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BIODIVERSITY KEEPS PEOPLE HEALTHY

PIM MARTENS AND CARIJN BEUMER

Abstract

Biodiversity and health mutually interact. Generally speaking, the greater the decline in biodiversity, the higher are the risks to human health – certainly over the long term (Corvalán et al., 2005). Guiding the health transition towards an era of sustainable health demands an integrated policy that embraces social, economic and ecological elements, recognising the complex relationships between them and looking further than a typically four-year period to the next government election.

Introduction: Biodiversity is Linked to Human Health

As stated by the World Health Organization (WHO) in its report, *Our Planet, Our Health, Our Future*, '[he]alth is our most basic human right and one of the most important indicators of sustainable development (WHO, 2011). Intuitively, we know that nature affects human health. However, people are generally less well acquainted with the fact that biodiversity – the rich variety of species – is in every way essential, indeed, indispensable, to the maintenance of human health and well-being (Corvalán et al., 2005). Without the complex web of interrelations and functional connections between different species in the natural environment, there would be few prospects for human health (Chivian, 2002). The way we are heading with our current trends in exploiting and degrading our environment may lead us towards tipping points that would reduce the ability of nature to provide the ecosystem services upon which all of us depend (CBD, 2010).

In order to sustain the ability of happy and healthy lives as humans, we need to foster an integrated way of thinking that directly connects the human sphere to the biosphere – our surrounding natural environment. This integrated

ecosociological way of thinking is the basis for a sustainable development towards a thriving future of human-natural life (Capra, 1996; Laszlo, 1996, 2006; Beumer et al., 2008; Beumer and Martens, 2010).

Health is essential in achieving a sustainable development process. Sustainable development needs healthy people to address global issues effectively. Health can also be used as a measure to monitor progress in the process of sustainable development (UNCSD, 2012). As is stated in *The Future We Want* – the outcome report of the RIO+20 Conference of the United Nations Commission on Sustainable Development (UNCSD) – '[s]ustainable development will not be achieved in [the] presence of [a] high burden on communicable/non-communicable diseases' (UNCSD, 2012). Nevertheless, although the UNCSD recognises the importance of ecosystemic health to the sustenance and improvement of human health, it does not directly link biodiversity to this issue.

Fortunately, the recognition of the important connections between biodiversity and human health has increased during the past decade. A growing number of reports have been published on the topic of the complex relation between biodiversity and human health, and new opportunities emerge that may support biodiversity conservation in the light of human health and well-being. Many of these studies address ecosystemic health and human health inclusively in the context of sustainable development (WHO, 2011). The Convention on Biological Diversity (CBD) states in its strategic Aichi Biodiversity Targets that '[b]y 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded' (CBD, 2011). Additionally, the CBD adopted 17 decisions referring to human well-being and health (WHO, 2011). The World Health Organization in its report, *Our Planet, Our Health, Our Future* (WHO, 2011), discusses some of the important connections between biodiversity and human health, and how ecosystem services – of which many are provided by a healthy biodiversity – are significant determinants of human well-being and health. Important insights reported in the documents of the Millennium Ecosystem Assessment (Corvalán et al., 2005; Duraiappah and Naeem, 2005) and in the reports of the Intergovernmental Panel on Climate Change (IPCC, 2007) increasingly guide local and global policymakers and institutions like WHO in reviewing their decisions in the light of the importance of ecosystems and biodiversity for human well-being and health.

The relationship between biodiversity and human health starts with the basics: are adequate supplies of healthy food, clean water and air of good quality available? A healthy ecosystem supplies these 'ecosystem services' free of charge (Costanza et al., 1997; TEEB, 2009). But, besides these primary services, there are many other, different ecosystem services that contribute to maintaining, boosting and improving human health (see Box 27.1). Even apart from these useful aspects, the richness of species has its own intrinsic value (Des Jardins, 2006).

Box 27.1 Examples of ecosystem services.

(Chivian, 2002; Huynen et al., 2004; Corvalán et al., 2005; TEEB, 2009)

Pollination

Insects, like bees and wasps, pollinate crops, providing us with a range of vegetables, fruit and grains for our food: the natural source of vitamins, fibre and many other nutrients indispensable to our bodily health.

Clean air

The leafy crown of forests and woods functions as a filter and chemical plant that regulates the atmosphere's composition. It cleans the air and contributes to the regulation of temperature, humidity and climate.

River basins

Forests regulate the flow of water to downstream areas, ensuring a fairly regular, predictable flow pattern. In this way, forests contribute to safety while also ensuring that water for drinking and/or irrigation does not immediately drain away.

Freshwater purification

Wetlands absorb and recycle nutrients from human settlement. As the water flows through the wetlands, the plants, microbes and sediments that are present cleanse it of harmful pollutants, such as nitrogen and phosphorus.

Management of potential infestations and disease-causing organisms

Many crops, insects, rodents, bacteria, moulds and other infestations compete with humans for food, influence the production of fibres and spread diseases. Some animals and microbes serve us by protecting us naturally against these infestations, which can cause diseases in plants, animals and humans.

Stabilising the countryside, protecting against erosion

Forests and grasslands provide a variety of natural ways to protect the soil against erosion, once again contributing to the safety of inhabited areas and crop security (the opportunity to use the soil for agriculture).

Carbon removal on the land and from the global climate

Land-based ecosystems are major carbon stores, both in plant tissues and the organic components of the soil. By absorbing carbon, such ecosystems help to restrain the increase of carbon dioxide in the atmosphere, thus contributing to limit climate change. The effects of climate change on human health are extremely complex and include such components as malaria, dengue fever and the West Nile virus, tick distribution, or the health effects of changing ecosystem services resulting from a changing natural environment.

Social and cultural services

Ecosystems supply crucial habitats for plants, animals and microbes, which have their own intrinsic value, as well as supplying services to humankind, such as food-crop pollination, physical and psychological health, sporting and leisure activities and other cultural, artistic and aesthetic services.

Genetic databank

The vast amount of genetic information stored in ecosystems – a great deal of which is still unknown to us – represents an opportunity to find solutions to an immense range of challenges, such as the alleviation of diseases. Nature can also represent a model for the discovery of ways to remedy health issues: during its long hibernation, for instance, the black bear (*Ursus americanus*) does not develop osteoporosis, while the polar bear's unusual energy metabolism may point the way to remedies for type 2 diabetes in humans.

Inspiration

Nature can inspire art and provide new technological discoveries, such as waterproof materials or energy generation from organic materials via photosynthesis.

These ecosystem services owe their existence to a dynamic, complex network of functions, relationships and interactions between the various species in their native habitats. In recent years, we have seen much research into the relationships between biodiversity and ecosystem stability and productivity, in terms of experimental research in the field, the formulation of concepts and theories through to quantitative field observations. This research has shown that greater biodiversity is linked to an increase in an ecosystem's stability: 'diversity = stability' (McCann, 2000; Rees, 2010; Ives and Carpenter, 2007; MacDougall et al., 2013). All the research conclusions lead unequivocally to the conclusion that biodiversity is an essential precondition for the maintenance and, indeed, the flourishing of human health and well-being.

The global loss of biodiversity may lead – directly or indirectly, in the short or long term – to a massive loss of health for humankind. The alarm bells are ringing throughout the world among ecologists, and also among eco-epidemiologists. Biodiversity has never vanished at such a rate as now: 1,000 times faster than the normal evolutionary rate at which species disappear (CBD, 2010). At the time of writing, the Red List maintained by the International Union for the Conservation of Nature (IUCN) contains 24,216 animal and plant species threatened with extinction, which is 1500 more than the year before. A total of 61,914 species were studied when the list was compiled (IUCN, 2012).

Ecosystems and Our Health

Many human activities that contribute to increasing prosperity are responsible for the loss of biodiversity, and thus for a reduction in our chance for a healthy life. This paradox illustrates the natural tension between the maintenance of biodiversity (and thus health) and prosperity. Not that the extinction of a given species by definition brings about a specific disease. But, a certain degree of biodiversity is necessary for a well-functioning ecosystem as a whole and for the services it supplies to humanity (Sala et al., 2000; Chapin et al., 2001). A great deal of research is still needed to discover the precise nature of the relationships between human health, biodiversity and ecosystems. Nevertheless, as seen above, a number of authors and institutions have already emphasised the link between nature and health (Chapin et al., 2001).

Agricultural and oceanic diversity, for example, are crucial in providing global food security. For instance, plants such as maize, rice and wheat are together responsible for 60 per cent of humankind's food supply. In the future, our food supply will also come to depend on the development of new crops derived from today's wild plants, since disease and pesticide resistance will ultimately render our present crops unfit for food production. The vitality of these crops – and with it, our food supply – relates directly to the variety of species (Fehr, 1984). So, we need natural diversity to maintain the health of our agricultural crops and our food (Fehr, 1984). On the other hand, the expansion of agriculture around the world – especially through monocultural methods – can contribute to the reduction of the resilience of ecosystems through the loss of often very rich forest biodiversity and by increasing contacts between humans, domestic animals and wildlife, with the increased risk of pathogen transfer as a result (WHO, 2011).

Maintaining healthy genetic diversity will be crucial in maintaining ecosystem and human health, including, for example, in the battle against growing antibiotic resistance (Jarlier et al., 2012). Much research money and attention is currently being spent on new genetically engineered food species and new ways of modifying pathogenic vectors and viruses in order to battle (infectious) diseases. There are serious health risks to humans and the global ecosystem involved with modifying living organisms with biotechnology (de Vendômois et al., 2012). What will the systemic impacts be, for example, of modifying malaria mosquitoes in a way that interferes with their malarial transmission capacity (Wang and Jacobs-Lorena, 2013)? Biodiversity decline or tempering with biodiversity in other ways can increase the spread of infectious diseases by reducing ecosystemic resilience and the capacity of ecosystems to buffer pests and diseases (Matt and Gebser, 2010). Genetically modified (GM) species introduced for food security or for human health reasons may, just as other

invasive alien species have, become invasive over time and add to the decrease of biodiversity and ecosystem resilience (Jeschke et al., 2013). Many questions concerning the complex relationships between human health, ecosystemic properties and modified species are still unanswered.

Exotic life forms that penetrate our own ecosystem can cause health problems for humans, both directly and indirectly (IUCN, 2009). Exotic birds, insects and rodents can carry and transfer diseases, causing harm to the health of humans and native species. Exotic plants, such as certain algae, can overrun freshwater ecosystems, choking them and thus ultimately reducing biodiversity. It is often extremely difficult to combat exotic infestations, with heavy social and economic costs. Populations can simply explode from a lack of natural enemies in the new surroundings, and native species are driven away. The pesticides used to combat exotics lead to the pollution of soils and fresh water, with associated damage to valuable native insects, other species and human health (Pyšek and Richardson, 2010).

So, the relationship between environmental change, health and biodiversity is complicated. This also means that more biodiversity is not better by definition. Existing ecosystems are often in a dynamic but subtle equilibrium, which can be disrupted easily by changes that new species bring with them. For example, new species or species from another region, transported to or thriving in a new area under a changing climate, can cause very serious local or regional problems, creating hazards both to humans and to the environment.

A Paradigm Shift: From Symptom to System

Many of the health effects that can be caused by a loss of biodiversity can be mitigated by technological developments, improved hygiene and by eliminating the disease-causing agents using chemicals and pesticides, plus the continuous development of new medicines for improved treatments and disease management. These approaches provide options for attacking symptoms, and are of proven effectiveness. But, future investments aimed at alleviating the damage to health from the rapidly increasing loss of natural ecosystems will cost far more than investing today in a healthy global ecosystem. Mother Nature, after all, has known throughout the ages how to maintain equilibrium and stay healthy – and 'for free'. We have a lot to learn from her.

Greater biodiversity, in the main, also leads to the more efficient use of available natural resources, since there is more likelihood that species will be present that can respond to specific changes in a given habitat. The species that populate the world today are the result of a process of natural selection that has been

continuing for three billion years, and which has conferred on them a significant degree of specialisation and great efficiency in the way they tackle a wide range of problems. We have a lot to learn from that, too.

The modern, narrow focus on 'treating the symptoms' can lead to serious health hazards, as we have seen in our use of antibiotics in the intensive cattle rearing industry (Jarlier et al., 2012). The more antibiotics we use to combat the symptoms of disease, the faster the bacteria develop resistance and the less we can use antibiotics to treat sick people. The way we currently use antibiotics shows how a reductionist focus on combating symptoms can lead us literally down a 'dead-end street'.

If we are to cope with disease in a sustainable way, we shall have to move towards an ecological approach: how can we take preventive measures to ensure that we improve our resistance to disease? How can we plan and manage our natural environment, our agriculture and the urban environment to help us do so?

The way we cope with disease and health will have to undergo a shift in paradigm to become based far more on such a 'systemic approach'. Of course, (new) diseases will always emerge and the symptoms will have to be alleviated. But, what we need to do now is shift our focus to a 'health ecology', in which we start to understand illness and health in terms of a global system of complex relationships between humans, animals and nature.

Whom we can learn much from, too, for our necessary transition towards a more ecosocio systemic approach to health are traditional Indigenous communities. Many communities with ancient traditional knowledge on crops, herbs and their specific uses are now being 'visited' by large food and pharmaceutical companies. Potential medicines and new food sources are abundant in areas rich in biodiversity. Often, these biodiversity hotspots are located near or in Indigenous community areas in developing countries. Access to regular health care is often poor, and the communities depend on their resources and traditional knowledge of ecosystems for subsistence. States and international property right regulations do not protect these Indigenous populations, their resources and their traditional ecological knowledge enough from the practices of commercial companies that enter the community areas for private gains by imposing patent claims on organisms that can be used as ingredients for medicines, foods (Mackey and Liang, 2012), pesticides (Orozco and Poonamallee, 2014) or cosmetics (Jolly et al., 2012). Often, communities become victims of biopiracy when bioprospecting is used by companies to gain exclusive intellectual property rights (IPRs) over resources and knowledge developed by others. Even after the adoption of the Nagoya Protocol – which aims to combat biopiracy and encourages equitable and joint benefit sharing of resources while sustainably managing biodiversity (UNEP-CBD, 2011) – global governance

remains ineffective in protecting local communities from biopiracy (Mackey and Liang, 2012). Biopiracy does not only enhance ethical concerns about equity, environmental justice and the question of the right to 'own' living organisms (Jolly et al., 2012); it also directly affects the health and well-being of local communities: by violating people the right to breed, develop and even use their own developed knowledge, resources and ethnomedicine further without paying the prospecting companies (Laursen, 2012); by the depletion of the biodiversity resources the communities depend on for subsistence (Mackey and Liang, 2012); or by conflicts that arise (Jolly et al., 2012). Obviously, bioprospecting is not the way we can learn sustainably about biodiversity and its relation to our health from other communities and civilisations, and the way towards benefit sharing as proposed by the Nagoya Protocol of the CBD should be walked very cautiously, and questioned at every step: for, after all, who is to decide what benefits are going to be shared with whom (Orozco and Poonamallee, 2014)?

Trade-offs: Short-term Gains versus Long-term Losses?

Changes in the environment that are beneficial to our health can be viewed as trade-offs with the ecosystem's existing equilibrium. Often, though, their positive effect involves only a short-term benefit to our health. It turns out that the long-term costs (ecological, economic, social and health related) of this short-termism are far higher than estimates have suggested. One example is the extermination of vampire bats in Latin America. These bats can infect cattle with rabies. So, in the short term, the local food supply benefits, as does the local population's health. Over the long term, however, this action leads to an explosive growth in the mosquito population, which allows other diseases to flourish, such as malaria or dengue fever.

Another example is the drainage of the swamps in America's Great Lakes region, which eliminated the malaria mosquitoes, thus improving human health. But, the loss of these swamps – wetlands – from the drainage networks can lead to major problems with traditional livelihoods (the collapse of local fisheries, for instance). The long-term effect of technological fixes for the health issues caused by the local environment are sometimes pushed into the background, as was the case (and increasingly is, once again) with the use of dichlorodiphenyl-trichloroethane (DDT) to combat malaria.

In brief, the relationship between humankind, biodiversity and health is an ambiguous one. On the one hand, greater species' biodiversity can signify a larger reservoir of pathogens. On the other hand, there are many indications that increased diversity can reduce the spread to humans of a number of

disease-causing agents. Think, for example, of preventing the spread of Lyme disease by maintaining a natural ecosystem. If sufficient numbers of large mammals such as deer can inhabit a sufficiently large area, then the ticks will prefer them to humans.

The Ecological Footprint of Health Care

Seen in a wider perspective – that of global human health – it appears that the changes throughout the world that we have witnessed in recent years are both a blessing and a curse. We have increased economic growth and achieved rapid development in both technology and medicine, which have improved the life expectancy and the health of many peoples. On the other hand, many aspects of globalisation are imperilling human health. Consider not only the reduction of biodiversity that we have been discussing but also the erosion of social conditions, the widening gap between rich and poor (both within and between countries) and the accelerated pace of consumption.

The health industry itself is having a major impact on the entire ecosocial system. Here, we can – again – cite the use of antibiotics and increased bacterial immunity; the mountainous waste of time-expired medicines and other medical waste (including nuclear waste) from hospitals and care homes; the exploitation and patenting of organisms from the rainforest to manufacture medicines; the pharmaceutical industry's chemical pollution; hormones released into the water from the use of birth control drugs, which affect the fertility and even the sex of the fish population.

The way we use our land for agriculture and cattle rearing, which involves the use of pesticides, also weakens the complex natural equilibrium in many ecosystems. The current paradigm that prefers quick cures and short-term prosperity to long-term prosperity magnifies the likelihood of serious ecological harm. The massive mortality among bee populations, for example, is being ascribed increasingly to the use of neonicotine, an insect nerve poison that has recently been banned from Europe (EEA, 2013) but is still being applied in many other parts of the world, like the USA, Asia and Africa.

Despite all these problems, there is also a good side to this story: many avenues are available to reduce the ecological footprint of the industries that aim to contribute to human health. If these avenues are followed by pharmaceutical and food-producing companies, then a systems approach is a prerequisite. Health interventions must be viewed in the wider context of complex relationships within the entire ecosocial system. Progress, both economic and technological, has brought us great benefits, but we must investigate and appraise the long-term consequences of health interventions.

The Health Transition

Health care in the Western world has progressed from a society in which infectious diseases were the greatest cause of mortality to one dominated by chronic diseases. This is called the 'health transition' (Huynen, 2008). In a globalising world, this trend will only be reinforced. The next logical step is to look at what the transition implies for our future health situation. To do this, we use three possible future scenarios (Martens, 2003; Huynen, 2008).

A sustainable world

A global, integrated, systems approach to humankind and nature will ensure a sustainable equilibrium for human health. Both a degree of economic growth and an improvement in sociocultural and ecological conditions (including countering the loss of biodiversity) will have a beneficial effect on health and prosperity, in the short term as well as (in fact, mainly) in the long term.

A market-oriented world

Medical technology provides quick fixes for health problems. Health risks from consumer lifestyles and biodiversity losses can be limited, time and again, thanks to new developments in technology and medicine: quick fixes. A precondition for this scenario is a constantly growing economy.

A fragmented, market-oriented world

The rise of infectious diseases, both known and new ones, has a significant, adverse impact on the health of the world's population. Combined with improved mobility, this will lead to microbiological resistance, problems with the provision of health care, increasing environmental problems and a further decrease in biodiversity, with declining stability of the biosphere.

While these future situations are fictional, they are based on exhaustive scenario studies (Gallopin et al., 1997; Glenn and Gordon, 1998; Hammond, 1998; WBCSD, 1998; IPCC, 2000; Corvalán et al., 2005; UNEP, 2007) and so they may be regarded as possible future phases in the health transition (Huynen, 2008). 'Incidents' like the outbreak and subsequent spread of new infectious disease like the coronavirus, antibiotic-resistant Enterohaemorrhagic *Escherichia coli* and other bacterial infections that are resistant to antibiotics show what can happen to our future health under certain 'business as usual' conditions. Our view is that it is imperative to make the transition to another, more sustainable and ecological approach to health. We regard that in the most desirable scenario, the possibility of continuing economic growth (the precondition in scenario 2) is nothing but a utopian dream (Martens, 2013). We need to refocus on other types of 'growth'

and 'development' as essential for our future health and well-being. These are the 'development' of a global systemic ecological literacy (Mitchell and Mueller, 2009) and the 'growth' of a healthy, diverse and thriving ecosocial system (Beumer and Martens, 2010).

Conclusion: Sustainable Health is Ecosocio Health

In our view, the most desirable vision of the future couples economic development and globalisation with a growing social and ecological awareness. Here, sustainability is accorded high priority and economic growth remains within the parameters set by social and ecological goals. As a result, the risks to human health will decline, even as biodiversity increases.

We have shown that biodiversity and health mutually interact. Generally speaking, the greater the decline in biodiversity, the higher are the risks to human health – certainly over the long term. In a world where countries, ecosystems and economies are increasingly dependent on each other, a marginal degree of biodiversity makes a poor foundation for the health of all people, be they rich or poor.

So, in our view, policymakers cannot escape the need to conserve biodiversity. Guiding the health transition towards an era of sustainable health demands an integrated policy that embraces social, economic and ecological elements, recognising the complex relationships between them and looking further than a typically four-year period to the next election.

Poverty and inaccessible health care will tend to accelerate rather than resolve the inverse relationship between biodiversity and health. This chapter, in other words, is not simply a jeremiad against prosperity. Rather, it is a plea for a sustainable approach to development that pays attention to long-term effects and to the entire ecosocial system of Planet Earth, on which we all live.

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