UNEP FRONTIERS 2016 REPORT

Emerging Issues of Environmental Concern

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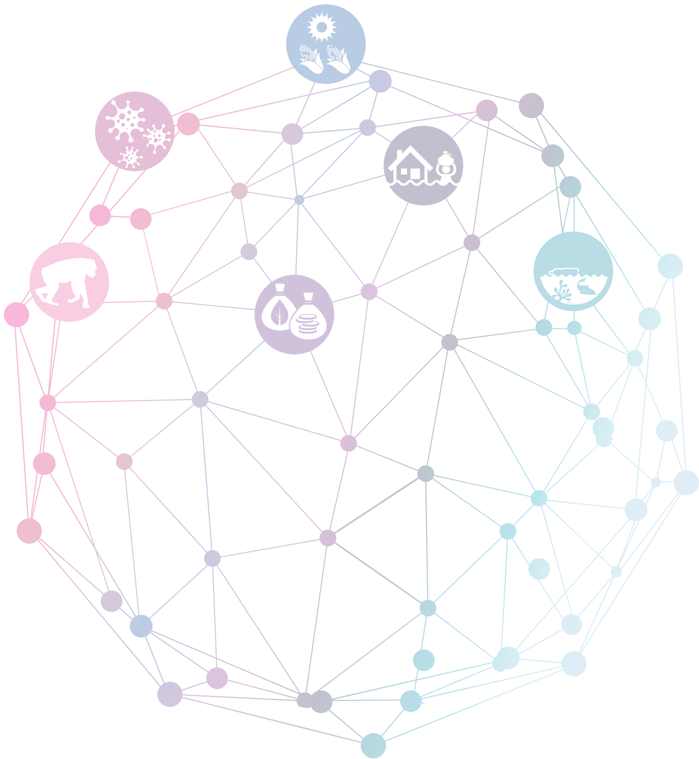

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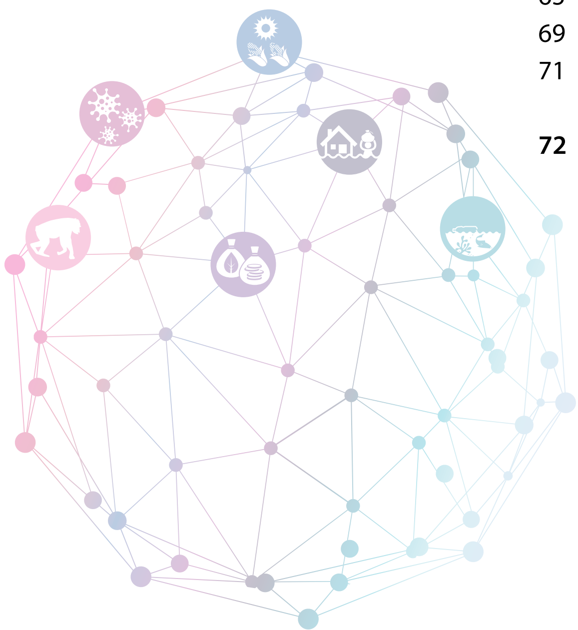


Preface

Over the past 10 years, UNEP has endeavoured to identify and highlight emerging issues of global concern through the UNEP Year Book series. This new UNEP Frontiers report advances this work, signalling environmental issues and solutions for effective and timely responses. Some issues may emerge as a result of new scientific findings and understanding of interactions between environmental, social and economic systems; others may be persistent issues for which new approaches and technologies have emerged to equip decision-makers and managers with more practical solutions and tools. Some issues may be local, relatively small-scale issues today, with a potential to become an issue of regional or global concern if not addressed early.

The UNEP Frontiers 2016 edition presents six emerging issues. It highlights, for example, that the global significance of the financial sector should not confine itself only to enhancing global economic growth, but also to advancing environmental sustainability. The financial sector has a crucial role to play in investing in new low-carbon, resource efficient and environmentally sound assets, and shifting capital away from traditional assets that have high impacts on the environment. The report presents a number of emerging financial initiatives led by the financial sector as innovative solutions to sustainability challenges.

There is a worldwide increase in disease emergence and epidemics particularly from zoonoses – diseases that can be passed on between animals and humans. The report illustrates how the emergence and re-emergence of zoonotic diseases are closely interlinked with the health of ecosystems. The risk of disease emergence and amplification increases with the intensification of human activities surrounding and encroaching into natural habitats, enabling pathogens in wildlife reservoirs to spill over to livestock and humans.

The recent years have seen a growing presence of plastic pollution in the aquatic environment, particularly in form of microplastics. While stakeholders are increasing their efforts to reduce the use of microplastics through innovative approaches and policy change, the scientific community is racing to understand the level of exposure and physiological impacts of microplastic contaminants on various organisms, as well as the risk to human health through consumption of contaminated food.

The UNEP Frontiers report also highlights two critical issues associated with climate change. The issue of loss and damage to ecosystems due to changing climate has risen to global attention in recent years, and has led to the establishment of the Warsaw international mechanism for loss and damage associated with climate change impacts. The report introduces a number of case studies on recent sudden- and slow-onset events that have caused losses and damages to ecosystems and human systems, and presents a range of risk management tools needed to avoid harm.

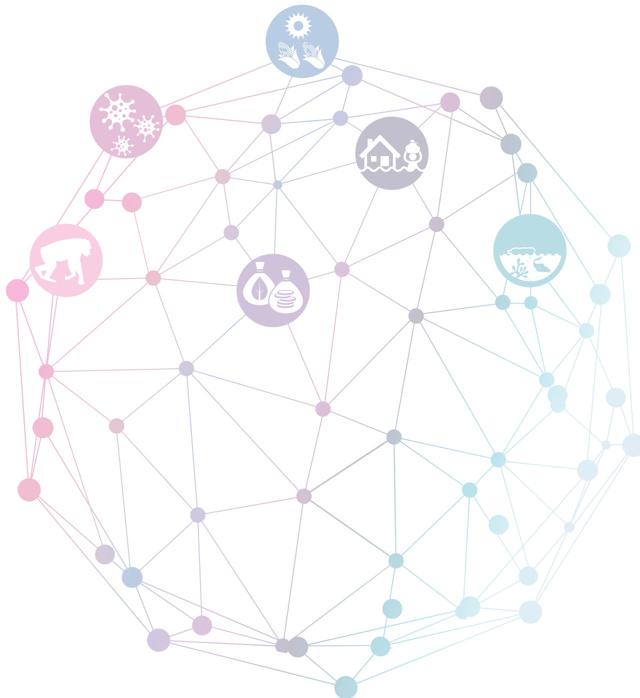
Changes in climatic patterns also have serious implications for food safety and security. Toxin accumulation in a variety of crops is one manifestation of climate change impacts that presents further challenges to agriculture and food production. Prolonged drought and high temperatures can trigger biophysical reactions in plants leading to an accumulation of chemical compounds toxic to animal and human health. Environmental stressors associated with climate variability can also make plants become more susceptible to infection by toxin-producing pathogens that, again, lead to toxin accumulation.

Latest Frontier is a unique section of the report providing perspectives on a breaking issue. Still on the global agenda, the illegal trade in wildlife continues to pose a serious threat to ecosystems and wildlife populations. The illegal trade in live animals and pet trade is building into a a lucrative business that attracts criminal networks throughout the supply chain. Not only threatening species survival, the illegal trade in live animals also exposes humans to zoonotic diseases associated with the traded species.

In summary, the report emphasises the critical relationship between a healthy environment and healthy people, and how human activities often undermine the long-term health and ability of ecosystems to support human well-being. The report provides encouraging examples on how certain issues may be addressed by innovating and rethinking policy interventions, new solutions or adapting existing practices. The UNEP Frontier series will continue to link new science to outcome-oriented policies, and by extension, keep the public informed of the health of the environment and its sustainability.

Achim Steiner

United Nations Under-Secretary-General and Executive Director,
United Nations Environment Programme



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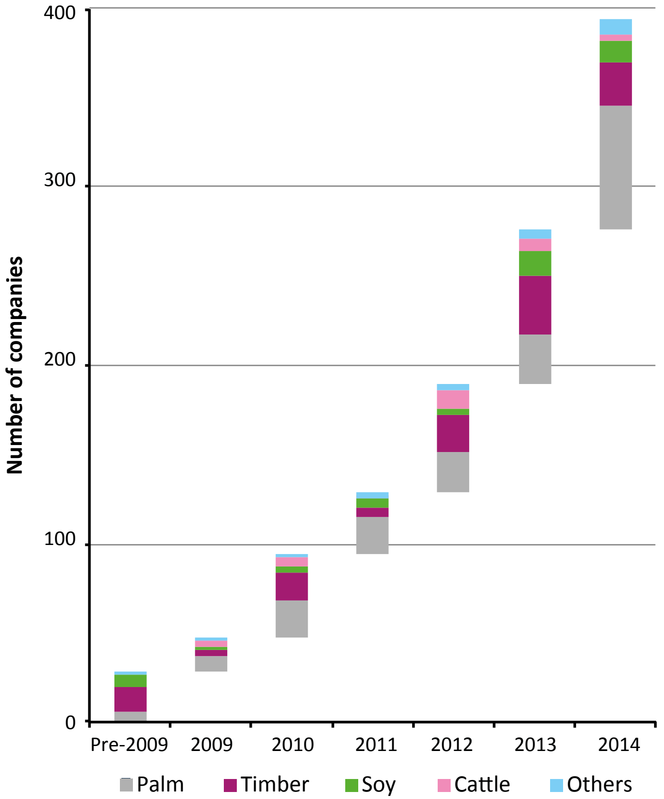
The Financial Sector:
A Linchpin to Advance Sustainable Development

The complex relationship between the private sector and the environment

According to the economic theory of the "tragedy of the commons", the earth's natural resources become overexploited when they are considered free, whereby individuals behave against to the common good. Business as usual expects government will create a suite of laws and regulations to manage the free-for-all. However, a growing number of private sector enterprises are moving ahead of government regulation because they understand their own self-interest is realized through efforts to reduce environmental damage and even to encourage tougher environmental regulation.

Climate change, ecosystem degradation, water scarcity, waste management, and other environmental challenges increasingly force the private sector to consider how are *damaging the environment*, for example through deforestation or greenhouse gas emissions as they and their suppliers conduct business; or how they are *dependent on the environment*, for example by using water for agricultural production or mineral extraction and processing. These activities can expose companies to a variety of risks including market, regulatory, and reputational risks as well as the physical risks from climate-related threats. A growing number of industries and individual companies acknowledge that diminishing exposure to these material risks is in their collective self-interest and requires them to reduce environmental damage.[1]

Number of companies making pledges to reduce deforestation and ecosystem impacts



Source: Adapted from Forest Trends (2015)[6] with additional unpublished data provided by Forest Trends Association in January 2016

Perhaps one of the best-known illustrations comes from Unilever. The company's 2010 "Sustainable Living Plan" pledges to cut the company's damaging environmental impact in half by 2020. It also vows to improve the health of one billion people and enhance livelihoods for millions, all while doubling Unilever's sales. By the end of 2014, Unilever's factories emitted 37 per cent fewer greenhouse gas compared to 2008 while producing more goods. In February 2016 the company announced that over 600 of their factories in 70 countries now generate zero waste to landfill.[2]

Private Sector

The private sector is the part of the economy that is not government controlled, and is run by individuals and companies for profit[7]

Risks

Market risk is defined as "the possibility for an investor to experience losses due to factors that affect the overall performance of the financial markets"[7]

Physical risk or operational risk A hurricane that damages a house is a physical risk that the homeowner and hence the insurance firm need to take into consideration. Water scarcity due to overuse by agriculture can be a physical or operational risk because reduced availability of water can lead to lower production levels

Regulatory risk refers to a change in laws and regulations that will materially impact a business or market by increasing the costs of operation, reducing the attractiveness of investment or changing the competitive landscape[7]

Reputational risk is defined as "a threat or danger to the good name or standing of a business or entity"[7]

Video: We mean business

Video Link: http://www.wemeanbusinesscoalition.org/about

These types of pledges are increasingly adopted at industry-level to stimulate sector peers to take action as well. A coalition of over 554 global companies and investors, with combined revenue of US$7.8 trillion, called We Mean Business, are committed to decarbonising their businesses through efforts including purchasing electricity from renewable sources, reducing short-lived climate pollutants, or investing in low carbon assets.[3]

The Consumer Goods Forum–an association of over 400 large retailers, manufacturers, and service providers across 70 countries with combined sales of around US$3 trillion–recommends that its members adopt a policy of "zero net deforestation" in their supply chains by 2020.[4] As a result, Wilmar, Cargill, Golden Agri Resources, Nestlé, Unilever, Mars and other companies have made commitments to deforestation-free sourcing, essentially decoupling production of vegetable oil, beef, or other commodities from forest damage. This effort got a boost during the 2014 UN Climate Summit when 130 governments, companies, civil society, and indigenous peoples' organisations signed New York Declaration on Forests. The signatories pledge to cut the loss of forests in half by 2020 and to end forest loss completely by 2030.[5] So far, 243 companies have pledged their commitments to reduce deforestation and ecosystem destruction when producing or procuring agricultural commodities.[6]

Global water challenges, and associated risks to business growth and viability, also invite private sector activism. The Water Stewardship initiative of the CEO Water Mandate has attracted over 140 leading companies from a wide range of industries in 40 countries to adopt water sustainability practices that are responsible to the environment and the society.

These different initiatives are significantly accelerating corporate commitments to advance towards environmental sustainability, which can minimise material risks in the present and enhance a company's financial stability and growth over the future.

Zero net deforestation

Zero-net deforestation pledge allows companies to offset the impacts of their practices on forests by replanting the deforested areas that can largely maintain forest 'quantity, quality and carbon density' in order to have an overall zero-net effect on deforestation

Zero deforestation pledge commits companies to completely remove deforestation from their supply chains

Decoupling

The concept of decoupling can be applied to sustainable development in two dimensions:

Impact decoupling means maintaining economic output while reducing the negative environmental impact of any economic activities that are undertaken

Resource decoupling means reducing the rate of use of resources per unit of economic activity. Absolute reductions of resource use are a consequence of decoupling when the growth rate of resource productivity exceeds the growth rate of the economy[24]

Photo Credit: Curraheeshutter/ Shutterstock.com

The underlying but influential role of the financial sector in environmental sustainability

Banks, pension funds, insurance companies, and other financial institutions provide a range of services that are an essential part of our daily lives such as offering cash, credit, and other forms of capital; saving and investment accounts; and insurance policies. Credit and liquidity provision as well as other risk management tools and services are core activities of the financial sector.[8]

Engaging the financial sector to advance environmental sustainability is justified by the value it adds to the global economy and the role it plays in our economy. At present, the industry contributes roughly 15 per cent to global GDP.[9] In terms of managed assets, banks, pension funds, insurance firms and others control around US$300 trillion.[10] The financial sector has an essential role in advancing environmental sustainability. Ultimately, the challenge is to shift capital away from unsustainable companies, projects and other assets that negatively affect the environmental and towards 'sustainable assets' that operate with minimal environmental costs or even with environmental benefits.

Video: What is financial sector?

© Invetopedia
Video Link: http://www.investopedia.com/video/play/financial-sector/
Photo Credit: Katjen/ Shutterstock.com

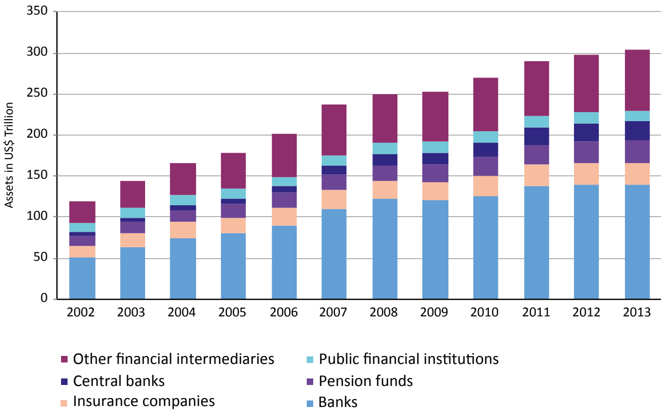
Credit

Credit is defined as "a contractual agreement in which a borrower receives something of value now and agrees to repay the lender at some date in the future, generally with interest. The term also refers to the borrowing capacity of an individual or company"[7]

Liquidity

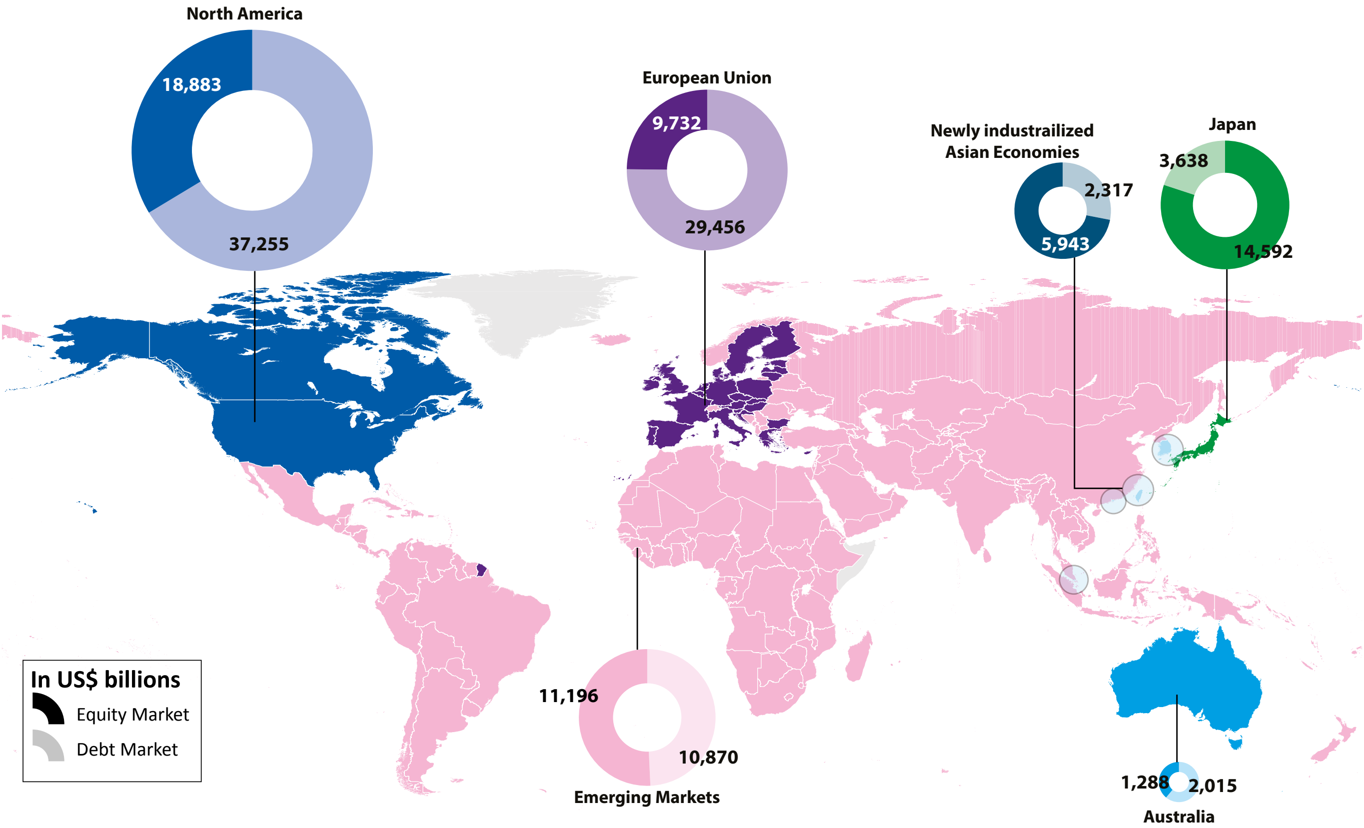
Liquidity describes "the degree to which an asset or security can be quickly bought or sold in the market without affecting the asset's price. Market liquidity refers to the extent to which a market, such as a country's stock market or a city's real estate market, allows assets to be bought and sold at stable prices. Cash is the most liquid asset, while real estate, fine art and collectibles are all relatively illiquid"[7]

The financial sector: Growth in assets by type of institution from 2000-2013



Source: Statista (2016)[10]

How large are capital markets?

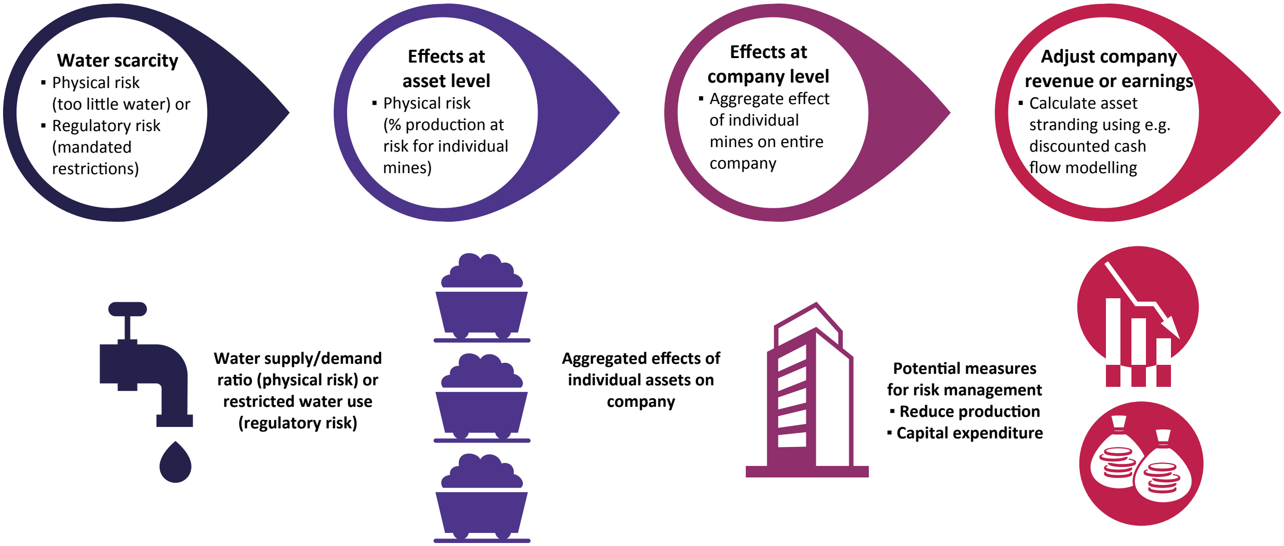


Source: Adapted from Goldman Sachs Interactive Guide to Capital Markets
http://www.goldmansachs.com/s/interactive-guide-to-capital-markets/

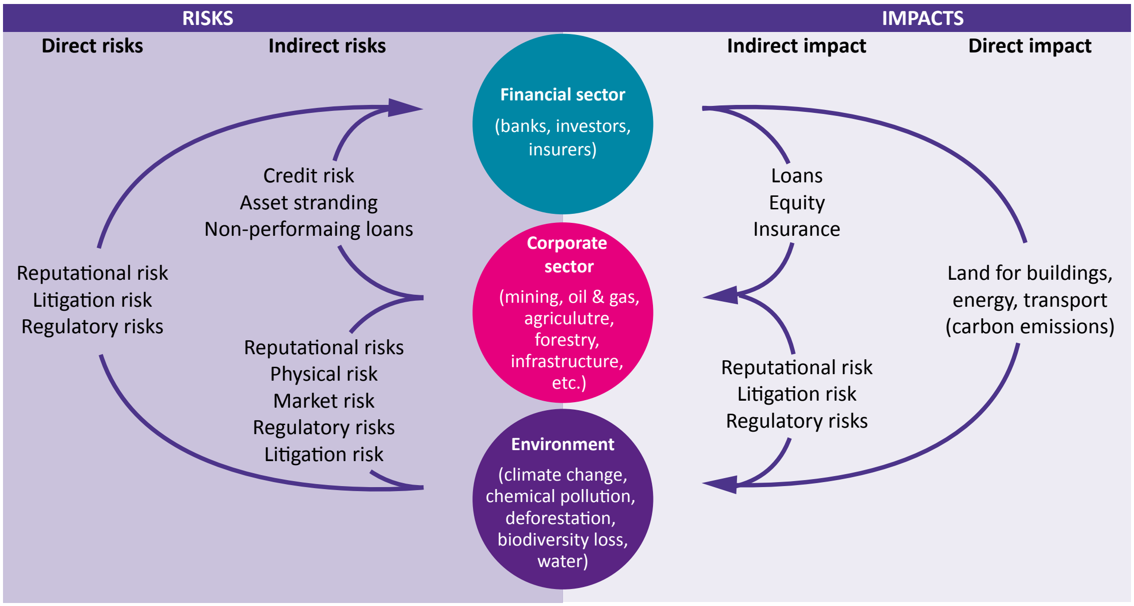
A rising number of financial institutions have developed environmental policies on a voluntary basis. However, the way the financial system is currently designed, and the way financial institutions currently allocate capital, discourages change – particularly the transformational change to a low-carbon, resource-efficient economy. The inclinations that create this inertia include short-termism and excessive leverage. These tendencies produce fast turnover of profit to pay off debt; and they emerge as significant drivers of instability throughout the economy. In this investment context, longer-term sustainability-related options are ignored in financial decision-making.[11]

Without changes in regulations and in costs, it is unlikely that the financial industry as whole will transform into a responsible mode. Concerted public-private sector initiatives are needed to encourage financial institutions to shift investments into low carbon, resource efficient, and environmentally sound assets. *Pricing environmental risk* and *regulatory changes* are two important levers to motivate banks, pension funds, and other actors in the financial system to accelerate towards environmental sustainability. Both supply and demand drivers need to be applied to enable a global transition to a low carbon, resource efficient and equitable economy.

Example of risks associated with water scarcity



The interlinkages between the financial sector, real economy and the environment



Levers to align the financial sector with sustainable development

There are multiple ways the financial industry can facilitate the transition to a green economy. Sustainability standards, such as the IFC Performance Standards, are the traditional way for the financial industry to self-regulate on environmental issues. However, additional levers are needed to further stimulate the financial sector to allocate capital differently. Two related solutions are emerging.

1. Pricing environmental risk

A number of initiatives, such as CarbonTracker and the Natural Capital Declaration, are developing models that quantify how the risks of climate change, ecosystem degradation, water scarcity, waste management, and other environmental challenges can affect company revenues. In extractive industries, energy, agriculture, and other sectors, environmental risks can be included in the cost of capital to borrow money or in the market value of public and private companies. Investors who fail to factor in such risks could potentially face legal action for failure to comply with their fiduciary duty.

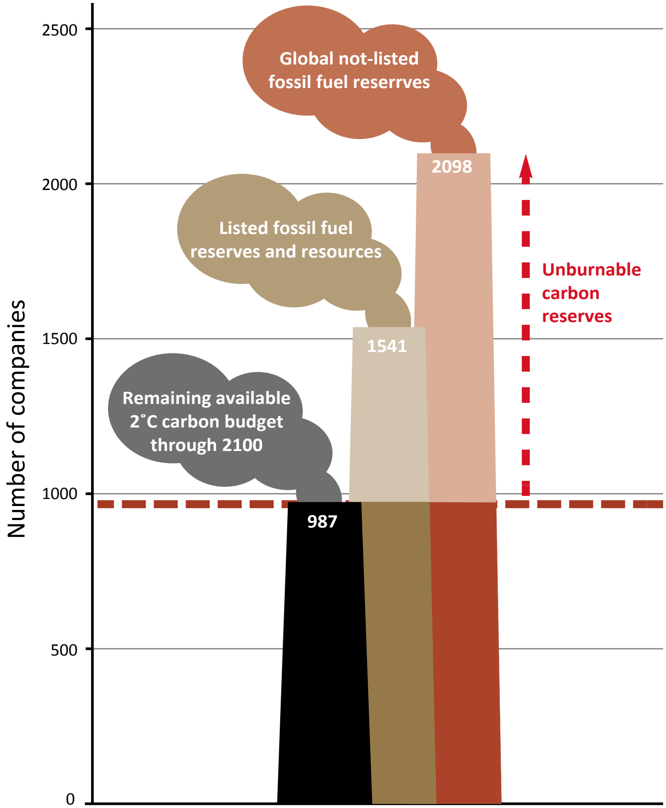
Consider the fossil fuel sector: the December 2015 Paris Agreement presents a monumental challenge for the global community to shift, systematically and rapidly, away from fossil fuels towards renewable energy. In addition, efforts to reduce emissions from deforestation, forest degradation, and other sources of greenhouse gas must be amplified.

The European Union is committed to at least a 40 per cent domestic reduction in greenhouse gas emissions by 2030 compared to 1990, as outlined in its Intended Nationally Determined Contribution or INDC.[13] The EU must enhance the process of decarbonisation in major carbon emitting sectors, including energy and transport, by stimulating greater investments in renewable energy technologies, as well as in energy storage solutions. At the same time investments in coal and other forms of carbon-intensive energy generation become riskier and less financially viable. In other words, these fossil fuel assets could become stranded assets.

Stranded assets

Stranded assets refer to investments becoming less profitable due to premature write-down, devaluations, or conversion to liabilities, which could be due to environmental issues[25]

Fossil fuel assets at risk



Source: Ceres and CarbonTracker (2013)[23]
http://www.ceres.org/issues/carbon-asset-risk

Water is another natural capital that must be factored into corporate risk assessment. Pervasive drought can strand assets, especially in water dependent industries including mining, energy, agriculture, and food processing. Mining companies worldwide spent about US$12 billion on water infrastructure in 2014, a 253 per cent increase of the US$3.4 billion spent in 2009.[14] A pioneering effort by Bloomberg LP and the Natural Capital Declaration enables financial analysts and portfolio managers to integrate water risks in the valuation of mining companies through a discounted cash flow model. The Water Risk Valuation Tool adjusts a mining company's future revenue and costs based on how much production may be affected by water.[15]

2. Reforming the regulatory regime

Financing the transition towards more sustainable development will require a redirection of capital flows towards critical priorities, and away from assets that deplete natural capital.[16] Without regulatory changes to the financial system this is unlikely to happen at the scale needed.

Climate change, water scarcity, and other forms of environmental risk do affect the economy and are a potential source of systemic material risk for the world economy. This risk threat in turn can provide the basis to engage bank supervisors, such as the Basel Committee on Bank Supervision, to stress test financial institutions on their exposure to material environmental risks and to identify opportunities for reform to reduce exposure.[17] The 2015 UNEP Inquiry into the Design of a Sustainable Financial System found over 100 exemplary policy measures across 40 countries that facilitate financial system support of sustainable development.[11]

In China, for example, greening finance is a growing focus through the promotion of green credit, green securities, and green insurance. Green credit has been the key policy for green finance in China's banking-dominated system.[18] In 2007 the State Environmental Protection Administration, the People's Bank of China, and the China Banking Regulatory Commission jointly called on banks to make compliance with environmental laws and regulations a necessary condition for loan approval. As a result green investment in China exceeded US$200 billion in 2012 or about 2.4% of China's GDP.

While these government initiatives are encouraging signs, more financial regulatory reforms are needed to accelerate the shift towards a green economy. Ultimately this means that the risk-adjusted return of an investment or loan will have to favour environmentally-sound assets.

IFC Performance Standards

The Performance Standards issued by the International Finance Corporation are a set of qualitative environmental and social standards, which are endorsed by financial institutions that cover about 80% of the project finance market effectively creating a level-playing field

Water Risk Valuation Tool

The Water Risk Valuation Tool (WRVT) maps specific mine assets against water scarcity indicators projected through 2030. Water risk is then integrated into the model through two primary pathways:

1. **Revenue:** the value of potentially unextractable ore due to water scarcity can be calculated;
2. **Cost:** a so-called "shadow price" is modeled based on a holistic value of water for citizens, agriculture and ecosystems

Video: **Fossil fuels: A risky business?**

Video Link: https://www.youtube.com/watch?v=hzOnTKHopS4

Amplifying and diffusing best practices

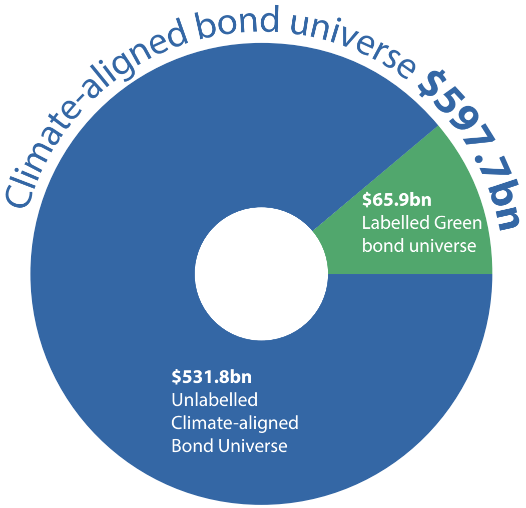
Many innovative financial initiatives are emerging. The Portfolio Decarbonization Coalition has engaged 25 institutions in decarbonizing the US$600 billion worth of assets in their portfolios by redirecting investments from carbon-intensive to carbon-efficient companies. Such developments have led to the rapid expansion of a new asset class, green bonds. Green bonds are financial instruments to raise capital to tackle climate change and protect the world's natural capital. In 2015, the total value of climate-aligned bonds stood at US$598 billion, a 20 per cent increase from the previous year.[20] Most current green bonds focus on financing low-carbon assets in the transport and energy sectors; however, pioneering efforts targeting the agriculture and forestry sectors are also rising.

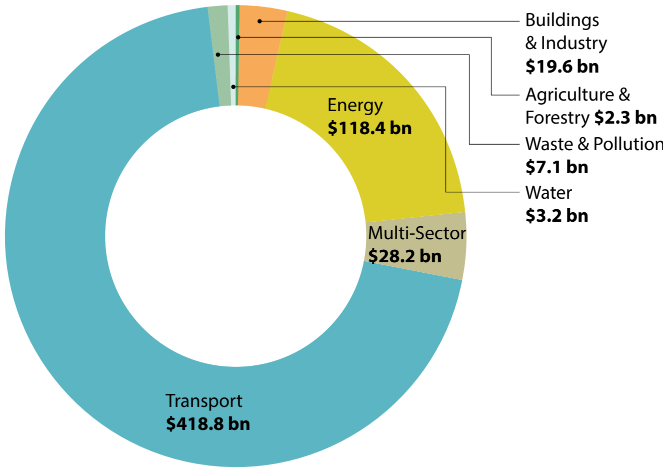
On the banking side, a promising development has been the call for a business-driven approach to finance by the Positive Impact Manifesto. Despite existing policy and regulatory misalignments, the Manifesto encourages banks, the broader finance sector, and stakeholders to go beyond risk-based approaches to sustainability and to focus on positive impacts on the economy, society, and the environment.[21] Another business-driven development is the proposal from the Financial Stability Board to establish an industry-led disclosure task force to develop voluntary climate-related disclosures necessary for lenders, insurers and investors in assessing material financial risks.[22]

2015 may be the year financial markets started their transition towards solutions for sustainability challenges. Many leading individuals and initiatives are guiding financial markets down this path. All of this necessary preparatory work produced widespread recognition that sustainable investing is an essential mechanism, not only to accomplish sustainability solutions, but also to stabilize and maximize financial value.

This is manifesting itself in many ways, with a 'race to the top' of commitments emerging–from Goldman Sachs committing to US$150 billion of clean energy investment through 2025 to the Bank of America Merrill Lynch US$125 billion commitment to invest in environmental sustainability. A bottom-up race

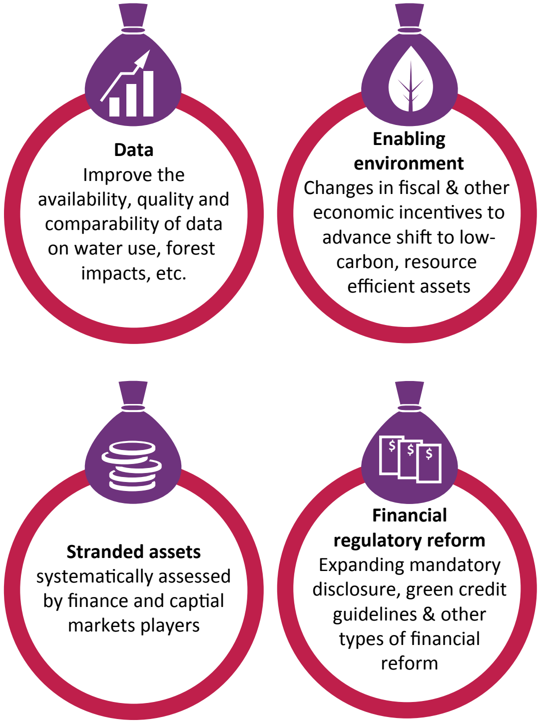
Green bonds on the rise





Source: Climate Bonds Initiative (2015)[20] is also underway to develop the positive impact investing. Finally, a wave of other interested parties have emerged, from students on campuses campaigning for fossil fuel divestment to members of pension funds demanding more transparency from their fiduciaries.

Continuing to accelerate this transition to a low carbon future must remain in focus, not only through investment practices, but also through policies. For example, if the global economy is dedicating a trillion dollars a year into new infrastructure, it must be environmentally sound infrastructure: Who builds it, with what materials, and to what end determines whether it contributes to sustainable development. To truly work towards sustainable development, efforts must consider not only changing climate, but also address water security concerns, deforestation, achieve ecosystem integrity, establish resource efficiency, foster social equity, and entrench the principles of a circular economy.



Green bonds

Green bonds refer to a fixed-income financial instrument (bond) that finances low-carbon and resource-efficient activities

Positive Impact Manifesto

The Manifesto provides a roadmap to establishing a new impact-based approach to banking and financing that produces a positive impact on the economy, society or the environment and contribute to the achievement of sustainable development. It is a result of the unique partnership between UNEP and the global financial sector under the UNEP Finance Initiative programme

UNEP Finance Initiative

Created in the context of the 1992 Rio Earth Summit, the UNEP FI works to understand today's environmental challenges, why they matter to finance, and how financial institutions can actively participate in addressing them. The UNEP FI partnership today includes a global network of over 200 banks, insurers and investors from over 50 countries.

Video: Climate change and financial stability speech by Mark Carney, Governor of the Bank of England

Video Link: http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx

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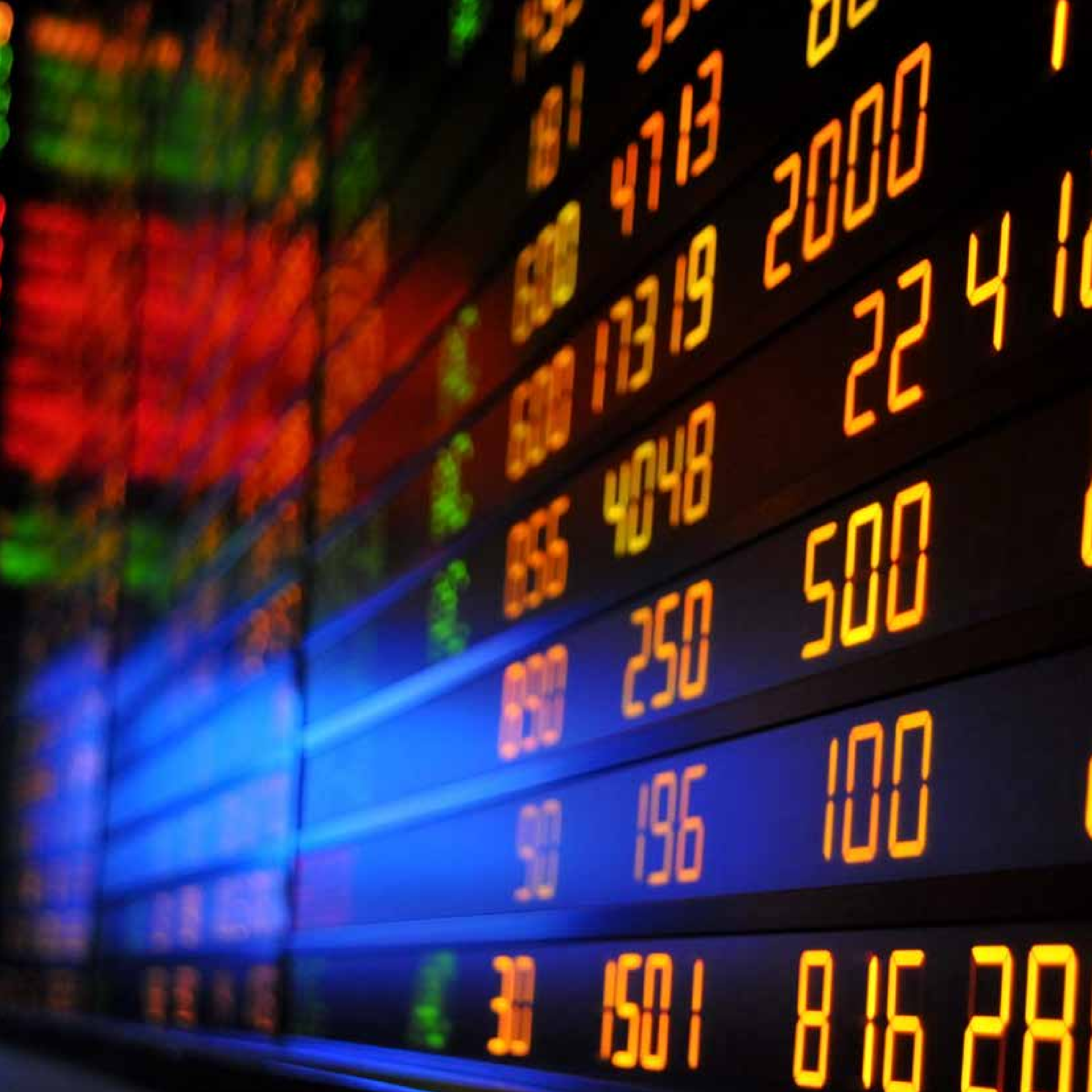
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Photo Credit: ILRI/ Nguyen Ngoc Huyen

Zoonoses:
Blurred Lines of Emergent Disease and Ecosystem Health

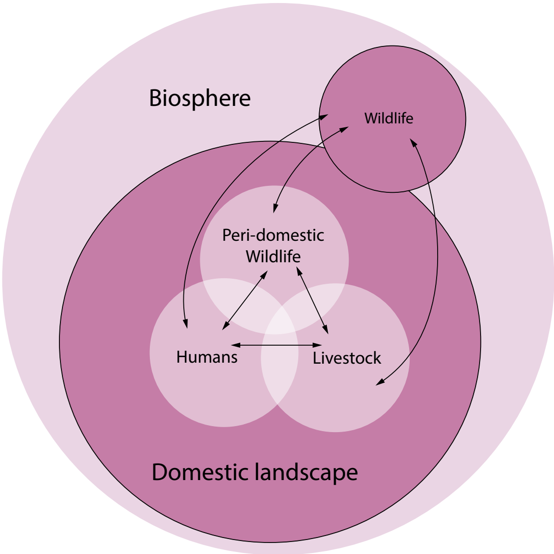
Emerging and neglected zoonotic diseases

The 20th century was a period of unprecedented ecological change, with dramatic reductions in natural ecosystems and biodiversity and equally dramatic increases in people and domestic animals. Never before have so many animals been kept by so many people—and never before have so many opportunities existed for pathogens to pass from wild and domestic animals through the biophysical environment to affect people causing zoonotic diseases or zoonoses. The result has been a worldwide increase in emerging zoonotic diseases, outbreaks of epidemic zoonoses as well as a rise in foodborne zoonoses globally, and a troubling persistence of neglected zoonotic diseases in poor countries.

Around 60 per cent of all infectious diseases in humans are zoonotic[1] as are 75 per cent of all emerging infectious diseases.[2] On average, one new infectious disease emerges in humans every four months.[3] While many originate in wildlife, livestock often serve as an epidemiological bridge between wildlife and human infections. This is especially the case for intensively-reared livestock which are often genetically similar within a herd or flock and therefore lack the genetic diversity that provides resilience: the result of being bred for production characteristics rather than disease resistance.[4] An example of livestock acting as a "disease bridge" is the case of bird flu or avian influenza pathogens, which first circulated in wild birds, then infected domestic poultry and from them passed to humans. The emergence of zoonotic diseases is often associated with environmental changes or ecological disturbances, such as agricultural intensification and human settlement, or encroachments into forests and other habitats.[5] Zoonoses are also opportunistic and tend to affect hosts that are already stressed by environmental, social, or economic conditions.[6]

Zoonoses threaten economic development, animal and human well-being, and ecosystem integrity. Over the last few years, several emerging zoonotic diseases made world headlines as they caused, or threatened to cause, major pandemics. These include Ebola, bird flu, Middle East respiratory syndrome (MERS), Rift Valley fever, sudden acute respiratory syndrome (SARS), West Nile virus, and Zika virus disease. The pathogens causing these diseases have wildlife reservoirs that serve as their long-term hosts. In the last two decades, emerging diseases have had direct costs of more than US$100 billion; if these outbreaks had become human pandemics, the losses would have amounted to several trillion dollars.[7]

Pathogen flow at the wildlife–livestock–human interface



Source: Jones *et al.* (2013)[5]

Another important group of zoonotic diseases are caused by foodborne pathogens such as Salmonella and Listeria bacteria that are passed from animal to humans. In 2015, the first global assessment of foodborne disease found the overall burden of foodborne disease was comparable to malaria or tuberculosis.[8]

Emerging zoonotic disease

Emerging zoonotic diseases are those that newly appear in a population or have existed previously but are now rapidly increasing in incidence or geographical range. Fortunately, most new diseases are not highly lethal and most do not spread widely. But some emerging diseases have enormous impacts. Human immune deficiency virus (HIV and AIDS), highly pathogenic avian influenza (bird flu), bovine spongiform encephalopathy (mad cow disease), and Ebola are well-known examples of particularly harmful emerging zoonoses.

Epidemic zoonoses

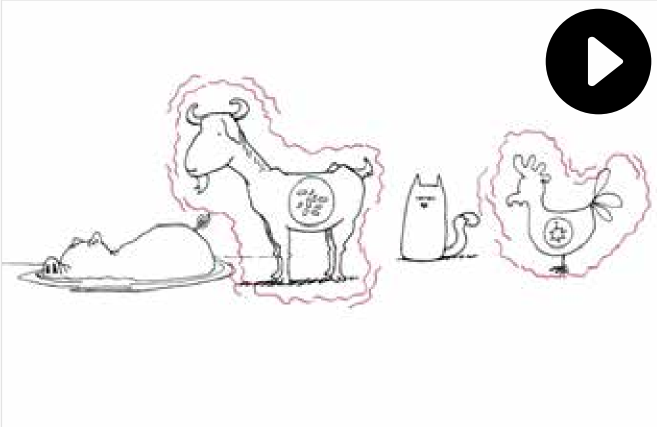
Outbreaks of epidemic zoonoses typically occur intermittently. Epidemic zoonoses are often triggered by events such as climate changes, flooding and other climate events, and famines. Their overall health burden is much less than that of endemic zoonoses but because they cause 'shocks' to food production and other systems, they can reduce the resilience of the affected communities. Examples are anthrax, rabies, Rift Valley fever, and leishmaniasis.

Neglected zoonotic diseases

Neglected zoonotic diseases are continually present to a greater or lesser degree in certain populations, but are often marginalised by health systems at national and international levels. Examples are anthrax, brucellosis, cysticercosis (pig tapeworm), echinococcosis (hydatid disease), Japanese encephalitis, leishmaniasis, leptospirosis, Q fever, rabies, foodborne trematodiases, trypanosomiasis and cattle tuberculosis.

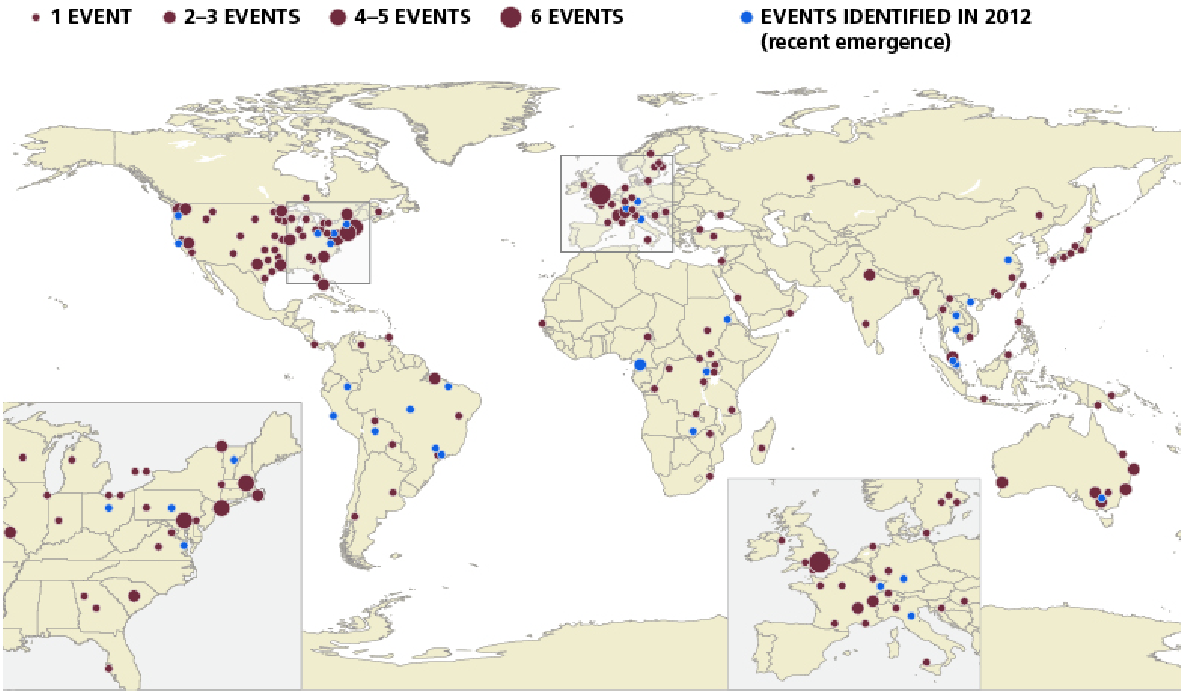
However, emerging diseases and those with the potential to cause pandemics are not the only problematic zoonoses. Neglected zoonotic diseases are endemic in affected poor populations, yet they receive much less international attention and funding than emerging diseases. Neglected zoonoses persist in communities with complex development problems.[6] Global concern currently focuses on anthrax, bovine tuberculosis, brucellosis, human African trypanosomiasis, Taena solium cysticercosis (pig tapeworm), cystic echinococcosis (hydatidosis), leishmaniasis, and rabies.[9] These diseases are common where poverty, the proximity of people and domesticated animals, low resilience, and people's reliance on livestock or wildlife converge to enable transmission.[10]

Video: How can animals make you ill?



Video Link: https://www.youtube.com/watch?v=J5qLKWUTNM4

Emerging zoonotic disease events, 1940-2012

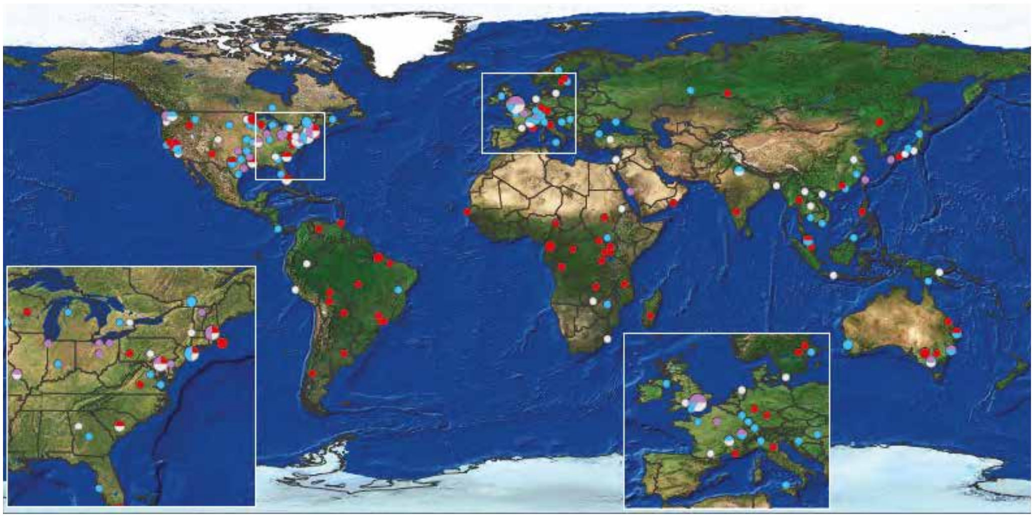


Source: International Livestock Research Institute (ILRI)

Impacts of zoonoses

Zoonosis	Primary transmission/ reservoir species	Impact
Avian Influenza		The 2004 outbreak in East Asia resulted in economic losses of US$ 20 billion over the following five years.[48] The 2015 outbreak in the US has cost the poultry industry US$ 3.3 billion and led to the death of 48 million birds either from the flu itself or from culling.[46,47]
Bovine tuberculosis		US$ 15 billion of economic losses from 1986-2009 in the UK.[7]
Ebola		The 2014-2015 Ebola outbreak in Guinea, Liberia and Sierra Leone led to 11,310 deaths and 28,616 confirmed cases.[48]
MERS		Since September 2012, 27 countries have reported confirmed cases, with about 624 deaths.[49]
Nipah virus		US$ 671 million of economic losses, one million pigs culled, and 100 people died from the 1998 outbreak in Malaysia.[7]
SARS		The impact of the 2002 outbreak was estimated at US$ 41.5 billion, with 8,000 confirmed infections and 800 deaths.[7]

Events of zoonotic disease emergence by type of animal hosts



Source: Grace *et al.* (2012)[6]

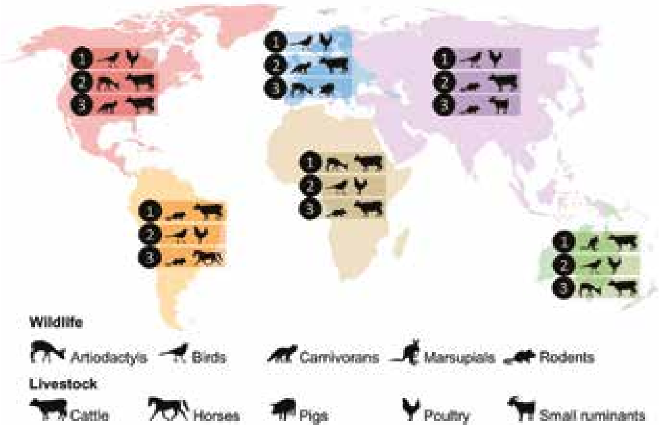
Drivers of zoonotic disease emergence

Researchers studying records that date from 1940 to 2004 detected an increase in the rate of emerging infectious disease over those years. Of the 335 documented events, 60.3 per cent were zoonotic and 71.8 per cent of the zoonoses originated in wildlife.[11] Generally scientists consider three different types of change that allow virulent pathogens to initiate a new move from animal host to human host: changes in the environment, in either host, or in the pathogen itself.

Changes in the environment are usually the result of human activities, ranging from land use change to changing climate. Encroachment on natural ecosystems through resource exploitation, agricultural activity, and human settlements provides opportunities for pathogens to spillover from wild animals to people, especially when the natural disease resistance that may result from rich biological diversity is lost.[5,12,13] Examples of zoonoses emerging when land is cleared for human activity can be found in many regions and on most continents.[5,14-16] Climate change is a major factor for disease emergence. It influences the environmental conditions that can enable or disable the survival, reproduction, abundance, and distribution of pathogens, vectors, and hosts, as well as the means of disease transmission and the outbreak frequency.[17] Growing evidence suggest that outbreaks or epidemic diseases may become more frequent as climate continues to change.[17-19]

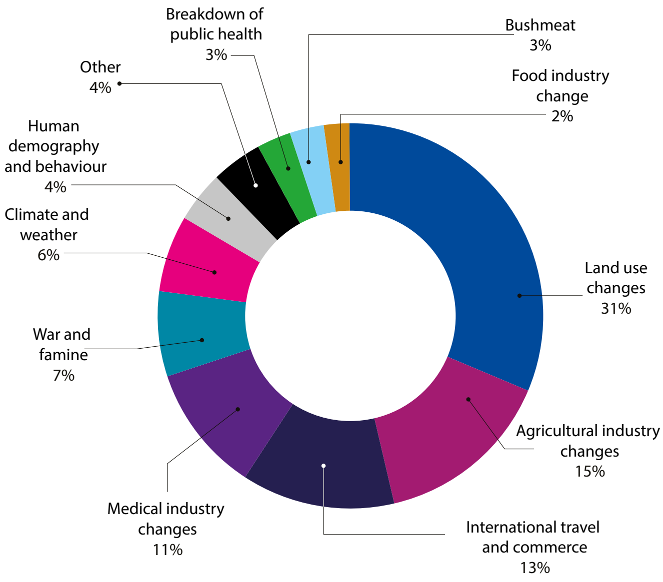
Changes in animal or human hosts are often the result of human action as well. Zoonotic transmission from wildlife hosts directly to human host is uncommon: domestic animals can bridge the gap.[20] Increasing demand for milk and meat, driven mainly by fast-growing populations of urban consumers in developing countries, is projected to double by 2050.[21] The Livestock Revolution paradigm is leading to rapid increases in livestock populations in developing countries, which increases the likelihood of disease transmission.[22] Demand for livestock products leads to more intensive production, that is greater populations of high yielding and

Top 3 reported interfaces, based on 13,293 research publications dated from 1912 to 2013



Source: Wiethoelter *et al.* (2015)[44]

Primary drivers of past disease emergence

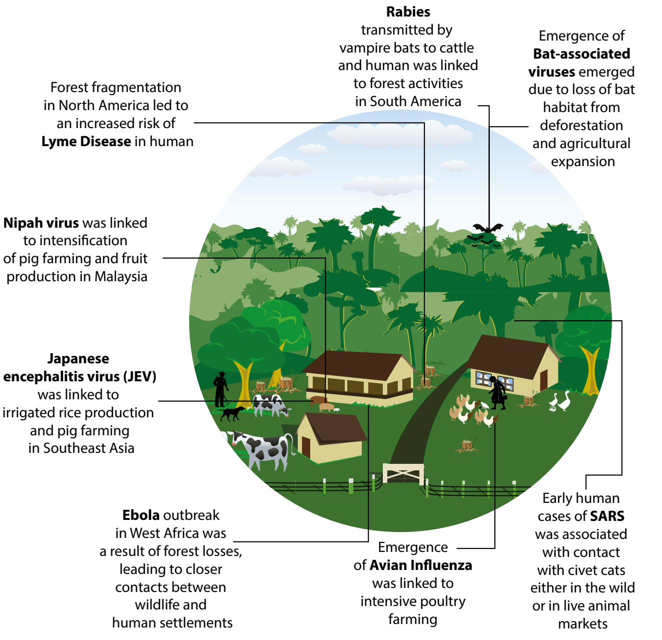


Source: Loh *et al.* (2015)[43]

genetically similar stock kept close together. Thus the animals are not only exposed to more contact opportunities but they also lack the genetic diversity that helps resist the spread of disease, a vulnerability known as the monoculture effect. Intensification of livestock production systems also results in increased fertiliser use (for feed and fodder) and increased production of livestock waste, which can create nutrient-rich environments that foster certain pathogens.[23] Changes in human host behaviours are also drivers of emerging zoonotic disease, including travel, conflict, migration, wildlife trade, globalization, urbanization, and changing dietary preferences.[24]

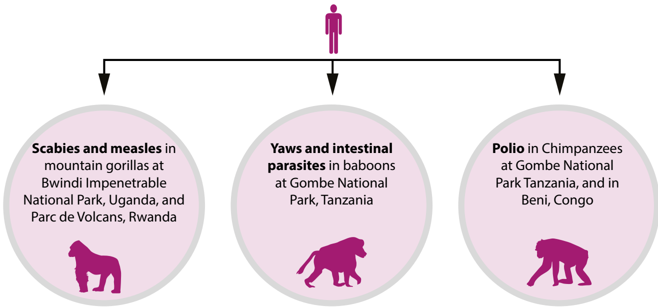
Changes in the pathogens themselves occur as they evolve to exploit new hosts or adapt to changing evolutionary pressures. An example of this is the emergence of resistance to antimicrobial drugs.[25] Antimicrobial resistance is the result of pathogens being exposed to antimicrobial drugs and building resistance over their short-lived generations. This most commonly occurs when people are prescribed antimicrobials or buy them without prescription and self-treat incorrectly. Antimicrobials are also widely used, or misused, in veterinary medicine, often as preventatives, and resistance to them is growing in domesticated animals especially in industrial-style production systems.[26] Antimicrobial resistance created in livestock can then affect humans, so when people get sick antibiotics no longer work.

Primary drivers of disease emergence associated with the past emerging zoonotic disease events



Created based on data from Jones *et al.* (2013)[5]

Suspected disease transmission from people to primates



Source: Kalema-Zikusoka (2005)[45]

Video: Zoonotic diseases among pastoralists in Uganda

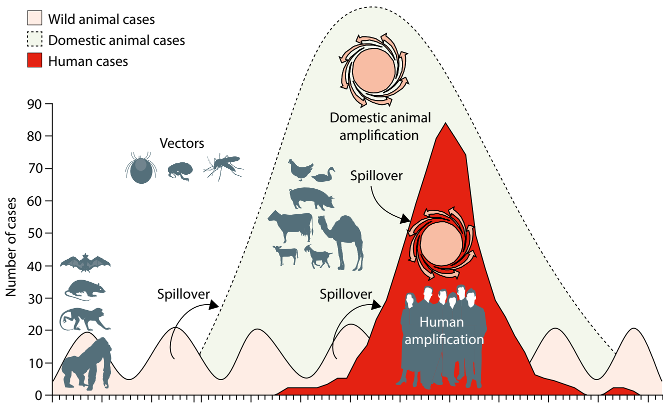
© IDRC/Government of Canada
Video Link: https://www.youtube.com/watch?v=fp4BhQTNjwQ
Photo Credit: ILRI/ Stevie Mann

Managing zoonoses for human, animal, and ecosystem health

Zoonotic diseases affect human health, agriculture, the economy, and environmental integrity. In just the last decade, around US$20 billion have been directly spent in responding to emerging zoonoses and in implementing initiatives for better progressive control of zoonoses, with a further estimate of US$200 billion in indirect costs to affected economies.[27] Zoonoses management requires an integrated and inter-sectoral approach. At the global level, three organizations have mandates that cover zoonotic disease: the World Health Organisation (WHO), the World Animal Health Organisation (OIE), and the Food and Agriculture Organization of the United Nations (FAO).

Environmental health initiatives have been less well represented in global zoonoses control programs. However, ecosystem integrity is a key factor in the innovative approaches taken by One Health and EcoHealth initiatives that are spearheading zoonoses control at regional and national levels. Applying inter-sectoral approaches has had some notable successes, which ultimately improved human health, such as controlling rabies in the Serengeti ecosystem, understanding the burden of brucellosis in Mongolia, and controlling leishmaniasis in Tunisia using ecosystem-based approaches and community-based interventions.[28-31] There has also been a surge in novel surveillance of wildlife and livestock health and reporting tools that draw on a wide range of field reports. These include the Program for Monitoring Emerging Diseases (ProMed), GeoChat, the World Animal Health Information Database (WAHIS) interface and WAHIS-Wild interface, HealthMap, Wildlife Health Australia and US Wildlife Health Information Sharing Partnership event reporting system (WHISpers).

Transmission of zoonotic diseases and amplification in people



Source: Karesh *et al.* (2012)[25]

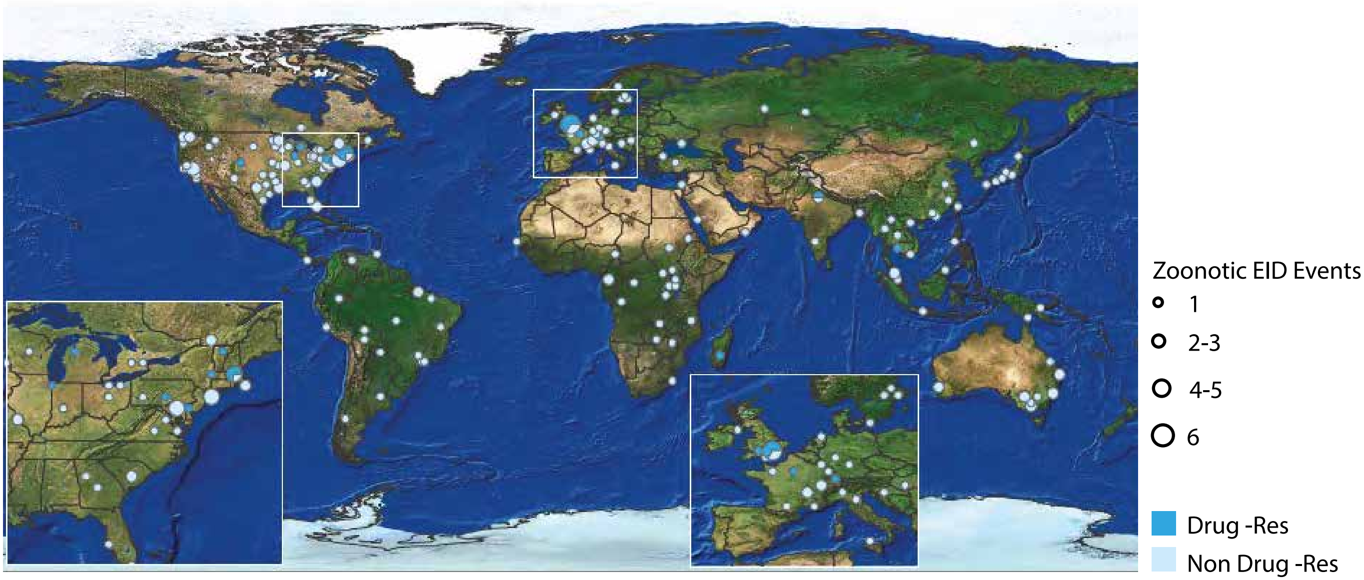
There have been many cases of successful management of endemic zoonotic disease such as pig tapeworm and rabies. Several developed countries have succeeded in reducing zoonotic foodborne disease over relatively short periods by instituting control mechanisms all along the food value chain, with an emphasis on reducing disease in the animal host. However, if such control measures are not maintained, the diseases will recur after an initial suppression. For this reason, several high-priority zoonoses have been targeted for 'progressive control towards elimination', including bird flu, rabies, and pig tapeworm.[32,33]

The track record on managing emerging zoonoses is mixed. For example, the rapid containment of SARS is considered one of the biggest success stories in public health in recent years. In 2003, WHO alerted the world that a severe acute respiratory syndrome of unknown cause was rapidly spreading from Southeast Asia. Within six months, this entirely new disease had been identified as a coronavirus, its transmission and risk factors had been elucidated, treatments developed and the disease spread stopped.[34] The more recent case of Ebola, however, shows control is not always straightforward. The Ebola outbreak at the intersection of Liberia, Sierra Leone, and Guinea affected some of the world's poorest and least developed countries. It took over three months just to confirm that Ebola was the cause of many severe illnesses and untimely deaths and by then large numbers of people were already affected. War, population growth, poverty, and poor health infrastructure likely contributed to the unprecedented expanse, duration, and size of the epidemic.[35]

Video: Hotbed of disease

Video Link: https://www.youtube.com/watch?v=9kGH7iC-7TQ

Events of zoonotic disease emergence classified in terms of drug resistance



Source: Grace *et al.* (2012)[6]

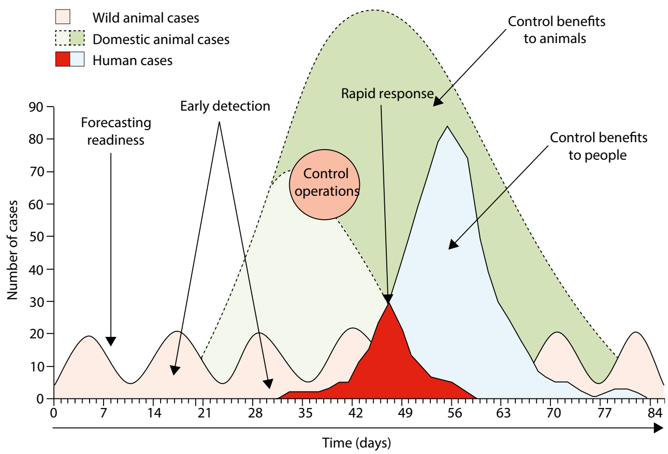
Ecosystem integrity underlines human health and development

Ecosystem integrity can help regulate diseases by supporting a diversity of species so that it is more difficult for one pathogen to spread rapidly or dominate. As the human population grows, ecosystems change. Forests are exploited for logging, landscapes are clear-cut for agriculture and mining interests, and the traditional buffer zones – once separating humans from animals or from the pathogens that they harbour – are notably reduced or lost. Because of historic underinvestment in the health sector of developing nations, and rapid development often at the cost of natural capital, disease emergence is likely to continue; hence, the importance of public health within the development and conservation continuum.[36]

Zoonotic diseases are particularly complex disorders that concern the three, often siloed, sectors of environment, agriculture, and health; so policy frameworks for dealing with these diseases are often weak.[37,38] In addition, in many developing countries there are major disconnects between policy and implementation. Successful control of zoonoses requires a judicious legal and policy framework, well-functioning institutions, adequate financing, rapid detection, and an intervention implementation plan. Collaborative multidisciplinary and multinational research will also be needed to explore the linkages among environmental dynamics, disease vectors, pathogens, and human susceptibility.[36]

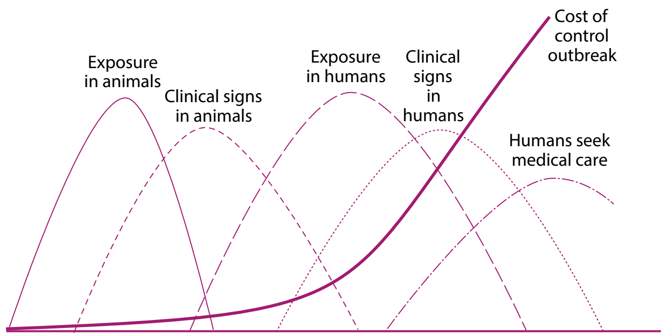
Both logic and experience suggest that zoonoses can be best tackled through interventions involving the livestock hosts of the disease pathogens–but, while there are many local success stories, a sound evidence base is lacking regarding the costs, benefits, acceptability, and scalability of such interventions.[39-42] A significant constraint to involving agriculture in the control of zoonoses is the lack of collaboration between medical and veterinary authorities, leaving zoonoses concerns sidelined,

Early detection and control efforts reduce disease incidence in people and animals



Source: Karesh *et al.* (2012)[25]

Early control of zoonotic disease is both cost-effective and prevents human disease



Source: World Bank (2012)[7]

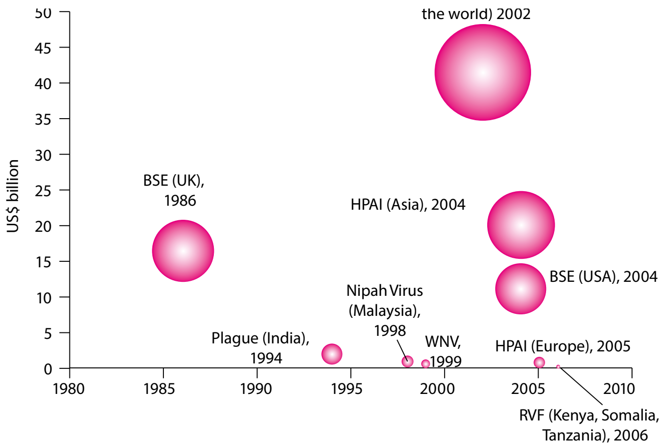
despite the promise of One Health and Ecohealth initiatives. These approaches have been widely endorsed, but are rarely used at local levels, where they are most needed.

Effective strategies already exist for controlling most neglected zoonoses; the main constraint is lack of investment rather than method.[36] The costs of controlling zoonoses can seem high when compared to public health benefits alone, but these costs are easily outweighed when a full cross-sector analysis is carried out and the benefits of control to the agricultural sector, to wildlife, and to society are taken into account.[36,41,42]

In the case of emerging diseases, investment in surveillance and in human and animal health services are needed to ensure 'emergence events' do not lead to large-scale zoonoses epidemics. The World Bank has estimated that an investment of US$3.4 billion in animal health systems per year would avert losses incurred through delayed or inadequate responses to zoonoses–losses estimated at US$6.7 billion per year.[7]

While improved surveillance and rapid response capacities are important and urgently needed, they, too, are insufficient means to controlling the emergence of zoonotic diseases. Success requires addressing the root causes of disease emergence–the fact that human activities are imposing extreme stresses on ecosystems and their ability to function. Addressing the problem at the necessary foundational level calls for reconciling human development within the biophysical environment. The ecosystem services on which the health of animals, people, and the planet depend must be restored, safeguarded, and prized.

Estimated costs of emerging zoonotic diseases (1986 - 2006)



Source: World Bank (2012)[7]

Video: **FAO: Changing disease landscapes - towards a global health approach**

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Video Link: https://www.youtube.com/watch?v=vHVSW5HwmZM

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Photo Credit: Chesapeake Bay Program

Microplastics:
Trouble in the Food Chain

Plastics in the environment

As the world's demand for plastic materials continues to grow, management of plastic waste will remain a global challenge. In 2014, global plastic production exceeded 311 million metric tons, a 4.0 per cent increase over 2013.[1] In 2010, out of 2.5 billion metric tons of solid waste generated by 192 countries, about 275 million tons consisted of plastic. It has been estimated that between 4.8 and 12.7 million tons ended up in the ocean as a result of inadequate solid waste management.[2]

Concern about visible plastic debris is increasing, while recent research reports the growing presence and abundance of microplastics in marine environments.[3-6] These small plastic pieces, between the size of a virus and an ant, now can be found worldwide: in the water of lakes and seas, in the sediments of rivers and deltas, and in the stomachs of various organisms ranging from zooplankton to whales. Microplastics have been detected in environments as remote as a Mongolian mountain lake and deep sea sediments deposited five kilometres below sea level.[7-9] One study estimated that, on average, every square kilometre of the world's oceans has 63,320 microplastic particles floating at the surface, with significant regional variations–for example, concentrations in East Asian seas are 27 times higher.[10,11] Marine organisms–including zooplankton, invertebrates, fishes, seabirds and whales–can be exposed to microplastics through direct ingestion of water and indirectly as predators in food webs.

Plastics that are originally manufactured in a particularly small size for specific applications are called primary microplastics. In the marine environment, plastic debris of every size can be mechanically broken down into smaller pieces by external forces such as UV radiation, wind, waves, or animals. This physical weathering produces secondary microplastics.[6,12]

Further breakdown of plastic into ever-smaller particles does not lead to a complete degradation into monomers. Instead, the original plastic polymer remains intact at microscopic scale unless the original polymer is converted into carbon dioxide, water, methane, hydrogen, ammonia, and other inorganic compounds, a process of biodegradation influenced by external conditions and the properties of the particular plastic polymer. This generally does not happen to plastics in the aquatic environment.

Photo Credit: Pressmaster/ Shutterstock.com

Microplastics

The term 'microplastics' is widely used to describe plastic particles with the size ranging from 1 nanometre to 5 millimetre[22]

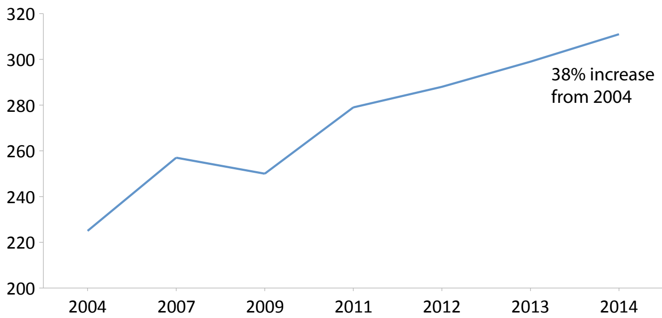
Monomer

Monomers are molecules capable of combining, by a process called polymerisation, to form a polymer. For example, the monomer ethylene (C_2H_4) is polymerised into a chain, using a catalyst, to form polyethylene $(C_2H_4)_n$

Polymer

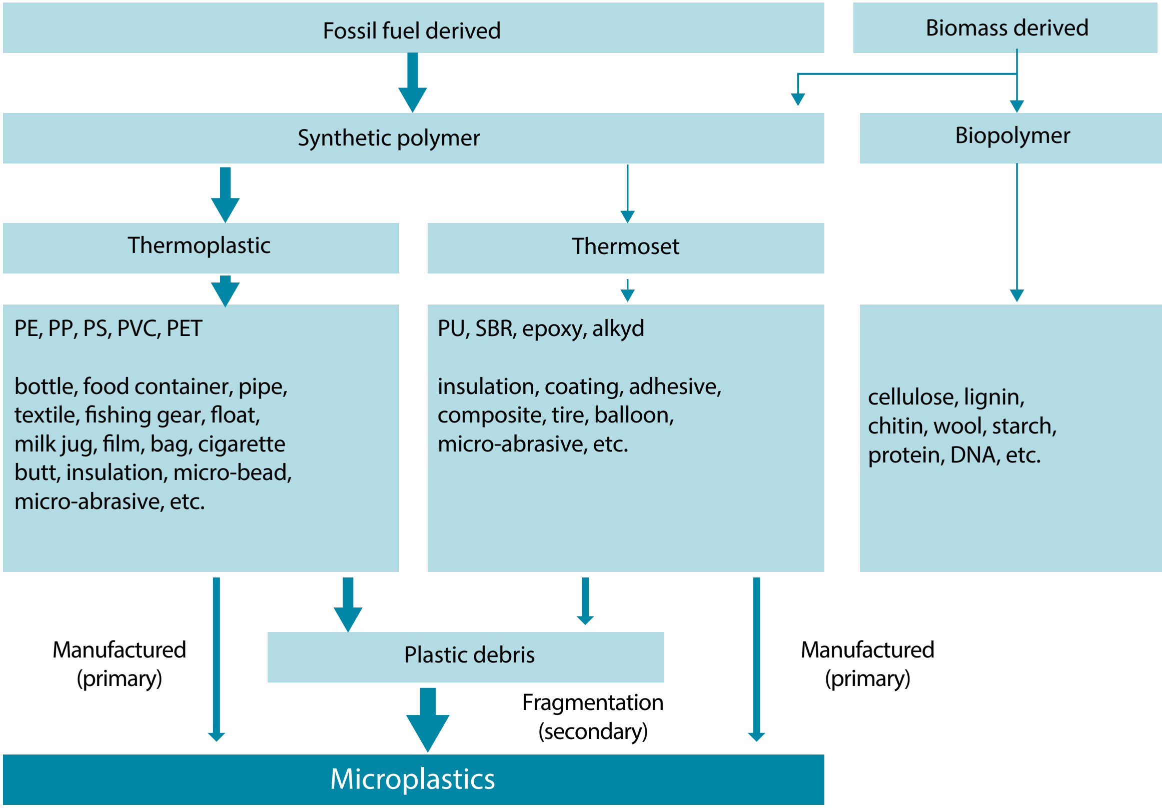
Polymers are large organic molecules composed of repeating carbon-based units or chains that occur naturally and can be synthesised. Common natural polymers include chiton (insect and crustacean exoskeleton), lignin (cell walls of plants), cellulose (cell walls of plants), and protein fibre (wool, silk)[6]

Global plastics production (metric tonnes)



Data source: PlasticsEurope (2015)

Schematic illustrating the relationship between primary materials source, synthetic and natural polymers, thermoplastic and thermoset plastics and their applications



Source: GESAMP (2015)[22], UNEP (2016)[6]

Exposure to UV radiation, oxygen, high temperatures, and microbial activity for an optimal duration can bio-degrade 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]

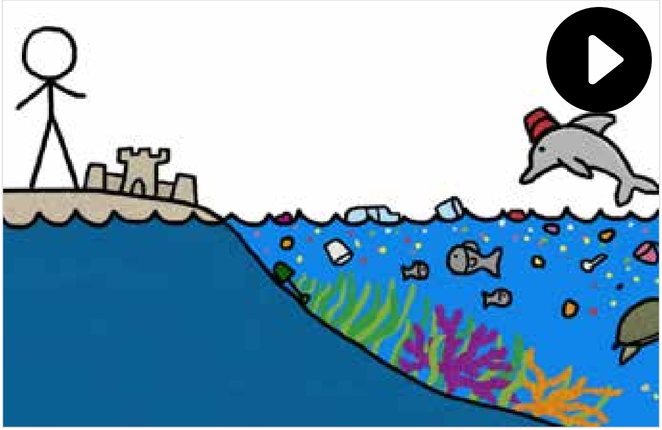
Biodegradable

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).[5]

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]

Photo Credit: Avemario/ Shutterstock.com

Video: Ocean confetti!



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

Video: What really happens to the plastic you throw away

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Video Link: https://www.youtube.com/watch?v=_6xlNyWPpB8
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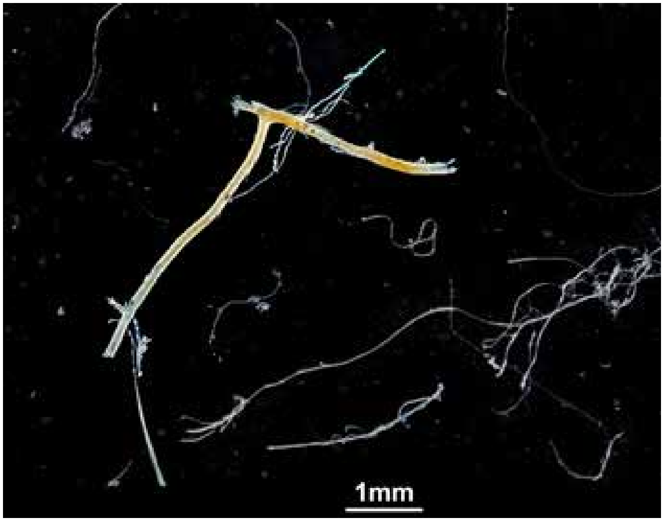
Common sources of microplastics

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.[18-20] Following public awareness campaigns widely supported by consumers, some producers responded by agreeing to remove the material from their goods.[21] 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.[22]

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.[22,23] 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.[19,24]

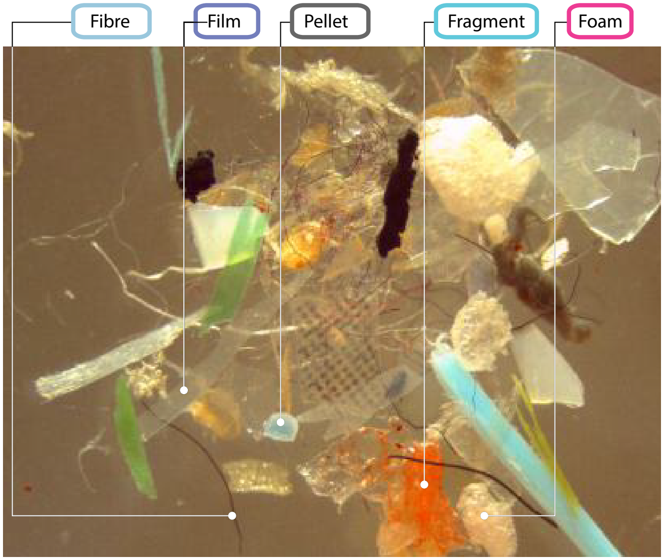
Growing evidence suggests that fibres from synthetic fabrics are a significant source of secondary microplastics commonly found in wastewater and in the aquatic environment.[25-28] The world's consumption of synthetic fibres as clothing and textiles for domestic and industrial uses exceeded 55 million tonnes in 2013, or 61 per cent of the global consumption of all fibres.[12] This reveals a sharp increase from 35.8 million tonnes



Mcroplastic filaments found in the deep-sea sediments[9]
Photo Credit: Courtesy of the Natural History Museum, London

Microplastics collected from a sandy shoreline in Europe (Wright *et al.* 2013)[45]
Photo Credit: This image was published in Current Biology, Vol.23, Wright *et al.* 2013, Copyright Elsevier (2013)

Different types of microplastics found in the Francisco Bay



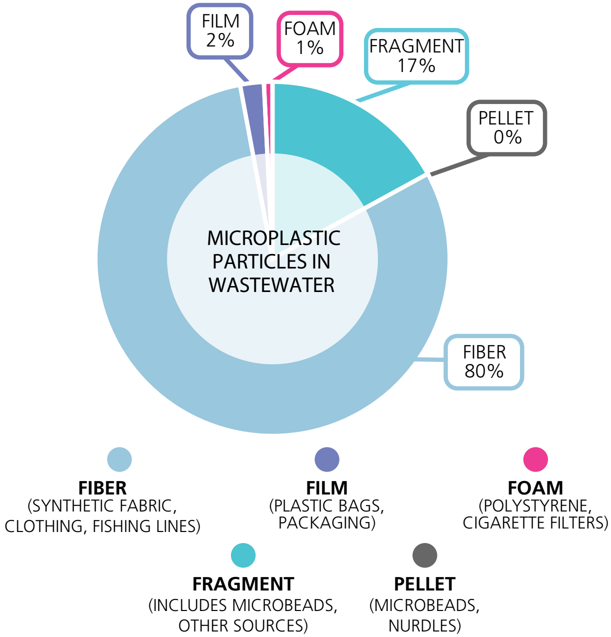


Photo Credit: Sherri A. Mason/State University of New York at Fredonia
Source: San Francisco Estuary Institute (2015)[43]

in 2009.[29] 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.[12] Experiments show that more than 1,900 microplastic fibres are released from a single synthetic garment in just one wash by a laundry machine.[30] 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.[31]

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.[6] 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.[32]

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 persistant 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

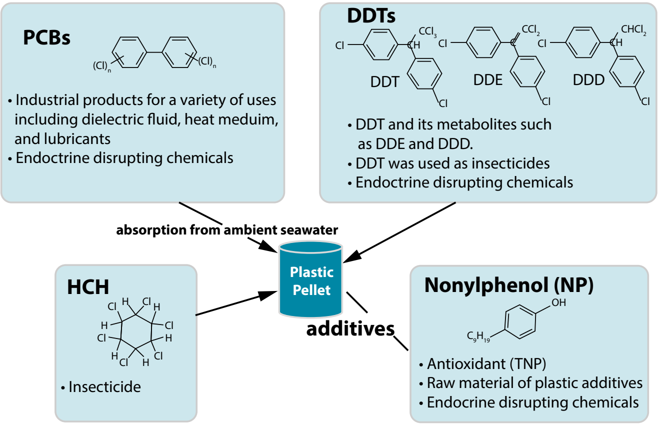
Persistent organic pollutants (POPs) are chemical substances that remain in the environment, are transported over large distances, bioaccumulate through the food web, and pose a risk of causing adverse effects to the environment and human health. POPs include pesticides such as DDT, industrial chemicals 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.[22,40] 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.[41,42] 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.[6,40]

Different types of microplastics found in the Francisco Bay



Courtesy of International Pellet Watch (2016)[44]

Plastic resin pellets

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

Biomagnify

The increasing concentration of a substance, such as a toxic chemical, in the tissues of organisms at successively higher levels in a food chain. As a result of biomagnification, organisms at the top of the food chain generally suffer greater harm from a persistent toxin or pollutant than those at lower levels

Video: Are microplastics in our water becoming a macroproblem?

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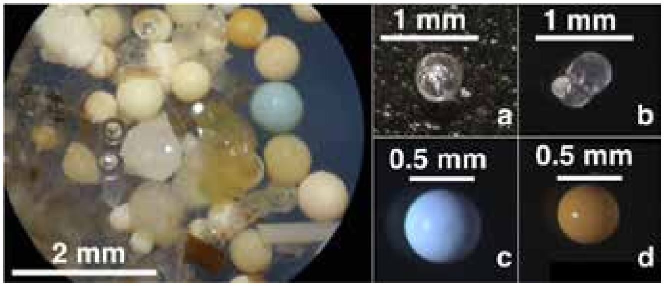
Video Link: https://www.youtube.com/watch?v=ZHCgA-n5wRw
Photo Credit: Coprid/ Shutterstock.com

Microplastic 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)[26]

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**

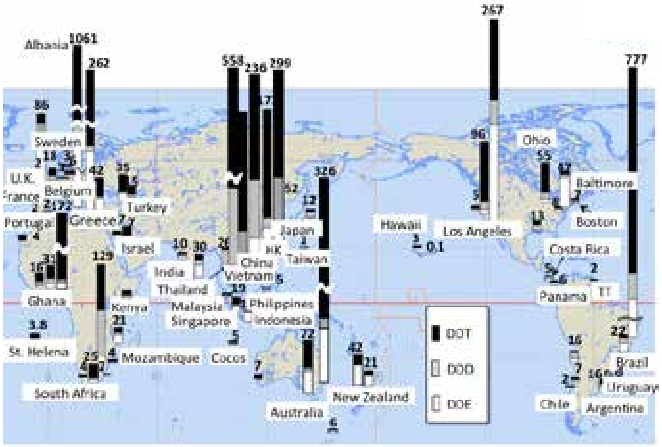
© Operation Clean Sweep/American Chemistry
Video Link: https://www.youtube.com/watch?v=54QQ8t8TePY
Photo Credit: XXLPhoto/ Shutterstock.com

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.

Photo Credit: UN Photo/Martine Perret

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



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

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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.[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.[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.[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.[5-8]

While there is no universally agreed definition to date,[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 efforts. Loss and damage become evident when adaptation measures are unsuccessful, insufficient, not implemented, or impossible to implement; or when adaption measures incur unrecoverable costs or turn out to be measures that increase vulnerabilities, called maladaptations.[11]

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.[12-15] Extreme events alter ecosystems. As a result, they disrupt food production, water supply, infrastructure and settlements, and human lives and livelihoods.[2] With more than 60 per cent of the ecosystems and their services already degraded or exploited unsustainably.[16] Climate change will cause further changes and adverse consequences, including alterations in the efficiency of ecosystem services.[17-19] 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**

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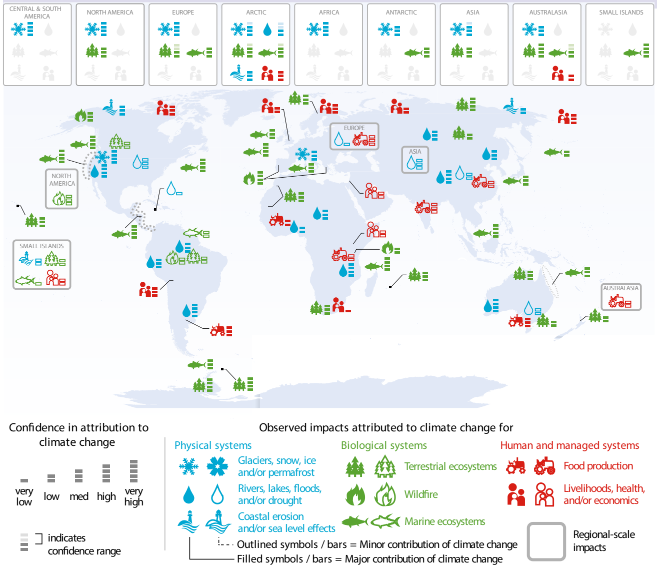
Video Link: https://www.youtube.com/watch?v=Pp8WEhG2UHs

Global patterns of observed climate change impacts



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.

IPCC (2014)[2]

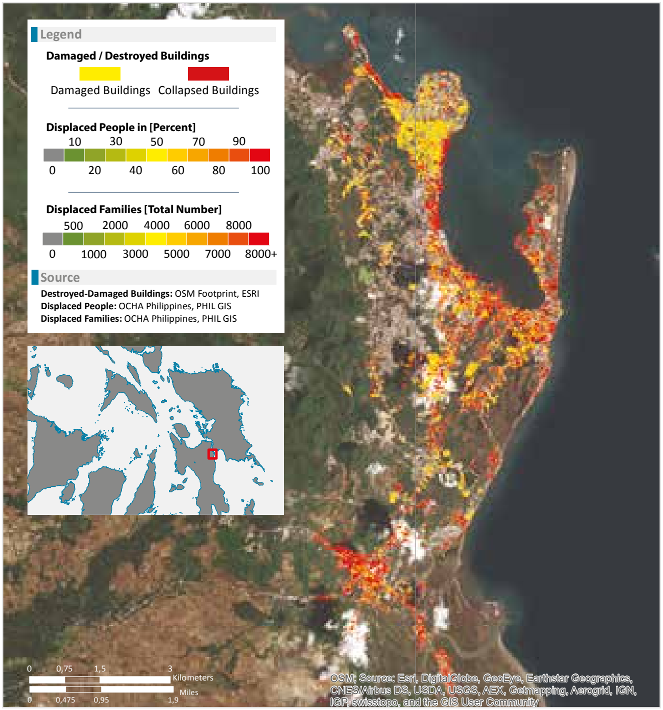
Expected loss of ecosystems and their services

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

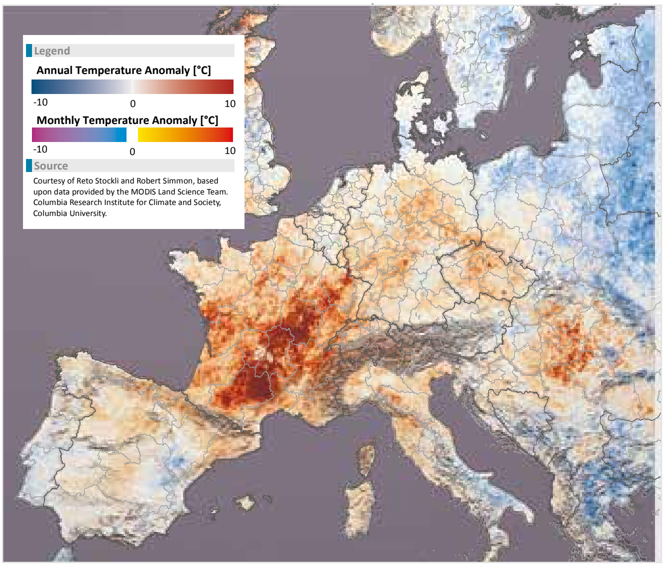
Loss and damage to people and properties due to Typhoon Haiyan



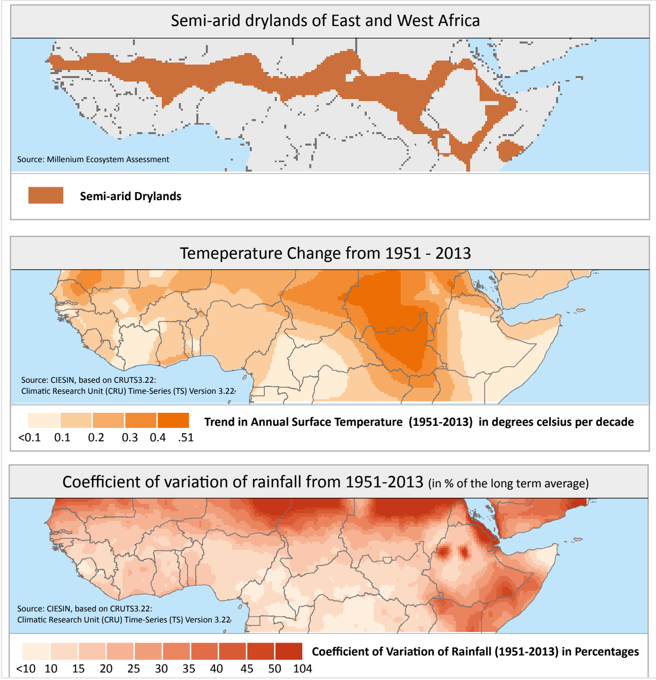
the great drought of the 1980s. During the same period in much of East Africa, rainfall trends have declined.[39-42]

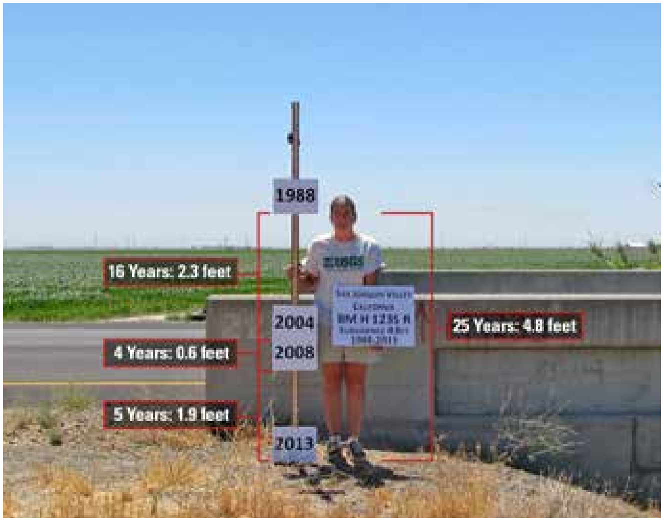
From 2012 through 2015, California experienced the most severe drought in the last 1,200 years.[43] A range of scientific research has suggested a link between anthropogenic warming and an increase in the occurrence, strength, and length of high impact droughts in this region of the U.S. The economic 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]

Temperature anomaly in the Central and Western Europe



Temperature and rainfall variation in East and West Africa





Land subsidence in California from 1988 to 2013
© USGS/Justin Brandt

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.[48] 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.[49] 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.[50] Further research suggests that global average sea level will continue to rise for at least 5,000 years.[51] 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.[52] 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.[52]

Risk transfer is a practice of formally or informally redistributing the risk of financial consequences for particular negative events from one party to another.[53] 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.[54] 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.[55] Insurance is not optimal for events that occur with very high frequency, such as recurrent inundation of flood plains.[56]

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.[49] 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.[49] Risk retention works more effectively when implemented together with other risk management approaches.[56]

Video: **Interview with Koko Warner, United Nations University**

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Video Link: https://www.youtube.com/watch?v=gSQCb3VWcWc

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".[57]

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.[57]

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.[58] 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**

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

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Poisoned Chalice:

Toxin Accumulation in Crops in the Era of Climate Change

Climate changes trigger accumulation of toxins in crops

Climate change is already underway, with shifting weather patterns that could 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.[1] 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.[2]

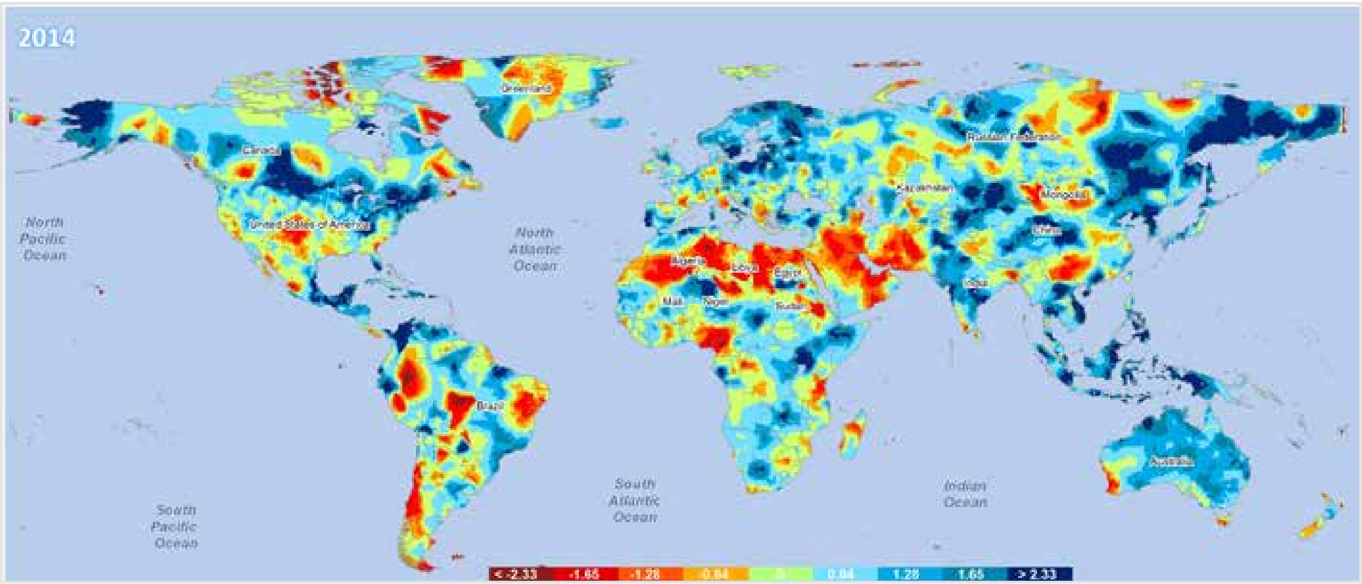
Given that more than 70 per cent of agricultural production relies on rainfall, increasing climate variability poses an unprecedented challenge to agriculture and to food production systems around the world.[3] Climate threats to food security are expected to be worse in countries at subtropical and tropical latitudes.[4] For instance, the frequency, severity, and range of droughts in the entire African continent have significantly increased between 1900 and 2013.[5,6] Specifically in East Africa, the well-documented 2010–2011 drought greatly affected agricultural yield and increased food insecurity in the region.[7] 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.[8] 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]

Stress caused by extreme climatic conditions can reduce crop yields, increase postharvest losses, and threaten animal and human health. Despite a plant's various protective responses, prolonged environmental stress could overwhelm its ability to thrive, and can weaken the plant further, leading to increased susceptibility to diseases and pests. Furthermore, environmental stress triggers biochemical reactions which could lead to synthesis and concentration of chemical compounds that could be harmful to animal and human health. In such cases, either the plant itself or invading the microbes can produce specific chemical compounds at levels toxic to animal and human health.

Video: A dry season

Video Link: https://www.youtube.com/watch?v=lbpuviS-s4c
Photo Credit: Earl D. Walker/ Shutterstock.com

Decadal world maps showing the Standardized Precipitation Evaporation Index (SPEI) over a 48 month time-scale. Areas shown in red were unusually dry during the indicated interval. The calibration period for the SPEI is January 1950 to December 2010. Based on data from © SPEI Global Drought Monitoring (Multiple maps available in eBook version)



http://sac.csic.es/spei/map/maps.html

Contamination pathways–implications for crops, animals, and people

Worldwide, over 80 plant species are known to cause poisoning from accumulation of nitrates.[10] Under normal growing conditions, 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.[11] Common crop plants most susceptible to nitrate accumulation are barley, maize, millet, sorghum, soybean, sudangrass, and wheat.[12] 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 may result in dangerous accumulation of compounds that give rise to toxic hydrogen cyanide (also called prussic acid).[13] Examples of plants that can accumulate prussic acid to toxic levels under extreme conditions are cassava, flax, sunflower, pigweed, maize, sorghum, sudangrass, arrow grass and velvet grass.[12]

Another important category of toxins associated with changing climate is mycotoxins, toxic chemicals produced by fungi that colonize crops. The type of damage by mycotoxins depends on the extent of exposure of the animals or humans. 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.[14,15]

Certain species of *Aspergillus* fungi produce aflatoxins, a mycotoxin whose accumulation can be prompted by drought conditions. About 4.5 billion people in developing countries are exposed to uncontrolled and unmonitored amounts of aflatoxins.[16] 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.[17] Exposure of Hepatitis B patients to aflatoxin increases chances of liver cancer.[18] The extreme conditions could lead to an increase in aflatoxin exposure and thus increased burden of liver cancer, particularly in sub-Saharan Africa, a region with highest prevalence of Hepatitis B.[19] Resource-poor farmers may feed mouldy grains to livestock, but this may not be safe, depending on the species, the lactation status and the domestic importance of the animal. Aflatoxins and other mycotoxin contaminants can reduce animal productivity and increase mortality, and they can be carried over to animal-source food products, especially milk, with potential impacts on human health and nutritional status.[20]

Photo Credit: UN Photo/James Bu

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.[21] Normally, environmental and climatic conditions in Serbia and other temperate regions do not favour the accumulation of aflatoxins, in contrast to tropical and sub-tropical zones where aflatoxin contamination is more evident.[22] However, the risk of aflatoxin contamination, particularly in maize, is expected to increase in higher latitudes due to rising temperature. A recent modelling study predicts that aflatoxin in maize will become a food safety issue for Europe, even if the increase in global temperatures can be limited to 2°C. Areas at high risk of aflatoxin outbreaks include Eastern Europe, the Balkan Peninsula, and the Mediterranean.[23]

Video: Nitrate toxicity in corn

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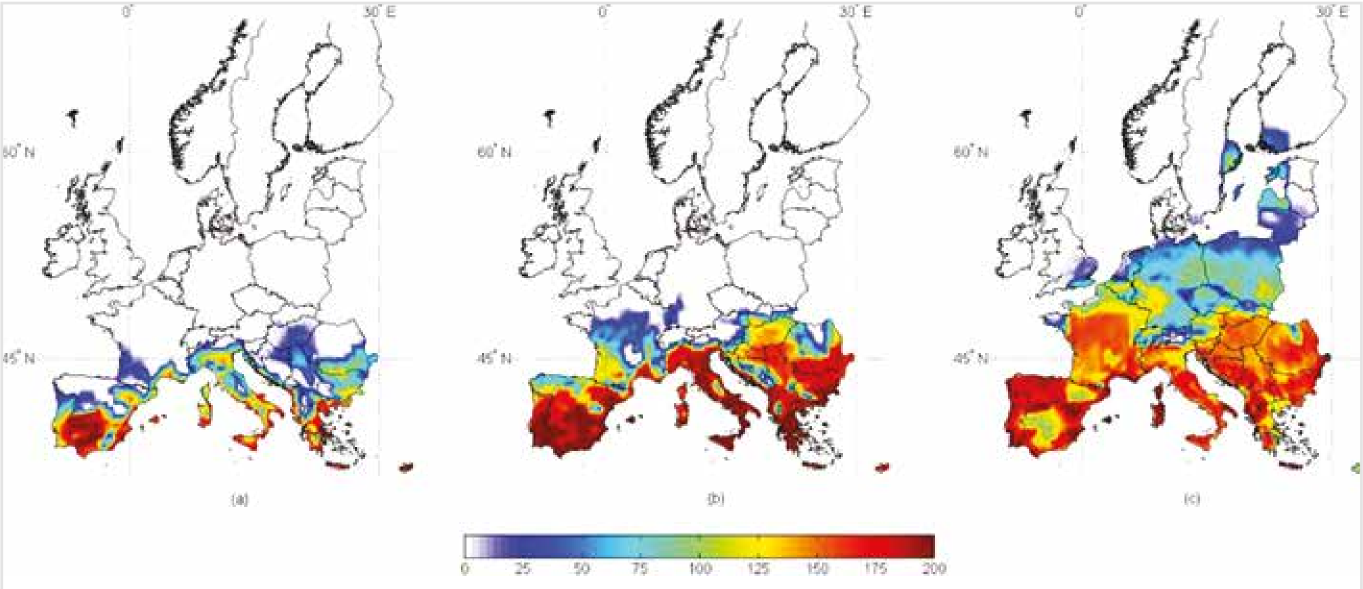
Video Link: https://www.youtube.com/watch?v=GguOOGzeOWk
Photo Credit: Kent Weakley/ Shutterstock.com

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



Source: Battilani *et al.* (2016)[23]
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Remediating toxic contamination in plants and animals

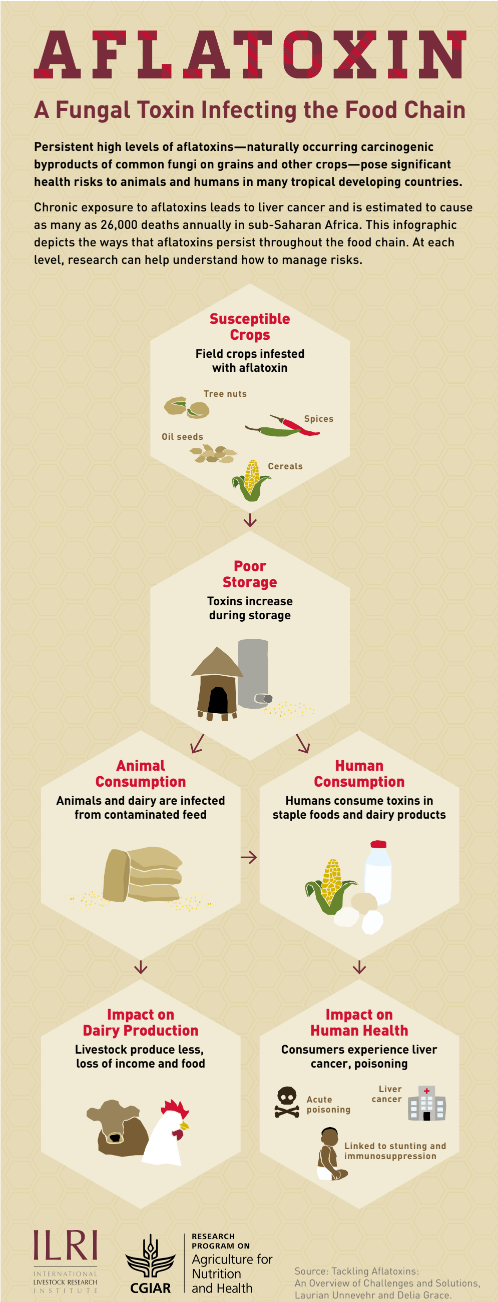
We are just beginning to recognize the magnitude of toxin-related issues confronting farmers in developing countries of the sub-tropics and tropics. As warmer climate zones expand towards the poles, countries in more temperate regions are facing new threats.[23-25] Deteriorating climatic conditions combined with enhanced capacities of diagnostic surveys for toxin detection 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.[26,27] 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.[28,29] 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, there are several relevant initiatives: the Comprehensive African Agricultural Development Program; the African Union Commission's Partnership for Aflatoxin Control in Africa (PACA); the Codex Alimentarius standards body; food safety and regulation efforts by the Food and Agriculture Organization of the United Nations (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".[30]

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.[31,32] Risk assessment and mapping are powerful tools for decision making based on an understanding of various aspects of contamination risk.[28,33] Some research focuses on strategies to develop more 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.[34]

Photo Credit: Smereka/ Shutterstock.com

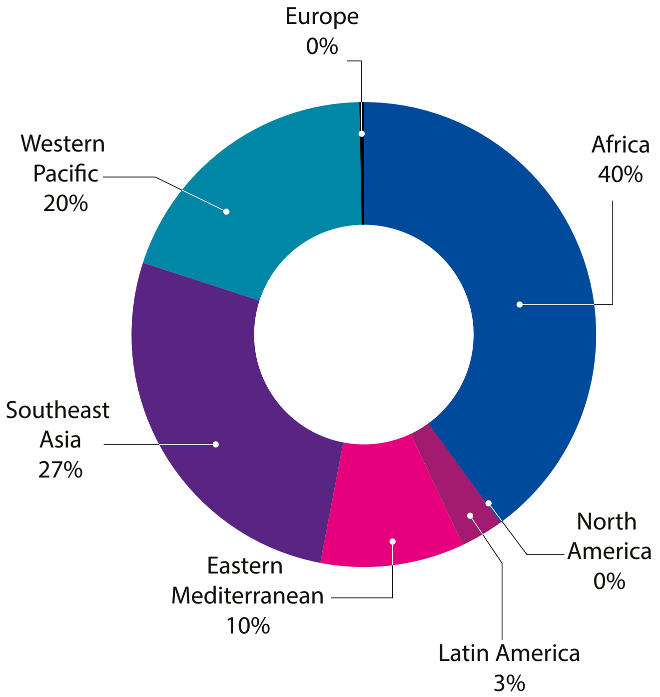


Source: © ILRI

Video: Aflatoxin contamination in Kenya

© UNEP

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



Data Source: Liu and Wu (2010)[35]

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 developed, tested, and scaled up. These efforts must be significantly expanded and accelerated to secure a safe harvest for current and future generations.[36]

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 presence, 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 toxin 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.
5. Reducing production and postharvest risk with best practice interventions.
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**

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The Latest Frontier

Exotic Consumerism: Illegal Trade in Live Animals

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 of Wild Fauna and Flora (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 37per cent were native to Thailand, while 63% were nonnative species. There is a growing number of documentaries and news briefings on this issue.

Photo Credit: Sumatran Orangutan Conservation Programme

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

Video: Stolen Apes

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Video Link: https://vimeo.com/60813938

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.

Photo Credit: Common Commons

Main international routes for the illegal trafficking of great apes

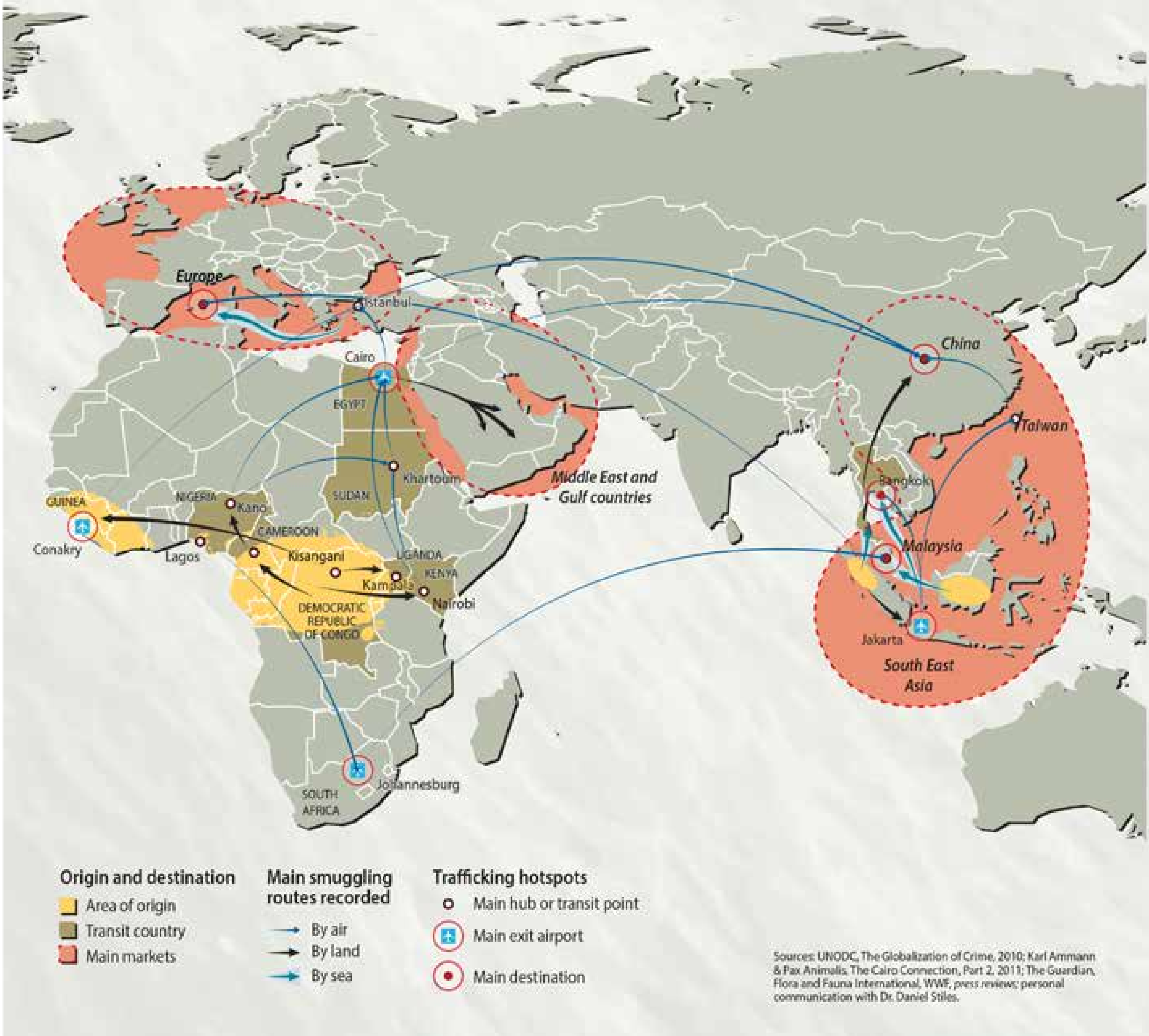

Photo Credit: GRASP

Photo Credit: Wildlife Conservation Society

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

Photo Credit: Creative Commons

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

Video: **Exotic animal species smuggled**

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Video Link: https://www.youtube.com/watch?v=KzgTAbp-Fyo
Photo Credit: IUCN

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

Video: Trafficked through Thailand: Cracking down on animal smuggling

© The New York Times
Video Link: https://www.youtube.com/watch?v=KzgTAbp-Fyo
Photo Credit: GRASP

Photo Credit: U.S. Fish and Wildlife Service

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 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.

Photo Credit: GRASP

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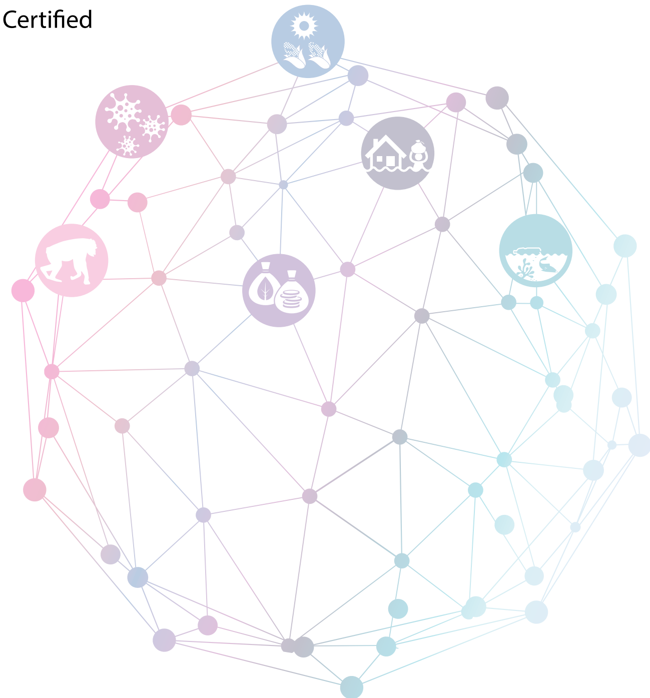

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