Chapter 3

The impact of ecosystems on human health

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Abstract

According to the Millennium Ecosystem Assessment (MA), approximately 60% of the services that ecosystems provide to humans are being degraded or used unsustainably. This also impacts on human health, which is one of the main categories of wellbeing considered by the MA. From a long-term societal perspective, preserving or restoring ecosystems is sometimes a better idea than applying technological solutions, as this can lead to more human wellbeing and lower costs. However, several aspects add to the complexity of the ecosystem–health relation, making it difficult to see the value of these ecosystem services. Examples are complex cause–effect chains with long-term effects, intertwined socio-economic processes and the existence of both positive and negative effects of ecosystems on human health. Research into how ecosystem alteration impacts on human health could benefit various stakeholder groups and society. This chapter zooms in on some research objectives with both scientific and societal relevance.

3.1 Introduction

Due to population growth, land use-change and climate change, humans are increasingly exerting pressure on the ecosystems that surround them and in which they live. (Ecosystems are complexes of plant, animal, and microorganism communities and the non-living environment.) The consequences that ecosystem change can have for human wellbeing became clear through the work of more than 1300 experts worldwide within the Millennium Ecosystem Assessment (MA). Although the transformation of the planet has contributed to substantial net gains in human wellbeing, the costs associated with these gains are only recently becoming apparent: the MA (Millennium Ecosystem Assessment 2005, see references for website link) assessed the state of "ecosystem services", which are services that ecosystems provide to humans. Approximately 60% of the ecosystem services examined, ranging from regulation of air quality to reduction of natural disasters, are being degraded or used unsustainably. This also impacts on human health, which is one of the main categories of well-being considered by the MA. Arguing from the "health side" of the problem, the World Health Organisation (WHO) also realises the important place ecosystems take amongst other environmental factors influencing human health (World Health Organization 2015, see below for website link). The MA's Health Synthesis report (MA 2005), written in collaboration with the WHO, is specifically devoted to the connection between ecosystems and human health.

A famous ecosystem services project that also illustrates an ecosystem service related to human health is that of New York's watershed filtration services: New York's 9 million inhabitants obtain 90% of their drinking water supplies from the Catskill and Delaware watersheds, situated 130 miles outside the city, which filter water through the ecosystem's waterways and wetlands. Historically, these watersheds provided very high quality drinking water, but by the late 1980s, the water quality had degraded through a combination of land conversion, development, and negligence. The estimated construction costs of building a water filtration plant were at least $6 billion, and a further $300 million in annual operating costs. Instead, therefore, the Catskill and Delaware watersheds were restored. The cost of restoring these ecosystems and hence their water filtration services were a maximum of $1.5 billion (Hancock 2010).

The New York water filtration story can be called a success from the point of view that maintaining ecosystem services is sometimes a better idea than applying technological solutions. However, the story is not undebated (Ecosystem Marketplace 2006, see below for website link). Moreover, many scientists claim that we also have to be aware of the existence of ecosystem disservices (functions of ecosystems that are perceived as negative for human wellbeing), and that they also need to be taken into account when choosing between land-use management options. Historically, this weighing of trade-offs between services and disservices was relatively easy, because overall stress on ecosystems was sufficiently small to allow the focus to be on manipulating ecosystems to get rid of the disservice. For example, a few hundred kilometres to the south of the New York watershed, other wetlands were causing an ecosystem disservice to the inhabitants of Washington D.C. in the form of the infectious disease malaria. Malaria-infested wetlands were therefore drained. At that time, water filtration did not affect the supply of high-quality water to the capital. Currently, however, the intensity of human land-use change has put this ecosystem service of water filtration under stress as well, making it necessary to come up with management options that stimulate ecosystem services, whilst not stimulating disservices. The problem is made more complex by the driver represented by climate change, which is suspected to make more northern regions of the world more suitable habitats for mosquito-borne diseases. Tools are required that render the different services and disservices visible, provide insight into their cause-effect relationships, and quantify the trade-offs.

The scientific community has produced many basic conceptual diagrams providing an overview of the link between ecosystems and human health. The relation between ecosystems and human health from an ecosystem services and disservices perspective is shown in Box 3.1. This overview of the ecosystem–human health theme leads to many questions, important ones being: How are the ecosystem services and health outcomes related? Are there important non-ecosystem-related factors contributing to the increase or decrease in health outcome, like social and economic processes? When do ecosystem services and disservices interact? What is the relative contribution of ecosystems to globally important diseases? What is the time scale at which a driver of ecosystem change has an effect on human health? And in which regions do the diseases occur?

Box 3.1 Several ecosystem services and disservices related to human health

Services

Provisioning

1. Provision of food
2. Provision of genetic resources and natural products
3. Provision of timber, fiber and fuel

Regulating

4. Air purification
5. Biological control of infectious diseases
6. Environmental microbial diversity
7. Noise reduction
8. Climate stabilization (cooling)
9. Protection from natural hazards (such as floods & droughts)
10. Waste management, processing and detoxification
11. Water purification

Cultural

12. Promotion of social interactions and cultural traditions
13. Recreation & nature experience

14. Provision of aesthetic environments

Disservices

1. Increased prevalence of allergens
2. Inhibiting human safety (for example falling branches, collisions with animals, dangerous wild animals, plant protection mechanisms)
3. Source of infectious diseases
4. Decreasing air quality
5. Decreasing water quality and/or quantity
6. Bringing about negative psychological effects

3.2 Complexity of the relation between ecosystems and human health

The report by the World Health Organisation on ecosystems and human wellbeing states: "The causal links between environmental change and human health are complex because often they are indirect, displaced in space and time and dependent on a number of modifying forces". The following aspects increase the complexity of the ecosystem–health relation, whilst they are also significant parts of its mechanism:

1. Multiple drivers of ecosystem change: Changes in climate, land use and resource availability drive ecosystem changes and the impacts of these drivers on ecosystem services can also change over time.
2. Long and complex cause-effect chains: The cause-effect chains between driver, ecosystem condition and human health are often long, long-term and complex, due to non-linearity and feedback loops.
3. Multiple and diverse health impacts: Degradation of a specific ecosystem type can produce several very different health outcomes. Forest conversion for example, can cause an increase in infectious diseases, malnutrition and mental disorders.
4. Ecosystem services as well as disservices: Ecosystems providing a health service preventing one particular disease can at the same time provide a health disservice enhancing another disease. Moreover, whilst some ecosystems provide a health service concerning a particular disease, other ecosystems could provide a health disservice for the same disease.
5. Spatial heterogeneity and multi-scalarity: The health outcomes associated with a particular ecosystem change (or a driver of change) can differ from location to location, and the underlying mechanisms as well. Some of these health impacts can be observed across one or several regions of the world, whilst others occur only locally. Moreover, global drivers of ecosystem change can have local health impacts and vice versa.

6. Interaction with socio-economic factors: Socio-economic factors are not only important health determinants themselves, but can also buffer or enhance the impact of ecosystems on human health.

In the past decade, the mechanisms of many linkages between the natural environment and health outcomes have been described in general terms, and the possible effects of tropical rain forest destruction on the discovery of new medicines have been well-documented. Recently, the specific biological mechanisms behind infectious diseases, and hence the relation between ecosystems and these diseases, is starting to be revealed. As regards other ecosystem–health relations, however, there are several knowledge gaps. Although some information is available on the influence of climate change on human health, no links, interlinkages, maps, and models to relate this driver to human health through ecosystem services have been explicitly documented. Few attempts have been made to gather health outcomes of ecosystems in an overview and to find the interlinkages. Such an overview could, for example, be useful to find drivers that cause multiple types of health outcomes, or to find ecosystem factors that contribute positively to one health outcome, but negatively to another.

There are several socio-economic processes that modify population-level vulnerability to ecosystem change and therefore make it hard to measure a direct correlation with health outcomes. Important processes are protection by infrastructure & technology, culturally determined or learned behaviours and the availability of health care. If we take our example of the loss of wetlands and their water-filtering capacity, this is less likely to cause disease among downstream populations if they have access to water filtration technology. An example of learned behaviours is that increased exposure to malaria leads to the use of mosquito bed nets and adapted behaviour, such as staying indoors during certain hours. Governance is another mediating factor of the health impact of ecosystem alteration: at regional, national, and international levels, the capacity to deliver resources can prevent local resource scarcity from causing severe health impacts (Myers and Patz 2009).

It is probably partially due to these complexity aspects that relations between ecosystem services and human health are often not quantified. Mapping and modelling ecosystem–health relations has also just started. The five complexity aspects of assessing the ecosystem–human health relationship are visualised and positioned in Figure 3.1.

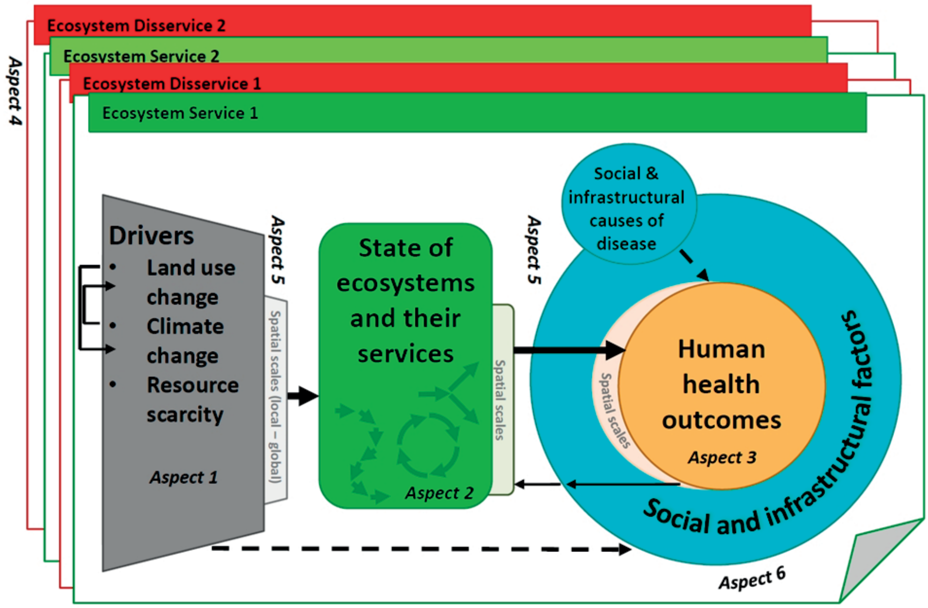

Figure 3.1 Conceptual framework for assessment of the impacts of ecosystems on human health. Thick black arrows: relations part of the main flow from drivers to health outcomes. Thin arrows: relations that create feedback loops and cross-connections. Dashed arrows: not part of an ecosystem-health assessment in a strict sense. In Italic: complexity aspects: 1) Multiple drivers of ecosystem change: 2) Long and complex cause-effect chains 3) Multiple and diverse health impacts 4) Ecosystem services as well as disservices 5) Spatial heterogeneity and multi-scalarity 6) Interaction with socio-economic factors. Figure adapted from Myers et al. (2013).

To cope with the multidisciplinarity and complexity of the effects of land-use change and climate change on several aspects of human wellbeing, sustainability scientists, environmental scientists, and policy scientists often strive towards an integrated (environmental / sustainability) assessment (IA). Acknowledged major aspects within this collective method include consideration of the long term, a cross-sectoral approach, changes in the impact of drivers, and multi-scalarity. However, the role of ecosystems as suppliers of both services and disservices to humans is an aspect not addressed yet in the IA approach. This might be an important reason why many ecosystem service assessments that do comprise several IA characteristics still lack an analysis of this balance. Many of the issues to which IA has been applied are relevant to human health, for example acidification, climate change, air pollution, and catchment management. However, few integrated assessments have been performed explicitly that included human health (Briggs 2008).

3.3 Transcending boundaries

The realisation of the importance of the ecosystem–human health connection does not solely come from the authors of the human health related chapters within the MA: it also comes from many other scientists in the field of health sciences (epidemiology, public health), natural sciences (ecology, biology), social sciences (economics, political science, sociology) and more interdisciplinary fields of science (environmental sciences, sustainability sciences). Beyond the science realm, at least four stakeholder groups could benefit from more knowledge on ecosystem–health relations.

1. Decision-makers and landscape management authorities
2. Human health agencies
3. Governmental bodies and (consultancy) agencies that manage environmental factors such as air and water quality, land use, and urban design
4. Citizens initiating sustainability projects

For all of these stakeholders, a better understanding of the disease impacts of various ecosystem factors and their linkages to each other and to diseases would aid in designing or recommending preventive health measures that are most efficient, or that represent the relatively best trade-off. Concrete advantages would be a reduction of the disease burden to the population, a longer-term impact as compared to solely medical treatment, and a more equitable solution, beneficial across social groups (Prüss-Üstün and Corvalán 2006). Some stakeholders might also benefit from the research outcomes in the form of the reduction of healthcare and other costs.

Pursuing only more fundamental scientific and thus less applied research objectives such as “exploring the mechanistic linkages between land use, ecosystems, and human health” would leave too large a bridge to be constructed by the above-mentioned stakeholders to be able to reap the societal benefits. Monetary valuation of ecosystem services and trade-off assessments between land-management options are already being performed for ecosystem services in general, and similar exercises specifically for services affecting human health have also just started. It is especially the implementation of ecosystem–human health processes as modules in general ecosystem assessment models, along with other societal needs, which would be a promising development towards transcending the boundaries: such a model would be able to provide the stakeholders not only with an idea of the impact of different ecosystem management options on human health, but also with a shared means of communication about the ecosystem–health system (including a shared terminology). The next section zooms in on some research objectives with both scientific and societal relevance.

3.4 Implementations of ecosystem–health research

Estimating (future) contributions of land-use change to infectious disease risk

Infectious diseases as a group make the largest contribution to the global human health burden when expressed in disability-adjusted life years (WHO 2014). Infectious diseases led to 6.9 million estimated deaths in 2011, representing 13% of all causes of death. The subgroup of infectious and parasitic diseases that contributes greatly to the global health burden of the overall disease group is that of parasitic and vector diseases, being second only to diarrhoeal diseases (WHO 2014). Major factors that define the prevalence of these diseases are part of a web of complex interactions between disease, several animal species, and the relationship with their non-living environment. These diseases are partially prevented by the presence of a high level of species diversity. However, contact between human communities and natural ecosystems in the tropical regions increases the risk of human infections. Converting nature areas into farmland or by urbanisation may reduce the ability of natural systems to buffer against disease. Climate change could also allow vector-transmitted diseases to expand their distribution to more northern areas. More insight into the influence of these drivers and the ecosystem service and disservice processes will provide a better idea of how much humans are contributing to disease prevalence through land-management decisions.

Balancing services and disservices and the ecosystem attributable fraction

Many researchers and institutions are currently addressing the need to be able to weigh both the costs and benefits of particular ecosystems, habitats, and species. This will enable a better choice between land-management approaches, in order to maximise human wellbeing. Ecosystem services and disservices that affect human health have an important place in such assessments. Apart from ecosystems, socio-economic causes of human health improvement might have a larger impact on human health. Moreover, other causes of human health decline might also have a larger impact, perhaps in the opposite direction. Cures for diseases and disease prevention protocols might in some cases be very well able to overcome unfavourable human health outcomes created by the lack of ecosystem services. These may be reasons to doubt the relative contribution of ecosystem services to the overall effect on human health. Calculating the relative contributions of ecosystem services and disservices to human health as a fraction of the total burden of a disease will help put the relevance of ecosystems into perspective even more.

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