Une f ronti èrs
2016 R e p o r t
Emerging Issues of Environmental Concern
UNEP FRONTIERS
2016 REPORT
Emerging Issues of Environmental Concern
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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 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
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.
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.

**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.”

**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.

**Reputational risk** is defined as “a threat or danger to the good name or standing of a business or entity.”

**Video:** We Mean Business

Source: Adapted from Forest Trends (2015) with additional unpublished data provided by Forest Trends Association in January 2016.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

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

© Investopedia

Photo Credit: Katjen/Shutterstock.com

Source: Statista (2016)10
How large are 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

**Water scarcity**
- Physical risk (too little water) or
- Regulatory risk (mandated restrictions)

**Effects at asset level**
- Physical risk (% production at risk for individual mines)

**Effects at company level**
- Aggregate effect of individual mines on entire company

**Adjust company revenue or earnings**
- Calculate asset stranding using e.g. discounted cash flow modelling

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

<table>
<thead>
<tr>
<th>RISKS</th>
<th>IMPACTS</th>
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<tbody>
<tr>
<td>Direct risks</td>
<td>Indirect risk</td>
</tr>
<tr>
<td><strong>Financial sector</strong> (banks, investors, insurers)</td>
<td>Loans Equity Insurance</td>
</tr>
<tr>
<td><strong>Corporate sector</strong> (mining, oil &amp; gas, agriculture, forestry, infrastructure, etc.)</td>
<td>Reputational risk Litigation risk Regulatory risks</td>
</tr>
<tr>
<td><strong>Environment</strong> (climate change, chemical pollution, deforestation, biodiversity loss, water)</td>
<td></td>
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</tbody>
</table>
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. 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.

<table>
<thead>
<tr>
<th>Stranded assets</th>
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<tbody>
<tr>
<td>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</td>
</tr>
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Fossil Fuel Assets at Risk

Source: Ceres and CarbonTracker (2013)
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. 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.

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. 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. 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.

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. 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. 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. 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.

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...
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.

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**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)
References


Photo Credit: Photofriday/Shutterstock.com
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. Zoonoses are also opportunistic and tend to affect hosts that are already stressed by environmental, social, or economic conditions.

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.

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.

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 trematodiasis, 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. Global concern currently focuses on anthrax, bovine tuberculosis, brucellosis, human African trypanosomiasis, Taena solium cysticercosis (pig tapeworm), cystic echinococcosis (hydatidosis), leishmaniasis, and rabies. 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.

Emerging zoonotic disease events, 1940-2012

Video: How can animals make you ill?

© RIVM/Government of the Netherlands

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

Source: International Livestock Research Institute (ILRI)
## Impacts of zoonoses

<table>
<thead>
<tr>
<th>Zoonosis</th>
<th>Primary transmission/reservoir species</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avian Influenza</td>
<td>![Chicken, Bird, Duck]</td>
<td>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</td>
</tr>
<tr>
<td>Ebola</td>
<td>![Human, Chimpanzee, Bat]</td>
<td>The 2014-2015 Ebola outbreak in Guinea, Liberia and Sierra Leone led to 11,310 deaths and 28,616 confirmed cases.48</td>
</tr>
<tr>
<td>MERS</td>
<td>![Camel, Bat]</td>
<td>Since September 2012, 27 countries have reported confirmed cases, with about 624 deaths.49</td>
</tr>
<tr>
<td>Nipah virus</td>
<td>![Pig, Bat]</td>
<td>US$ 671 million of economic losses, one million pigs culled, and 100 people died from the 1998 outbreak in Malaysia.7</td>
</tr>
<tr>
<td>SARS</td>
<td>![Human, Bat]</td>
<td>The impact of the 2002 outbreak was estimated at US$ 41.5 billion, with 8,000 confirmed infections and 800 deaths.7</td>
</tr>
</tbody>
</table>

## Events of zoonotic disease emergence by type of animal hosts

![Map showing zoonotic EID events worldwide](image)

**Zoonotic EID Events**
- 1
- 2-3
- 4-5
- 6

**Legend**
- Red: Wild
- Purple: Non-Wild
- Blue: Both
- Light Blue: Unknown

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. 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. Examples of zoonoses emerging when land is cleared for human activity can be found in many regions and on most continents. 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. Growing evidence suggest that outbreaks or epidemic diseases may become more frequent as climate continues to change.

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. Increasing demand for milk and meat, driven mainly by fast-growing populations of urban consumers in developing countries, is projected to double by 2050. The Livestock Revolution paradigm is leading to rapid increases in livestock populations in developing countries, which increases the likelihood of disease transmission. Demand for livestock products leads to more intensive production, that is greater populations of high yielding and

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

1. Wildlife
2. Livestock
3. Other

**Primary drivers of past disease emergence**

- Land use changes: 31%
- Agricultural industry changes: 15%
- International travel and commerce: 13%
- Medical industry changes: 11%
- War and famine: 7%
- Climate and weather: 6%
- Human demography and behaviour: 4%
- Breakdown of public health: 3%
- Food industry change: 2%
- Other: 4%
- Bushmeat: 3%

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Source: Loh et al. (2015)
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. Changes in human host behaviours are also drivers of emerging zoonotic disease, including travel, conflict, migration, wildlife trade, globalization, urbanization, and changing dietary preferences.

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. Antimicrobial resistance is the result of pathways 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 preventative, and resistance to them is growing in domesticated animals especially in industrial-style production systems. Antimicrobial resistance created in livestock can then affect humans, so when people get sick antibiotics no longer work.

Suspected disease transmission from people to primates

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

- **Ebola** outbreak in West Africa was a result of forest losses, leading to closer contacts between wildlife and human settlements.
- **Scabies and measles** in mountain gorillas at Bwindi Impenetrable National Park, Uganda, and Parc de Volcans, Rwanda.
- **Yaws and intestinal parasites** in baboons at Gombe National Park, Tanzania.
- **Polio** in Chimpanzees at Gombe National Park, Tanzania, and in Beni, Congo.
- **Nipah virus** was linked to intensification of pig farming and fruit production in Malaysia.
- **Japanese encephalitis virus (JEV)** was linked to irrigated rice production and pig farming in Southeast Asia.
- Forest fragmentation in North America led to an increased risk of **Lyme Disease** in human.
- Rabies transmitted by vampire bats to cattle and human was linked to forest activities in South America.
- Emergence of **Bat-associated viruses** emerged due to loss of bat habitat from deforestation and agricultural expansion.
- Emergence of **Avian influenza** was linked to intensive poultry farming.
- Early human cases of **SARS** was associated with contact with civet cats either in the wild or in live animal markets.

Created based on data from Jones et al. (2013)

**Video:** Zoonotic Diseases Among Pastoralists in Uganda

[Video Link](https://www.youtube.com/watch?v=fp48hQTNjwQ)

Photo Credit: ILRI/ Stevie Mann

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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).

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.\textsuperscript{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.\textsuperscript{35}
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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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,
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. 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.

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.

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.
References


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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.³⁴⁶ 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.⁷⁸ 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.¹⁰¹¹ 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.

**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 (\(\text{C}_2\text{H}_4\)) is polymerised into a chain, using a catalyst, to form polyethylene (\(\text{C}_2\text{H}_4\)\(_n\)).

**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)
- **38% increase from 2004**

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