byproducts of common fungi on grains and other crops—pose significant health risks to animals and humans in many tropical developing countries.

Chronic exposure to aflatoxins leads to liver cancer and is estimated to cause as many as 26,000 deaths annually in sub-Saharan Africa. This infographic depicts the ways that aflatoxins persist throughout the food chain. At each level, research can help understand how to manage risks.

**Susceptible Crops**
- Field crops infested with aflatoxin
  - Tree nuts
  - Spices
  - Oilseeds
  - Cereals

**Poor Storage**
- Toxins increase during storage

**Animal Consumption**
- Animals and dairy are infected from contaminated feed

**Human Consumption**
- Humans consume toxins in staple foods and dairy products

**Impact on Dairy Production**
- Livestock produce less, loss of income and food

**Impact on Human Health**
- Consumers experience liver cancer, poisoning
  - Acute poisoning
  - Liver cancer
  - Linked to stunting and immunosuppression

**Distribution of liver cancer cases attributable to aflatoxin in different regions of the world**

- **Europe**: 0%
- **Africa**: 40%
- **Western Pacific**: 20%
- **Southeast Asia**: 27%
- **North America**: 0%
- **Eastern Mediterranean**: 10%
- **Latin America**: 3%

Data Source: Liu and Wu (2010)
Integrated approaches to meet the challenge

As farmers and consumers the world over face increasing challenges to boost food production, an aggressive strategy to safeguard agricultural yields in drought-prone areas is an essential part of efforts to safely feed the world’s growing population. Mitigation strategies are being resolved, tested, and scaled up. These efforts must be significantly expanded and accelerated to secure a safe harvest for current and future generations.33

National and regional agricultural systems – from research to extension to policy and regulatory – must be engaged and strengthened to sustainably address these complex challenges at appropriate intervention points. A number of critical elements are lacking today that can be addressed through such strategically inclusive and integrated research for development systems.

1. Building the evidence base for the prevalence and human health implication of various toxins, particularly for long-term exposure to sub-acute levels of toxins in the diet.
2. Recognising the interactions between animal health, human health, and the environment and addressing the issue in the context of One Health and EcoHealth approaches.
3. Characterizing and modelling the factors affecting toxins’ accumulation in different crops, and identifying mitigation measures that are effective, adoptable, and scalable within different farming and agroecological systems.
4. Prospecting existing or traditional on-farm practices for solutions.
6. Using risk assessment and mapping to predict contamination hotspots and assess mitigation options.
7. Advancing and deploying mobile testing, and incentivizing farmers by providing an alternative-use market for contaminated products where possible.
8. Continuing research to continually evolve options to produce a sufficient and safe harvest in marginal areas around the world.

Technology solutions must work in concert with stakeholder consultations and be supported by agricultural field extension in rural communities. Appropriate and effective capacity building at various levels must underpin intervention deployment. Equipped with a rapidly increasing understanding of the hidden dangers of crop production under changing climate, we must work to secure a sufficient and safe harvest for all.

Video: Intiatives to tackle the aflatoxin contamination in Africa

© UNEP
References


Photo Credit: UN Photo/Fred Nay
Pet trade

As the passengers at the Cairo International Airport gathered to board a recent flight to Kuwait, one solitary man was different from the rest. It was not his height or his clothes that set him apart, or even his nationality. It was the fact that he had a live chimpanzee in his carry-on bag.

When officials behind the security x-ray machine saw the skeleton of a hunched-up animal on their screens, they unzipped the suitcase to find an infant chimpanzee staring up at them.

Egyptian customs officials confiscated the chimpanzee, which is an endangered species listed as Appendix I by the Convention on International Trade in Endangered Species (CITES). Trade is prohibited in such species in all but the rarest of cases, and then only with proper documentation – of which this shipment had none.

But the attempt to smuggle an exotic animal through a major international hub only hints at the massive and lucrative illegal trade in live animals that threatens to decimate wild populations and ecosystems, even as it exposes entire cities and regions to corruption, violence and deadly diseases.

Great apes and other live animals comprise a highly profitable and symbolic aspect of the US$23 billion illegal wildlife trade—the fourth most lucrative black market after drugs, people and arms smuggling – and the live trade relies heavily on corrupt officials and steely couriers to sustain the traffic. Commonly known as the “pet trade,” this criminal network is able to
supply cheetahs to the United Arab Emirates, bonobos to Armenia, macaws to the Czech Republic, and chimpanzees to China. Although data on the scale and scope of the live illegal wildlife trade is limited, it is clearly big business that attracts drug cartels, arms suppliers, counterfeit organizations, and a host of other illegal networks.

It is estimated that millions of live animals and plants are shuttled illegally around the world each day, sometimes as openly as the infant bonobo that was hand-carried in a bassinet like a baby through the Paris airport in 2006, or the gibbon stuffed inside a suitcase that was discovered at the Jakarta airport in 2014. Exact numbers are difficult to come by, but it is estimated that 40,000 live primates, 4 million live birds, 640,000 live reptiles, and 350 million live tropical fish are traded globally each year. In a single market in North Sulawesi, Indonesia, up to 90,000 mammals were sold in a single year, and a survey at a market in Thailand that spanned 25 weekends found 70,000 birds, representing of 276 species, were sold. A similar survey of four markets in Bangkok found that of the 36,537 birds observed, only 37% were native to Thailand, while 63% were nonnative species. There is a growing number of documentaries and news briefings on this issue.

The illegal trade in live animals is markedly different than the more commonly discussed traffic in elephant ivory, rhino horn, shark fins or pangolin scales. To begin with, all of those commodities are dead, and carry little of the urgency – or risk – associated with the live trade. Animals transported alive nearly always require a courier, a human being to accompany them along the supply line, thereby raising the stakes for law enforcement and seizure if an arrest is made. The live trade is also time-sensitive – most animals cannot survive for long in the cramped, contrived manner in which they are shipped – so the fastest route is usually the favored route.

Disease transmission

The live trade often requires a degree of corruption in order to pass through customs and security check-points, but the greatest risk is posed by the illicit traffic of animals and plants is the threat of disease transmission. None of the fauna or flora that comprises the illegal live trade goes through quarantine or any veterinary screens. As a result, animals – many of whom have been kept in unsanitary conditions for days and weeks – pass through transit countries and arrive at their destinations carrying all of the bacteria and parasites capable of spreading diseases.

In fact, experts point to pandemics such as severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), Avian flu, Monkeypox and even Ebola as some of the diseases most likely to make the jump to global human populations in the future as a result of the live trade in illegal wildlife. Since 1980, a new infectious disease has emerged in humans at an average of one every four months. The origin of HIV is likely linked to human consumption of nonhuman primates, for instance, and recent Ebola hemorrhagic fever outbreaks in humans have been traced to contact with infected great apes that are hunted for food. Meanwhile, the SARS-associated coronavirus has been associated with the international trade in small carnivores.

Many diseases are transmitted through the same species of parasites carried by imported animals. From November 1994

Photo Credit: Sumatran Orangutan Conservation Programme
to January 1995, the U.S. Department of Agriculture inspected 349 reptile shipments from 22 countries containing 117,690 animals. Ticks were removed from animals in 97 shipments, and infested shipments included 54,376 animals. Ticks carry many diseases that threaten livestock and human health, including heartwater disease, Lyme disease, and babesiosis.

But what about the animals themselves? A wide range of factors are used to gauge the real loss to wild populations of the live illegal pet trade – such as 10 dead chimpanzees killed during the hunt and capture for every live specimen that is procured for sale – but most of those numbers are inexact, or require verified data as to the size and location of wild populations. CITES used to require countries to monitor the loss of specimens held in captivity prior to trade, but that rule was quietly dropped in 2007. Nevertheless, a recent study by Pro Wildlife show that, incredibly, up to 100 percent of birds in Senegal and Indonesia, up to 85 percent of ornamental fish in India and Hawaii, and up to 50 percent of chameleons in Madagascar die after they’re captured and before they’re exported.

Yet even those species that do survive the gruesome ordeal of capture and trade face an uncertain future. Many countries face crisis-level issues related to invasive species that have been imported and then released, turning ecosystems inside out and decimating native wildlife populations. The exotic pet trade is responsible for six species of pythons being introduced into Florida in the U.S., and a 20-year study indicates that 52 other species have become established there as well. As a result, the U.S. spends over $135 million USD each year on programmes to eradicate invasive species.

Yet a series of confiscations and arrests in recent months suggests that the global trade remains considerable – and consistent. In July 2015, officials at the Kuwait airport intercepted a pair of infant orangutans being smuggled into the country from Indonesia, and six months later, and Qatar law enforcement officials arrested a man attempting to sell a live chimpanzee in the Doha suburb of Al Aziziya. Meanwhile, a pet tiger fell off a truck in Doha in late 2015 and spent several hours wandering among the city’s rush-hour traffic.
Main international routes for the illegal trafficking of great apes

Origin and destination
- Area of origin
- Transit country
- Main markets

Main smuggling routes recorded
- By air
- By land
- By sea

 Trafficking hotspots
- Main hub or transit point
- Main exit airport
- Main destination


Photo Credit: GRASP
The Middle East has long played a pivotal role in the illegal traffic of live animals. Beginning in the 1990s, it was a destination market to supply the private menageries of the wealthy elite, and many of the Gulf States established pipelines to exotic wildlife cartels in Egypt. A decade later, however, the Middle East had evolved into a transit market to feed the burgeoning live animal trade in China, Thailand and other Asian consumers.

Today, the Middle East serves as both a transit and destination market for illegally traded wildlife, an industry that now uses the internet and popular social media sites such as Facebook and Instagram to contract customers. But it’s not just great apes, and it’s not just the Middle East. Millions of live animals and plants – many of them endangered or critically endangered species – are being moved between major cities via airports and ports and rail routes every day, all going to serve lucrative markets.

According to data from the United States Fish and Wildlife Service (USFWS), 3,726 illegal shipments containing nearly 330,000 live animals attempted to enter the United States between 2005 and 2014. Yet much of the trade is still invisible.

It is estimated that less than 10% of illegal wildlife is actually detected. Analysts suggest that as many as 13 million live animals were actually brought into the U.S. in that time period – and up to 9.7 million of them died before they reached the intended buyer.

The U.S. trade data found that some of the most popular wildlife in illegal trade included tropical fish, freshwater turtles, coral, and pythons. In fact, the U.S. data reported that 53,799 individual tropical fish were seized during the 2005-2014 period, along with 68,680 turtles and 18,000 pythons. Coral, which is sourced for jewelry and other artifacts, was almost entirely illegal and sourced from the wild (91 percent).

Rare and exotic birds also comprise a huge element of the live illegal trade in wildlife. BirdLife International estimates that several million birds are trafficked annually from 4,000 species involved in the domestic and international trade, many of them traded as infants and stuffed head-first into plastic water bottles to avoid detection. It is estimated that one-third of all living bird species have been recorded as traded internationally for the pet trade and other purposes. Given that 266 of these species are considered globally threatened, and over half of these (152) are faced with potentially unsustainable exploitation, it is now estimated that 1,375 species – or 13% of extant species, basically one in eight -- are globally threatened with extinction.

The most commonly affected families of birds involved in the pet trade include finches, weavers, parrots and raptors. Small birds comprise 70 percent of the trade, while large birds such as macaws, parrots, cockatoos, parakeets, and lorikeets account for 20 percent of the trade. Prior to the enactment of the Wild Bird Conservation Act in 1992, approximately 800,000 wild-harvested birds were imported annually to the U.S. to supply the pet trade.

Reptiles and amphibians are also big-ticket items among the exotic and illegal pet traders. In late 2014, a Chinese national named Kai Xu – also known as “Turtle Man” – was apprehended at the Canadian border with 51 live turtles
carefully taped to his legs and hidden in his groin. Xu was already a suspect in the smuggling of thousands of reptiles all over the world, and his arrest in the Detroit-Windsor tunnel that connects the U.S. to Canada was a major break in cracking the illegal live trade.

A few weeks later, Xu, while out on bail, drove a hired car to Detroit Metropolitan Airport in the U.S. His accomplice carried two suitcases containing almost 1,000 turtles – valued at over $30,000 USD on the black market. Agents made the discovery while inspecting the bags, and both men were arrested and faced federal charges. Experts say that some endangered turtles can be sold for $1,800 USD in North America and Europe, and triple that amount in China.

Meanwhile, Egyptian customs officials made another horrifying discovery in April 2016 when they detected suspicious movement while monitoring the X-ray baggage scanner. Sixty Egyptian cobras – one of the largest and deadliest snakes in Africa -- were found to be stuffed in six bags inside two foam boxes and surrounded by ice to keep their movement limited, their mouths closed with surgical thread.

**Exotic consumerism**

But what facilitates this live trade in illegal wildlife? Clearly, markets willing to pay $40,000 for a gorilla in China or $10,000 for a Cheetah in Kuwait are enough to sustain the supply lines, and the rapidly expanding use of social media sites such as Facebook and Instagram to advertise wildlife makes transactions easier than ever. A recent survey by TRAFFIC of 14 Facebook sites in Malaysia over a period of five months uncovered over 300 wild, live animals for sale as pets, including gibbons, sun bears, binturongs and other endangered species – but the fact that those posts involved 106 different sellers indicates the widespread nature of the problem.

The illegal trade in live animals is also a big enough business to attract drug cartels. In Mexico, the record high prices offered for sea cucumbers -- a slug-like species that is considered a delicacy in Asia and sells for $500 USD per kilogram -- led to pitched battles between rival gangs in Yucatán and Campeche in 2014. One year later, 10 armed men attacked three armed guards and stole 3.5 tonnes of dehydrated sea cucumber in El Cuyo on the Yucatán peninsula, and Mexican customs officials followed soon after.

**Video: Exotic animal species smuggled**
thereafter with a seizure of 17 tonnes of live sea cucumbers at the Cancun International Airport, the largest confiscation ever of that species.

Sea cucumber numbers have plummeted across Latin America, with the fisheries depleted on Ecuador’s mainland coast and in the Galapagos Islands, and highly impacted in Mexico.

Back in Egypt, meanwhile, pet shop owners alternate between the internet and walk-up business to deliver the goods. Many stores promise same-day delivery from vast wildlife holding centers along the Cairo-Alexandria Road, while one Facebook advert guarantees a lion cub delivery within 25 days.

These sellers, however, are decidedly upscale compared to some of the wild animal markets that exist in Africa and Asia. Sprawling, semi-permanent open-air markets thrive in a number of major cities, such as the Benfica market in Angola, the Juba market in Nigeria, or the Taipint market in China, all of which offer wildlife for sale that violates CITES regulations on a daily basis. While the wildlife on offer in these sites is predominantly destined for human consumption, much of it is sold alive and none of it is regulated. The disease risks are clear, and the legal implications are equally troubling.

In fact, a 2014 study of seven live wildlife trade markets in China’s Guangdong and Guangxi provinces uncovered 13 endangered or critically species for sale, along with Indochinese box turtles and Burmese pythons, indicating that trans-border trade was occurring in species without proper documentation.

But even documents can be procured, if necessary. The 2015 arrest of the former wildlife director of Guinea, Ansoumane Doumbouya, pulled back the curtain on a West African empire of live illegal wildlife trade that spanned nearly a decade and resulted in the illegal export of hundreds of animals. Doumbouya, who also served as the head of Guinea’s CITES authority beginning in 2008, issued fraudulent permits for chimpanzees, gorillas, manatees, bonobos, parrots and other endangered wildlife on a regular basis that fueled a complex web of illegal traders and ultimately led to Guinea's

Video: Trafficked through Thailand: Cracking down on animal smuggling

Video Link: https://www.youtube.com/watch?v=KzgTAbo-Fyo

Photo Credit: GRASP
trade suspension from CITES in 2013. Nevertheless, when Doumbouya was arrested, he was still carrying blank CITES export permits, several years after he’d left his post.

And where did those animals go? China was a major importer of chimpanzees from Guinea beginning around 2007, since that country’s rapidly expanding middle class demanded zoos and safari parks and animal entertainment shows that are popular in China. In 2010 alone, China imported 69 chimpanzees from Guinea under fraudulent CITES permits that indicated the animal were “captive-bred” and therefore legal to trade, and existing data indicates a total of 138 chimpanzees and 10 gorillas were sent to China over a period of several years.

**Crossing the frontier**

The illegal trade in elephant ivory or rhino horn is a grim traffic that tolls a steady march towards extinction. Yet the numbers – no matter how devastating – are clear: every pair of tusks represents a dead elephant, and every horn represents a dead rhinoceros. The live illegal wildlife trade, however, only hints at the devastation and the loss of biodiversity. Who can say how many bonobos really died as a result of the infant that was seized from a speedboat in the Democratic Republic of Congo last month? What do the dozens of slow lorises confiscated in a recent raid on Bangkok’s Chatuchak market say about the impact on wild populations? More information is clearly needed to understand the scale and scope of the live illegal trade in wildlife, but the more pertinent questions are what are the levers that policy-makers can use to stop live trade and have we left enough time to put them in place.
Acknowledgements

The Financial Sector: A Linchpin to Advance Sustainable Development
Authors
Ivo Mulder, UNEP, Nairobi, Kenya
Eric Usher, UNEP Finance Initiative, Geneva, Switzerland
Gabriel Thoumi, Climate Advisors, Washington DC, United States
Cary Krosinky, Brown University, Rhode Island, United States

Reviewers
Careen Abb, UNEP Finance Initiative, Geneva, Switzerland
Annie Degen, UNEP Finance Initiative, Geneva, Switzerland
Philip Drost, UNEP, Nairobi, Kenya
Iain Henderson, UNEP Finance Initiative, Geneva, Switzerland
Hunter Lovins, Natural Capitalism Solutions, Colorado, United States
Anders Nordheim, UNEP Finance Initiative, Geneva, Switzerland

Zoonoses: Blurred Lines of Emergent Disease and Ecosystem Health
Authors
Delia Grace, International Livestock Research Institute (ILRI), Nairobi, Kenya
Bernard Bett, ILRI, Nairobi, Kenya
Hu Suk Lee, ILRI, Nairobi, Kenya
Susan Macmillan, ILRI, Nairobi, Kenya

Reviewers
Robyn Alders, University of Sydney, Australia
John McDermott, CGIAR Program on Agriculture for Nutrition and Health, Washington DC, United States
Franklin Odhiambo, UNEP, Nairobi, Kenya

Microplastics: Trouble in the Food Chain
Authors
Pinya Sarasas, UNEP, Nairobi, Kenya
Peter Kershaw, GESAMP, United Kingdom
Heidi Savelli, UNEP, Nairobi, Kenya
Jing Zhang, China

Reviewers
Christopher Corbin, UNEP, Kingston, Jamaica
Tamara Galloway, University of Exeter, Devon, United Kingdom
Chelsea Rochman, University of California, Davis, California, United States

Loss and Damage: Unavoidable Impacts of Climate Change on Ecosystems
Authors
Kees van der Geest, United Nations University, Bonn, Germany
Stefan Kienberger, University of Salzburg, Salzburg, Austria
Alex de Sherbinin, Center for International Earth Science Information Network (CIESIN), New York, United States
Gillisann Harootunian, California State University, California, United States
Asha Sitati, UNEP, Nairobi, Kenya
Stephanie Andrei, International Centre for Climate Change and Development (ICCCAD), Dhaka, Bangladesh

Reviewers
Zinta Zommers, UNEP, Nairobi, Kenya
Janak Pathak, UNEP, Nairobi, Kenya
Barney Dickson, UNEP, Nairobi, Kenya
Mohammad Hafijul Islam Khan, Centre for Climate Justice-Bangladesh, Dhaka, Bangladesh
Poisoned Chalice: Toxin Accumulation in Crops in the Era of Climate Change

Authors
Jagger Harvey, ILRI, Nairobi, Kenya
Monika Macdevette, UNEP, Nairobi, Kenya
Josiah Mutuku, ILRI, Nairobi, Kenya
Samuel Mutiga, ILRI, Nairobi, Kenya
Peter Emmrich, ILRI, Nairobi, Kenya
Tilly Eldridge, ILRI, Nairobi, Kenya

Reviewers
Mozaharul Alam, UNEP, Bangkok, Thailand
Abdelkader Bensada, UNEP, Nairobi, Kenya
Volodymyr Demkine, UNEP, Nairobi, Kenya
Felix Fritschi, University of Missouri, Missouri, United States
Janak Pathak, UNEP, Nairobi, Kenya
Ken Shirasu, RIKEN Center for Sustainable Resource Science, Yokohama, Japan
Edoardo Zandri, UNEP, Nairobi, Kenya

The Latest Frontier
Exotic Consumerism: Illegal Trade in Live Animals

Author
Douglas Cress, UNEP, Nairobi, Kenya

Production team
Pinya Sarasas (editor-in-chief) and Asha Sitati, UNEP, Nairobi, Kenya

Copy Editor
Catherine McMullen, Ireland

Graphics, multimedia, design and layout
Audrey Ringler and Chris Mungai, UNEP, Nairobi, Kenya; Jinita Shah and Samuel Kinyanjui, UNON, Nairobi, Kenya

Printing
UNON/Publishing Services Section/Nairobi, ISO14001:2004-Certified