The Millennium Development Goals in 2010 – threats to ecosystem services from air pollution, energy generation and pesticide use

Key Findings

- Air pollution, energy use and production and pesticides may affect provisioning, regulating and supporting ecosystem services. The supply of ecosystem services is crucial for finding ways out of poverty and hunger. The margin for negative impacts on ecosystem services is thus very small.
- Air pollutants, such as ground-level ozone (O_3), nitrogen oxides (NO_x), ammonia (NH_3) and sulphur dioxide (SO_2), all have major effects on ecosystem services. It is likely that these impacts represent a barrier to attaining the MDGs both in terms of providing sufficient crop growth to reduce hunger and maintaining diverse natural ecosystems.
- In sub-Saharan Africa and developing Asia, the progress towards achieving basic levels of energy access has been slow and is not projected to be met under current trends. Failure to achieve even basic levels of energy access is likely to have implications on meeting the MDG targets in these regions, both directly through lack of energy for development and indirectly through negative effects on the ecosystem services, for example effects from increased forest clearing.
- Unintended negative effects from pesticide use have been reported on several ecosystem services (pollination, natural pest control, nutrient cycling and wild food supplies). The uncontrolled handling of pesticides in many parts of the world is bringing high risks of severe negative effects on the health of farmers and their families as well as on the supply of local ecosystem services.

Ecosystem services for the Millennium Development Goals

In their 2010 annual Millennium Development Goals Report, the UN concluded that earlier advances towards reaching the Millennium Development Goals (MDGs) had stalled and some positive trends even reversed due to the global financial crisis and economic downturn in 2008-2009 (figure 1). Additional tens of millions are left in extreme poverty and the prevalence of hunger is still high. Already before the latest financial crisis it was reported by the Millennium Ecosystem Assessment (MA) that the current degradation of ecosystem services could grow significantly worse during the decades ahead, thus in itself preventing the attainment of the MDGs. The MA concluded that the last 50 years have led to an unprecedented change of ecosystems due to the pressure of human demands. Approximately 60 per cent of the ecosystem services examined in the MA are being degraded or used unsustainably. Ecosystem services are fundamental not only for reaching the MDG targets by 2015, but for the continued reduction of poverty and eradication of hunger in a sustainable way.

Linking the efforts to attain the MDGs to the ecosystem services on which we depend is thus essential in order to improve human well-being in the long-term. To make this possible, we have to understand how ecosystem services are connected to each other, both in supply and demand at different temporal and geographic scales. The synergies and trade-offs between different ecosystem services are crucial to manage. Research is beginning to clarify how certain types of ecosystem services can

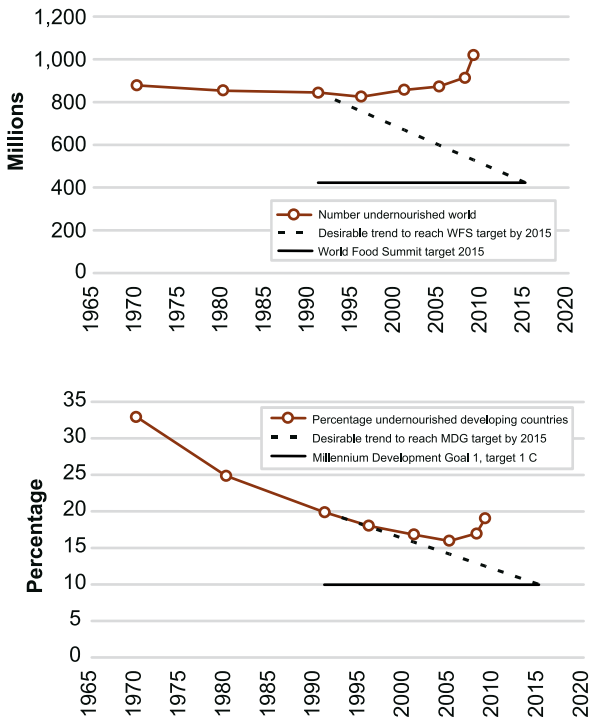

Figure 1(a and b): Number of undernourished in the world and proportion of undernourished in developing countries, 1969–71 to 2009.

Based on data from FAO (2009)

Table 1: Major ecological effects of air pollution and their impacts on ecosystem services

Pollutant	Ecological effect	Ecosystem service impact		
		Provisioning	Regulating	Supporting
O_3	Reduced plant growth	Reduced plant and biomass production	Altered climate regulation through C sequestration	Reduced net primary production
NO_x	Acidification Eutrophication		Altered nutrient cycling and increased system losses	Increased net primary production
NH_3	Eutrophication	Reduced food provision from aquatic systems	Altered nutrient cycling and increased system losses	Increased net primary production
SO_2	Acidification			Reduced biodiversity

be produced from the same geographic area, while others may not be compatible with each other. Agricultural activities may be organised in a way that allows for multiple additional ecosystem services still to be accessed in that particular area. However, research suggests that while agricultural activities result in the supply of provisioning services like crop production, it is often at the expense of regulating and cultural services. We also have to better understand how the supply and demand of the ecosystem services depend on economic and social drivers and how ecosystems respond to the various pressures to which they are subjected, such as air pollution or pesticide contamination.

Air pollution

Key air pollutants like ground-level ozone (O_3), nitrogen oxides (NO_x), ammonia (NH_3) and sulphur dioxide (SO_2) all have major effects on ecosystem services (table 1). The current evidence suggests that developing nations, especially those in Asia, are also affected, a situation that is likely to become more pronounced in the future. It is even possible that tropospheric ozone pollution may become a major barrier to achieving the MDG on hunger alleviation in South Asia. The global proportion of children under five who are underweight has fallen since 1990 but is still highest in developing regions, with the largest

Table 2: Key impacts on ESS from effects of energy production and use

Energy source	Consequences	Possible ecosystem effects	Possible effects on ecosystem services
Fossil fuels (large) Traditional biomass (medium) Modern biomass (small to medium) Hydro (small) Modern renewable (small) Nuclear (Small)	Greenhouse gas emissions	Climate change: Temperature rises Acidification of oceans Changes in precipitation Reduced soil organic carbon sequestration Heat stressed plants leading to reduced productivity and reduced capacity to absorb carbon dioxide	Changes in pest patterns on crops, livestock and aquacultures leading to decreased yields and catches. Changes in regulating services such as flood control affecting food production and livelihoods. Soil formation and nutrient cycling changed by certain types of biomass cultivation systems.
Fossil fuels (large)	Nitrogen oxides	Plant productivity Acidification of land and water	Reduced crop yields
Fossil fuels	Sulphur oxides	Acidification of water and soils	Reduced crop yields
Fossil fuels	Oil leakage	Aquatic ecosystems impacts	Reduced catches of wild and cultivated fish and other marine organisms
Fossil and traditional biomass	Particulates	Human health Acidification	Reduced yields from aquatic systems
Fossil fuels Nuclear energy	Mining	Sulphur acid (coal) Terrestrial ecosystems Water contamination	Land use trade offs – ie crop production and wild food catches are smaller if mining is done on land that would otherwise deliver food related services Water contamination may lead to lower catches of aquatic organisms
Fossil fuels Nuclear	Thermal pollution	Aquatic ecosystems	Reduced yields from aquatic systems
Nuclear	Nuclear contamination	Kills mammals Areas uninhabitable by humans	Most food related services unavailable due to contamination
Large hydro power	Disruption in natural river cycles	Aquatic ecosystems Crop productivity	Reduced crop yields, reduced yields from aquatic systems
Traditional biomass	Black carbon	Climate change	As above
Traditional biomass	Deforestation and degradation	Soil erosion Carbon sequestration loss Fresh water loss	Reduced crop yields from soil erosion
All energy systems	Site preparations	Soil erosion Removal of vegetation Transformation of hydrological features	Reduced crop yields from soil erosion

proportion in south Asia (46 per cent). Crop yield losses caused by ozone are expected to be severe in this region and may have severe effects on food security.

Although predictions of future emissions and impacts are highly dependent on the socioeconomic and legislative scenarios used, with all the attendant uncertainties, scenarios such as the IIASA MFR show that population increase need not be inevitably linked to environmental degradation. In agricultural terms, it is essential that future agricultural policy favours the optimisation of fertiliser use and minimises NH_4 output from livestock and fertilisation wherever possible. This will act to reduce both the direct impacts of ammonia and its effects on ecosystem regulatory services through acidification and eutrophication. Moreover, the SRES B2-CLE scenario used by the Royal Society demonstrates the importance of legislation in limiting ozone concentrations. It is crucial therefore that any growth in GDP associated with meeting the MDGs should be coupled with prioritisation of emission-limiting technologies to mitigate the worst air pollution effects associated with economic growth.

Energy

Current pressure exerted on ecosystems as a result of energy generation and consumption is unsustainable (table 2). When the balance of ecosystems and their services are disrupted, already vulnerable populations suffer most.

The progress made in the last five years towards increasing basic pro-poor energy access has been mixed. In some developing regions, including Latin America, North Africa and China, access to what is considered necessary basic energy to meet the MDGs has been or is on track to be achieved by 2015. In other regions, particularly in sub-Saharan Africa and in developing Asia, the progress towards achieving basic levels of energy access has been slow and is not projected to be met under the current increase rates in access. Looking ahead, we can conclude that by 2015 the energy-poor will primarily be found in sub-Saharan Africa and in India and Indonesia and that by 2030 the energy-poor will primarily be found in sub-Saharan Africa and Indonesia. Not achieving even basic levels of energy access is likely to have implications on meeting the MDG targets in these regions. It is likely to impact the quality of providing social services such as education and health services. Further, support for income-generating activities and productivity in agriculture and other sectors will be lacking. It will also threaten health objectives by forcing a large share of the population to rely on inefficient and smoky solid fuels for cooking and heating.

The growing demand for energy services to support the attainment of the MDGs and economic growth means that it is critically important to carefully evaluate the different forms of energy that can meet these needs and how they impact upon ecosystem services. To avoid making the achievement of the MDGs even more difficult, it is important to consider all the ecosystem services on which the poor are particularly dependent and how energy choices might impact these services. Policies that encourage investments in renewable energy, energy efficiency and discourage investments in fossil fuel-based energy systems are needed.

Table 3: Possible negative effects of pesticide use on ecosystem services

Ecosystem services	Possible negative effects of pesticide use
1. Provisioning services	
Crops	Lower yields through indirect impact by effects on e.g. pollination and nutrient circulation. Direct impact on crops possible if pesticides are not used at correct doses and timing in the crop cycle.
Livestock	No direct impacts from pesticides used on crops.
Capture fisheries	Lower catches if pesticides with toxicity to fish reach water bodies.
Aquaculture	Lower yields if ponds are contaminated with pesticides through spray-drift or runoff or in mixed systems, e.g. cultivation of fish and other aquatic species in fields that are also used for crop production, such as rice.
Wild foods	Reduced catches, indirect if pollination services are hit, direct if wild species come into contact with pesticides e.g. by feeding on treated seeds or through spray-drift or run-off.
Timber	Lower yields if natural enemies of common pests have been reduced in numbers by pesticide applications.
Cotton, hemp, silk	Lower yields if natural enemies of common pests have been reduced by pesticide applications.
Genetic resources	Possible effects if the pesticide use in an area reduces the biodiversity.
Biochemicals, natural medicines, pharmaceuticals	Possible effects if the pesticide use in an area reduces the biodiversity.
Fresh water	Lower quality of fresh water available if pesticides enter fresh water supplies such as streams, lakes or ground water.
2. Regulating services	
Regulation of air quality, climate, water, erosion and natural hazard	No direct effects.
Water purification and waste treatment	No direct effects.
Disease and pest regulation	Increased pest populations if natural enemies of the pest species are hit by pesticide applications.
Pollination	Decreased yields of crops dependent on managed or wild pollinators that are hit by the pesticide applications.

Pesticides

There are reports in the literature of unintended negative effects from pesticide use on ecosystem services vital to food production such as pollination, natural pest control, nutrient cycling and wild food supplies (table 3). It is of special concern that pesticides are used in an uncontrolled way in some parts of the world; the risks of severe negative effects on the health of the farmers and their families as well as on the supply of local ecosystems services are high. Pesticides, like carbaryl and cypermethrin that are reported to be used in an inappropriate way by farmers in Laos, Cambodia and Vietnam, have a very high potential for reducing the supply of wild foods collected in or nearby the rice paddies such as insects, frogs, crabs, fish and snails.

Agriculture has become more dependent on animal pollination over time and the trend is expected to continue, especially in the developing world. It has been suggested that this will result in increased pressure for supply of agricultural land which in turn will lead to further pollinator habitat destruction, possibly causing further declines in pollinating services. Another concern is the grave lack of knowledge when it comes to the effects of pesticides on the soil microorganisms that are responsible for the nutrient and carbon circulation.

The potential risk of pesticide use for ecosystem services has to be seen in relation to the potential yield gain of the pesticide use. But the yield gain in the short term perspective has to be seen in the context of potential long term effects by pesticides on the ecosystem services. Here there are important knowledge gaps.

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Recommendations

- Urgently improve the pro-poor energy development, air pollution emission controls and chemicals management to support the attainment of the MDGs through decreased pressure on ecosystem services.
- There is an urgent need to improve the management of ecosystems for multiple ecosystem services and to consider various ecosystem pressures in local and national planning for development in order to reach the MDGs.
- Immediate air pollution emission controls are needed in all countries in order to curb negative impacts on crop yields, especially in south Asia.
- Pro-poor energy policies and regulatory frameworks are needed at the national level to attract required investments and to build the national capacity within the public and private sectors to deliver sustainable energy to the poor.
- Legislation on pesticides and other chemicals must be tougher and better enforced in line with the Strategic Approach to International Chemicals Management (SAICM) in order to reduce the current high risks to people and their supporting environment.
- Training of farmers in Integrated Pest Management as well as in pesticide risk reduction schemes is crucial in order to avoid decreased supplies of local ecosystem services needed for MDG attainment.

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