

# Implications for Achieving the Millennium Development Goals

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## Main Messages

**Progress toward achieving the 2015 targets of the Millennium Development Goals will need to be accelerated dramatically** (*high certainty*). In particular, sub-Saharan Africa, Central Asia, parts of South and Southeast Asia, and some regions in Latin America, are currently off track with respect to meeting the goals.

**Knowledge and information about ecosystems and ecosystem services are vital for developing ways to achieve target 9 on environmental sustainability** (*high certainty*). The MA provides information about the ways in which ecosystems and the services they provide to local, regional, and global communities affect human well-being. The evidence synthesized by the MA underlines that ecosystem services can only be sustained in the long term if the integrity and completeness of ecosystems are maintained or restored. This information and the tools for improved management of ecosystems need to be integrated more systematically into development strategies such as poverty and hunger reduction strategies.

**The MDGs and their 15 targets form a set of highly interdependent objectives that can only be met through integrated strategies instead of isolated interventions or “silver bullets.” Greater collective gains are possible through simultaneous rather than sequential interventions** (*high certainty*). This integrated and synchronous approach requires a focus on improved management of ecosystems and their services. This is a particularly important prerequisite for achieving the targets relating to poverty, hunger, gender equality, water, and sanitation and health. Countries that are not on track to achieving the 2015 targets are experiencing rapid environmental degradation and loss of ecosystem services that can be slowed or reversed through improved ecosystem management. In many places, the sustainability and continuity of particularly agroecosystems is threatened by structural shortage of measures to maintain their services and productivity. By restoring those functions, there is more room for other less productive systems, but that requires clear choices at the local, regional, national, and international level.

**Particular emphasis needs to be placed on the sustainable intensification of existing cultivated ecosystems to satisfy growing demand for food and other ecosystem services** (*high certainty*). Maintaining the present cultivated land in lieu of expanding into new areas will be possible when intensification and modernization of present agroecosystems is promoted with higher productivity per hectare, per person hour, and per kilogram input. As a result of this intensification counter intuitively total use of inputs such as fertilizers or pesticides is decreased in absolute terms and per unit of product. Thus environmental side effects decrease. Moreover the higher productivity per ha spares space for nature and untouched ecosystems, thus safeguarding as much as possible biodiversity. Thus the protection of fragile and vulnerable ecosystems such as wetlands, mangroves, and upland areas that provide many ecosystem services is facilitated.

**Intensification of production systems such as agroecosystems (plant and animal) and aquaculture needs to be carried out by the most socially and economically appropriate ecological techniques such that ecosystem degradation is prevented.** Various ecosystems are threatened by mismanagement, overuse, or insufficient care for continuity. That holds for many aquaecosystems (overfishing, etc.), rain fed agroecosystems by inadequate insufficient maintenance of soil fertility, and most importantly expansion of cultivated area, logging of tropical rainforest, and cultivating former coastal ecosystems such as mangrove ecosystems. The use of ecotechnological advanced production techniques requires a good understanding of the basic processes (chemical, physical, physiological, ecological) that determine agroecosystem behavior.

**Modified ecosystem management as part of a strategy to achieve the 2015 targets has to consider that several drivers affect environmental change. Therefore, policies, institutions and reorientation acting at local, regional, and global scales need to address several drivers at the same time** (*medium certainty*). To achieve the 2015 targets, particular attention needs to be placed on improving ecosystem management and the capacity for policy-making at the national and local level as well as addressing global challenges including long-term climate change and the depletion of international fisheries.

**The complexity of human–nature interactions makes it difficult, though not impossible, to formulate quantitative targets using the best available science synthesized by the Millennium Ecosystem Assessment** (*medium certainty*). In the face of this uncertainty, communities, countries, regions, and the international system need to agree on and set well defined local, national, and regional quantified goals for preserving, managing, and utilizing ecosystems. The findings of the MA may provide guidance for developing targets and for designing strategies to achieve them.

**Available monitoring systems for ecosystems and the services they provide are inadequate in many parts of the developing world** (*high certainty*). Monitoring and documenting progress toward achieving the 2015 targets may require strengthening monitoring systems for soil fertility, hydrological flows, biodiversity, climate, and so forth. Documenting progress will provide invaluable information for analysis, research, and the development of technology and mitigation strategies.

## 19.1 Introduction

This chapter explains how the MA contributes to the achievement of the 2015 targets of the Millennium Development Goals. Based on the MA conceptual framework (MA 2003) and key findings regarding current conditions of ecosystem services and alternative scenarios, this chapter explains the implications for achieving the 2015 targets. The chapter integrates the MA findings and focuses them toward the politically and widely accepted MDGs.

With 1990 as the baseline, the MDGs aim to improve human well-being by reducing poverty, hunger, child and maternal mortality; ensuring education for all, controlling and managing diseases, tackling gender disparity, ensuring sustainable development and pursuing global partnerships by 2015. (See Table 19.1.) Like the MA conceptual framework (see Chapter 2, Box 2.1), the MDGs support the multidimensional concept of sustainable development and the potential benefits of identifying the linkages between ecosystem services and HWB. As this chapter suggests, the 2015 targets are more likely to be achieved if the goals are addressed simultaneously.

While the MDGs are focused on human goals, the MA is primarily concerned with ecosystem services and how to best manage them for the benefit of HWB. Ecosystem services are categorized by supporting, provisioning, regulating, and cultural services. (See Table 19.2.) HWB, as defined by the MA, involves multiple constituents, including basic material for a good life, freedoms and choices, health, good social relations, and security (MA 2003).

In adapting the MA conceptual framework to the MDGs, this chapter identifies which goals are directly or indirectly dependent on supporting, provisioning, regulating, and cultural services. While most targets (such as poverty, hunger, gender, child mortality, disease water, and sustainable development) are dependent on ecosystem services as discussed in the goal-by-goal analysis, some

**Table 19.1. Millennium Development Goals**

Goals and Targets	Indicators
<b>Goal 1: Eradicate extreme poverty and hunger</b>	
Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	<ol style="list-style-type: none"> <li>1. Proportion of population below \$1 per day (PPP values)</li> <li>2. Poverty gap ratio [incidence x depth of poverty]</li> <li>3. Share of poorest quintile in national consumption</li> </ol>
Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	<ol style="list-style-type: none"> <li>4. Prevalence of underweight children (under five years of age)</li> <li>5. Proportion of population below minimum level of dietary energy consumption</li> </ol>
<b>Goal 2: Achieve universal primary education</b>	
Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	<ol style="list-style-type: none"> <li>6. Net enrolment ratio in primary education</li> <li>7. Proportion of pupils starting grade 1 who reach grade 5</li> <li>8. Literacy rate of 15–24 year olds</li> </ol>
<b>Goal 3: Promote gender equality and empower women</b>	
Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and at all levels of education no later than 2015	<ol style="list-style-type: none"> <li>9. Ratio of girls to boys in primary, secondary, and tertiary education</li> <li>10. Ratio of literate females to males of 15–24 year olds</li> <li>11. Share of women in wage employment in the nonagricultural sector</li> <li>12. Proportion of seats held by women in national parliament</li> </ol>
<b>Goal 4: Reduce child mortality</b>	
Target 5: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate	<ol style="list-style-type: none"> <li>13. Under-five mortality rate</li> <li>14. Infant mortality rate</li> <li>15. Proportion of 1-year-old children immunized against measles</li> </ol>
<b>Goal 5: Improve maternal health</b>	
Target 6: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio	<ol style="list-style-type: none"> <li>16. Maternal mortality ratio</li> <li>17. Proportion of births attended by skilled health personnel</li> </ol>
<b>Goal 6: Combat HIV/AIDS, malaria, and other disease</b>	
Target 7: Have halted by 2015, and begun to reverse, the spread of HIV/AIDS	<ol style="list-style-type: none"> <li>18. HIV prevalence among 15–24-year-old pregnant women</li> <li>19. Contraceptive prevalence rate</li> <li>20. Number of children orphaned by HIV/AIDS</li> </ol>
Target 8: Have halted by 2015, and begun to reverse, the incidence of malaria and other major diseases	<ol style="list-style-type: none"> <li>21. Prevalence and death rates associated with malaria</li> <li>22. Proportion of population in malaria risk areas using effective malaria prevention and treatment measures</li> <li>23. Prevalence and death rates associated with tuberculosis</li> <li>24. Proportion of TB cases detected and cured under DOTS (Directly Observed Treatment Short Course).</li> </ol>
<b>Goal 7: Ensure environmental sustainability</b>	
Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources	<ol style="list-style-type: none"> <li>25. Proportion of land area covered by forest</li> <li>26. Land area protected to maintain biological diversity</li> <li>27. GDP per unit of energy use (as proxy for energy efficiency)</li> <li>28. Carbon dioxide emissions (per capita) (Plus two figures of global atmospheric pollution: ozone depletion and accumulation of global warming gases)</li> </ol>
Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water	<ol style="list-style-type: none"> <li>29. Proportion of population with sustainable access to an improved water source</li> </ol>
Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	<ol style="list-style-type: none"> <li>30. Proportion of people with access to improved sanitation</li> <li>31. Proportion of people with access to secure tenure (urban/rural disaggregation of several of the above indicators may be relevant for monitoring improvement in the lives of slum dwellers)</li> </ol>

**Goal 8: Develop a global partnership for development**

Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system

(includes a commitment to good governance, development, and poverty reduction, both nationally and internationally)

Target 13: Address the special needs of the least developed countries

(includes tariff and quota free access for LDC exports; enhanced program of debt relief for heavily indebted poor countries and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction)

Target 14: Address the special needs of landlocked countries and small island developing states

(through Barbados Programme and 22nd General Assembly provisions)

Target 15: Deal comprehensively with the debt problems of developing countries through national and international measures to make debt sustainable in the long term

*Official Development Assistance*

- 32. Net ODA as percentage of DAC donors' GNP (targets of 0.7% in total and 0.15% for LDCs)
- 33. Proportion of ODA to basic social services (basic education, primary health care, nutrition, safe water, and sanitation)
- 34. Proportion of ODA that is untied
- 35. Proportion of ODA for environment in small island developing states
- 36. Proportion of ODA for transport sector in land-locked countries

*Market Access*

- 37. Proportion of exports (by value and excluding arms) admitted free of duties and quotas
- 38. Average tariffs and quota on agricultural products and textiles and clothing
- 39. Domestic and export agriculture subsidies in OECD countries
- 40. Proportion of ODA provided to help build trade capacity

*Debt Sustainability*

- 41. Proportion of official bilateral HIPC debt cancelled
- 42. Debt service as a percentage of exports of goods and services
- 43. Proportion of ODA provided as debt relief
- 44. Number of countries reaching HIPC decision and completion points

**Table 19.2. Ecosystem Services Clustered by Major Categories**

<b>Supporting Services</b> <i>(Services necessary for the production of other ecosystem services)</i>	<b>Provisioning Services</b> <i>(Products obtained from ecosystems)</i>	<b>Regulating Services</b> <i>(Benefits obtained from regulation of ecosystem processes)</i>	<b>Cultural Services</b> <i>(Nonmaterial benefits obtained from ecosystems)</i>
Soil formation	Food	Climate regulation	Spiritual and religious
Nutrient cycling	Freshwater	Disease regulation	Recreation and ecotourism
Primary production	Fuelwood	Water regulation	Aesthetic
Pollination	Fiber	Water purification	Inspirational
Habitat maintenance	Biochemicals	Landscape stabilization against erosion	Educational
Seed dispersal	Genetic resources	Binding of toxic compounds	Sense of place
		Air purification	Cultural heritage
		Pest and pathogen control	
		Carbon sequestration	

2015 targets are less dependent or indirectly linked to ecosystem services and these targets include education, maternal mortality, and global partnerships.

Emanating from the United Nations Millennium Declaration, the eight MDGs bind countries to do more and join forces in the fight against poverty, illiteracy, hunger, lack of education, gender inequality, child and maternal mortality, disease, and environmen-

tal degradation. The eighth goal, reaffirmed in Monterrey and Johannesburg, calls on industrial countries to relieve debt, increase aid, and give poor countries fair access to their markets and their technology. The MDGs are a test of political will to build stronger partnerships. Developing countries have the responsibility to undertake policy reforms and strengthen governance to liberate the creative energies of their people. But they cannot reach the goals on their own without new aid commitments, equitable trading rules, and debt relief. The goals offer the world a means to accelerate the pace of development and to measure results. While there may be alternative views on what the MDG goals and targets should be, we are confining our analysis to the official ones as established by the Millennium Declaration.

The MDGs' first focus is on priority countries that face the greatest hurdles in achieving the goals. The international community has been closely monitoring the achievement of the 2015 targets in particular regions of the world, including sub-Saharan Africa, Central Asia, parts of South and Southeast Asia, and Latin America. Recent trends published by the World Bank and the United Nations Development Programme indicate that these regions have a long way to go to reach the 2015 targets. Sub-Saharan Africa, for example, has seen an increase in maternal deaths and in poverty (those living on less than \$1 per day) and it is forecasted that the number of people living in poverty will rise from 315 million in 1999 to 404 million by 2015 (World Bank 2003).

The Millennium Task Forces that were established by the U.N. Millennium Project is a major initiative addressing each MDG. They have identified specific interventions for each goal. Whereas the Task Force's interventions are distinct and consider immediate action, the interventions identified in this chapter range from short to long term and are broader in their perspective. The chapter authors have defined the interventions in consideration of those of the U.N. Millennium Project's Task Forces.

The MA has much to share on the ecological challenges and opportunities for poverty alleviation in various regions with

strong focus on sub-Saharan Africa as well as other priority regions such as South Asia and Latin America where ecological change is expected to have major consequences for HWB.

The MA scenarios can serve to support analysis of the status of ecosystems by 2015, albeit only under certain MA scenario themes where 2015 has expressly been used as a target date for analysis. Though the MA is looking to 2050, there are lessons from it for 2015, and particularly for gauging what different paths to 2015 and beyond may hold for sustaining HWB in the longer-term. Having said this, it is noted that the MA scenarios were not produced with the MDGs in mind and, therefore, they cannot be expected to be directly applicable to the goals.

Achieving the 2015 targets and sustaining these targets beyond 2015 will require that we preserve the productive capacity of natural ecosystems for future generations. The challenge has two dimensions: addressing natural resource scarcity for the world's poor people and reversing environmental damage resulting from high consumption by rich people. For instance, soil degradation affects nearly two billion hectares, damages livelihoods of up to one billion people living on drylands. Around 70% of commercial fisheries are either fully or overexploited and 1.7 billion people—a third of the developing world population—live in countries facing water stress.

Also of utmost importance to achieving the 2015 targets is the fact that many ecological changes of global importance to all countries are suffering from pressures not only within poor countries but from the world's wealthy. Climate change is an example, where high emissions by industrial countries may well impact the sustainability of development activities in sub-Saharan Africa and elsewhere. However, poverty as such has a detrimental effect on many ecosystems in sub-Saharan Africa and Asia.

This chapter on the MDGs has been constructed through a goal-by-goal analysis presenting a qualitative assessment of how ecosystem services will respond to the proposed interventions. The chapter highlights those interventions that are directly or indirectly related to ecosystem services and the positive or negative effects on them.

The MDG chapter was formed near the final work of the MA, which has limited the depth of detail in the MDG chapter, and our ability to consider numerous case studies. Throughout, we note where our findings are robust and where there are gaps in knowledge. Based on this individual goal-by-goal analysis, we then determine where multiple MDGs might be dependent on the same service. We note that our suggestions are not prescriptive and may, in many cases, be geographically bound.

## 19.2 Goal-by-goal and Target Analysis

The goal-by-goal analysis examines each of the 2015 targets by addressing dependencies, interventions, synergies, and trade-offs. The examination of dependencies identifies the direct link the target in question has on ecosystem services. Interventions describe potential actions policy-makers can take to achieve the target. Subsequently, synergies and trade-offs identify the potential positive and negative impacts of implementing the suggested interventions.

### 19.2.1. MDG 1: Eradicate Extreme Poverty and Hunger, Target 1

Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.

#### 19.2.1.1 Introduction

In the Millennium Declaration, global poverty is identified as the most daunting of all problems facing the world in the new century. Despite the higher living standards that globalization has delivered in large parts of the world, hundreds of millions of people still experience economic reversals rather than advances (World Bank 2003). Millions of people fight for daily survival as they live on less than \$1 per day. Many suffer from low human development, which is defined by UNDP (2003) by longevity (measured by life expectancy at birth), knowledge (measured by adult literacy rate and the net enrollment ratios in primary, secondary and tertiary levels), and standard of living (measured by GDP per capita). Low human development is often associated with poor health and lack of any sort of education as well as of freedom and political voice to choose what is best to improve their well-being (Sen 1999; Duraipappah 1998; Chapter 17). About 70% of the poor live in the rural areas. Most of them are in South Asia and sub-Saharan Africa where coincidence between deepening poverty and acceleration of ecosystem degradation has been most striking in the past decade (Chapter 17).

Helping these people escape the poverty trap requires clear understanding of the complex and dynamic relationship between poverty and environment and the identification and adoption of appropriate intervention measures that will help the poor improve their well-being. Table 19.3 summarizes the dependencies, interventions, synergies, and trade-offs for MDG Target 1.

#### 19.2.1.2 Dependencies

The environment matters greatly to people living in poverty as they often depend directly on a wide range of natural resources and ecosystem services for their livelihoods, health, and sense of empowerment and ability to control their lives (*high certainty*; Chapter 17). Forest ecosystems, agroecosystems, grasslands, and freshwater and coastal ecosystems provide a wide range of services that are essential in increasing agricultural productivity (for example, natural predators, wild pollination, etc); providing primary source of energy (for example, wood fuel); protecting watershed and hydrological stability, including recharging of water tables and buffering of extreme hydrological conditions that might otherwise precipitate drought or flood conditions; maintaining of soil fertility through storage and recycling of essential nutrients; and breaking down waste and pollutants. Healthy ecosystems and their provision of abundant and diversified ecosystem services increase livelihood options, promote livelihood diversification, and improve food security, especially for those living in more marginal environments where access to external technology and other inputs are limited.

Agricultural productivity improvement, the cornerstone for poverty reduction strategies in many countries, is now seriously threatened by land and water degradation, nutrient mining, extensive ecosystem conversion, growing susceptibility of diseases and build up of pest resistance, and erosion of genetic diversity. Current estimates are that up to one billion people are affected by soil erosion and land degradation due to deforestation, overgrazing, and agriculture. Water scarcity is now a major issue in more than 20 developing countries. Water management decisions without regard to the ecosystems' reaction has led to shifts in the distribution of economic benefits from large numbers of local beneficiaries who obtain their livelihood at a very modest level from fisheries to a few who could afford to invest in international fish exports. Shortage of wood fuel and water imposes time and financial costs on billions of poor households, especially women and girls for their increased time, physical burden, and personal

Table 19.3. MDG 1, Target 1: Dependencies, Interventions, Synergies, and Trade-offs for Poverty

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Poverty	opportunities to expand livelihood strategies for the poor: <ul style="list-style-type: none"> <li>• agricultural production expansion</li> <li>• rural-based and non-rural employment opportunities</li> </ul>	economic interventions <ul style="list-style-type: none"> <li>• develop infrastructure facilities to help make markets function correctly</li> <li>• promote agro-based industries</li> </ul> financial interventions <ul style="list-style-type: none"> <li>• establish micro-credit schemes</li> <li>• establish risk management institute</li> </ul> technical interventions <ul style="list-style-type: none"> <li>• develop appropriate technologies based on traditional practices</li> </ul> social interventions <ul style="list-style-type: none"> <li>• more effective extension and training services to educate the poor and enhance their capacity to manage ecosystem</li> </ul> other interventions <ul style="list-style-type: none"> <li>• effective property rights policy, for example, rational land reform system</li> </ul>	less pressure on the use of natural resources for production and reduced exploitation of crop/animal/fish/marine species and their wild relatives  more efficient ecosystem management  demographic transition toward smaller families	change in land use brought about by migration and shifts in demand preferences for food and other needs  more rapid industrialization  development of tourism and recreational centers, etc.  development of infrastructure facilities  greater competition for water, energy, etc.  increased pollution of air, fresh waters, estuaries, and coastal marine ecosystems

risk in having to travel greater distances to collect fuel, fodder, and clean water.

Where employment and output needs are intense, the result is exploitation of the ecosystem and the services they render. The poor allocate a low weight to the future since poverty requires prioritizing immediate needs and thus encourages the overutilization of resources. To them, their decisions are rational in the context of the constraints they face in the short term. But resource degradation and reduction of ecosystem services cannot be totally blamed on them. People living in the industrial world who keep high living standards likewise continue to consume and exploit resources, even from developing countries.

The causal relationship between poverty and environmental degradation runs in both directions (Dasgupta et al. 1994; Southgate 1998). Poverty leads to natural resources degradation/depletion through a very high rate of discount. Conversely, persistent environmental degradation (caused by industrial countries as well) can contribute to poverty, particularly among subsistence farmers, fishermen, livestock keepers, nomads, and others. Suitable adaptive intervention measures need to embrace, understand, and respect the complexity of this linkage not only in the developing countries but also in industrial countries.

**19.2.1.3 Interventions**

Numerous interventions have been identified to curb the unsustainable relationship between poverty and ecosystem use and to break the unsustainability spiral through the use of external inputs. In identifying the appropriate intervention measures, it is necessary to consider the different degrees and types of use of ecosystem services. This ensures that no stakeholders are marginalized in the process and avoids the ever increasing conflicts caused by appropriation of ecosystem services by some groups at the expense of other disenfranchised groups.

The key intervention measures are focused on increasing the entitlements of the poor through greater choices and enhanced sources of livelihood opportunities for farmers and rural folks (Sen 1991). Suitable measures that would enhance the capability of the poor and strengthen their resource rights to increase their economic and social entitlements have been found to play a fundamental role in the poverty–environment nexus. Individual or collective rights to some resources provide additional income opportunities and access to various services such as credit, training, and extension. Strengthening land rights, rationalizing land reform programs, providing water permits, allowing direct management of forests by indigenous people, and promoting company–community or private–public partnership of productive public resources including the protection of local scientific knowledge could facilitate more sustainable resource–management investment among the poor (*high certainty*).

Expanding access to environmentally sound and locally appropriate technologies such as crop production technologies that conserve soil and water and minimize the use of pesticides have been the mainstay in finding substitutes for ecosystem services. But many of these technologies have been developed from outside of the areas where they would be used. This has been the primary reason why many technologies introduced in developing countries have not worked. Technology development should consider and incorporate the indigenous practices and traditional knowledge of farmers (*high certainty*).

Economic and financial interventions that are aimed at increasing opportunities to enhance incomes will enable poor farmers to participate in the market and take advantage of the benefits of globalization (*medium certainty*). Promotion of agro-based industries will provide alternative employment opportunities that would make farmers more financially secure in terms of the capital needs for production activities. Low prices and farmers’ inaccessibility to markets have put them at the mercy of unscrupulous

traders and thereby deterred them from taking advantage of reasonable prices for their produce. This can be reduced by providing efficient functioning labor and credit markets, reliable market information, and appropriate infrastructure to allow easy flow of both products and inputs. Easy access to credit, particularly for the production of traditional foods and handicrafts that tend to be more in balance with ecosystem goods and services, will reduce or eliminate dependence on middlemen that charge huge interest rates that would be paid forever and lead to more reliable and efficient intermediate structures. In addition, the availability of risk management institutions through schemes that are convivial to small producers is extremely essential to keep them from totally being wiped out in case of calamities that lead to investment losses (*medium certainty*).

Social opportunities in the form of training, capacity building, and education enable greater understanding of the important role of ecosystem services. These opportunities would increase their knowledge and capability to manage the resources properly and safeguard them from harm and degradation. In many agroecosystems, this will require the judicious use of external inputs to maintain soil fertility and to manage water and ecosystems in an appropriate manner.

#### **19.2.1.4 Synergies and Trade-offs**

There are both positive and negative impacts on ecosystems and the services they provide of poverty reduction.

##### *19.2.1.4.1 Positive impacts*

Provision of more sustainable and more diverse livelihood opportunities that alleviate poverty would help reduce reliance of the poor on subsistence and resource-based production activities. This will lessen pressure on ecosystems and enable them to recover or be restored. This includes the preservation of various species and their wild relatives. Richer soil fertility, cleaner and more abundant water, denser forests, preservation of various species and their wild relatives, all of these will enable the poor to produce more food and meet other basic needs.

Poverty reduction can also result in better human development such as in health and education. This results in the demographic transition, as people would aim for smaller family sizes in order to attain relatively higher quality life standards (*MA Scenarios*, Chapter 7). Studies have shown, however, that poor and food-insecure households tend to be larger and to have higher numbers of dependents (Reardon 1991). This is due to cultural contexts where having many children is perceived as positive and not as a negative impact of poverty. Accompanying poverty reduction are changes in cultural and moral values. While poverty pressed the poor to exploit these resources, the poor would now be more protected through the use of better and more adaptive participatory management practices.

##### *19.2.1.4.2 Negative impacts*

Alleviating poverty can result in some negative consequences on the environment if not carefully managed. Because poverty alleviation can only occur in tandem with economic development, another dimension will be the increased demand for high value products as illustrated in the *MA Global Orchestration Scenario*. Increased preferences for meat and other livestock products as well as fish and other marine products take place with income growth. While such a trend is clearly favorable due to improved nutrition for low-income populations that do not currently have a balanced diet with respect to the essential nutrients, the ancillary effects on ecosystem services could be damaging, depending on

the manner in which livestock production and/or marine and aquaculture cultivation take place. An example is the shift in land use toward uncontrolled land clearing or deforestation to give way for animal grazing and development of infrastructure for animal production. This could lead to both soil and water degradation that is harmful to increasing agricultural production. The most valuable policies are those that safeguard unsustainable land clearing and deforestation and improve food distribution channels to increase availability and accessibility.

Changes in land use would also be triggered by the need to expand commercial, industrial, and social services as demand for them increases with continued improvement in the well-being and economic status of the poor. The risk is, however, of diverting the rural poor into economic traps that could expose them to market uncertainty. The expanded services involve the development and improvement of infrastructure facilities like roads, better water supply system, better drainage system, better waste disposal system, etc as well as the greater provision of health centers and recreation and tourism services. Without effective policies and enforcement measures to promote proper governance and orchestration of these development efforts, the effect would not be beneficial, as these could lead, among other things, to increased competition for resources, particularly of land, water and energy, and to greater incidence of water and air pollution that could be detrimental to promoting a sustained and healthy environment.

#### **19.2.2 MDG 1: Eradicate Extreme Poverty and Hunger, Target 2**

Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

##### **19.2.2.1 Introduction**

Society is facing a daunting task as it works to reduce hunger across the globe. The Food and Agriculture Organization of the United Nations estimates that about 840 million people go to bed hungry each night. One of the major challenges of the new millennium is to meet the food needs of these people while maintaining the environment's capacity to deliver services such as the cleansing of the air and water, the recycling of nutrients, the stabilization of landscapes against erosion and so much more.

At the same time the rapidly increasing consumption of medicaments including for example, minerals and vitamins ends up through the human digestive system into waterways resulting in serious consequences for marine species, for example, tadpole growth retardation. Hence contamination of ecosystems needs to be given consideration in this context. Table 19.4 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 2.

##### **19.2.2.2 Dependencies**

Food production on land and in fresh and marine waters depends on a large number of ecosystem services that we often take for granted. On land, the maintenance of soil structure, the recycling of nutrients essential to plants, and the pollination of plants are essential for growing crops. In aquatic and marine ecosystems, fish and other animals harvested for food depend on the recycling of nutrients, detoxification of water, and the provisioning of nursery habitats.

##### **19.2.2.3 Agricultural Interventions**

Interventions to reduce hunger have been generally divided into three categories: increasing yield (and also nutrient fortification),

Table 19.4. MDG 1, Target 2: Dependencies, Interventions, Synergies, and Trade-offs for Hunger

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Hunger	soil structure, the recycling of nutrients essential to plants, and the pollination of plants	increasing inputs to increase crop yield: <ul style="list-style-type: none"> <li>• fertilizer</li> <li>• herbicides/pesticides</li> <li>• water</li> </ul> precision agriculture, nutrition, and water saving	reduced demand for new agricultural land, leading to habitat/biodiversity preservation	increased water pollution increased water demand reduced agro-biodiversity and resilience
		introducing genetically modified organisms to increase crop yield crops of relevance to the poor nutrient fortification, for example, golden rice	reduced demand for new agricultural land, leading to habitat/biodiversity preservation reduced need for herbicides/pesticides, leading to decreased water pollution	potential threat to biodiversity through hybridization
		increasing the area of agricultural land	none apparent	potential threat to biodiversity through habitat loss increased erosion and degradation of streams draining agricultural areas increased incidence of floods local to regional climate modifications
		reducing post-harvest crop losses	reduced demand for new agricultural land, leading to habitat/biodiversity preservation	none apparent

increasing the area in agriculture, and reducing post harvest losses (through measures such as crop protection and appropriate storage of harvests). The MA has identified ways in which some of the major interventions will affect ecosystem services. Some of these effects will be positive and others negative. Here we briefly review the potential consequences of some of the major interventions

Increasing crop yield through agricultural intensification is a first major intervention. Many of the crop-yield increases attained over the last several decades of the twentieth century resulted from increasing inputs to agriculture in the form of fertilizer, pesticides, and water. Introducing new crop varieties bred from extant genetic stock has also increased crop yields. In the future, an additional intervention for increasing yield may be the introduction of genetically modified organisms.

Increased use of fertilizers and pesticides in agriculture has been documented by the FAO for several decades. In 2002, FAO estimated that just over 138 million tons of nutrients (nitrogen, phosphorus, and potash) were applied to the world's agricultural lands. Developing countries accounted for about 60% of this total. The quantity of pesticides used in global agriculture is not as well known. Many countries do not report pesticide usage information and measurement methods vary among those that do report. Pesticide use is known to be high in some tropical countries that

specialize in growing cash crops for the international market. For example, Costa Rica reported to the FAO that pesticide use was 51.2 kilograms per hectare of commercial cropland (primarily fruit plantations).

High rates of crop nutrients and pesticide applications to croplands can result in water pollution and major changes in ecosystems and the degradation of ecosystem services. For example, nitrogen leaching from agricultural soils into estuaries and coastal waters is a factor of the increase in oxygen-starved bottom-waters in these places. Increased flows of nitrogen and other nutrients from agricultural runoff stimulate blooms of algae in brackish and salt waters. When the algae die, they sink to the bottom and are decomposed by microorganisms. These microorganisms also use most of the oxygen in the system, resulting in very low oxygen levels in the water, creating an inhospitable habitat for fish, shellfish, and other living things. In recent decades, large regions of coastal waters with severely depleted oxygen levels have been observed and clearly linked with agricultural runoff.

Chapter 6 recognizes both the importance of fertilizer and pesticide inputs to achieving higher crop yield, and their environmental costs. To minimize these costs in the future, it urges the use of a range of agricultural methods. Some of these methods (such as the "Leaf Color Chart" of the International Rice Research Institute) enable farmers to better manage their nitrogen

application at relatively low-cost, are technologically simple, and are especially well suited for small farms. Other methods, including precision farming, cost much more, are technologically advanced, and are well suited for large industrial agriculture. Precision farming, also called site-specific management, refers to the “as-needed” application of inputs to management units (fields) that accounts for fine-scale heterogeneity, often measured in square meters, in site characteristics. Satellite-based monitoring technologies linked to farm machinery are being commercially developed to make precision farming a reality. Precision farming is an important element of production ecology where all biological mechanisms are fully used and fine-tuned to specific needs.

Another approach offered in the MA to minimize or eliminate the environmental impacts of fertilizer and pesticide inputs is organic farming. In this approach, farmers are not allowed to use synthetic pesticides or fertilizers. Rather, they rely on developing biological diversity in the agricultural fields to disrupt the habitat for pest organisms, and work toward the purposeful maintenance of soil fertility through practices such as the cultivation of nitrogen-fixing plants. With respect to fertilizer impacts, all forms of farming, including organic farming, must incorporate good nutrient management techniques that tightly couple plant nutrient demand with nutrient supply. While organic farming will not replace other forms of farming as the primary means of meeting the growing demand for food, it certainly has a place in twenty-first century agriculture, for a specific group of consumers that are willing to pay the price for a farming method that is ultimately less environmental friendly and less productive than the advanced eco-technological approach.

Crop irrigation is another important management tool used in many areas to enhance agricultural yield. Of the world’s 1.6 billion hectares of arable cropland (the developing-country share is 60%), about 10% is irrigated (total irrigated land is 271 million hectares, with developing countries accounting for 75% of this). According to FAO statistics, countries in Asia, the Middle East, and North Africa have some of the highest percentages of croplands under irrigation. Virtually all cropland in some countries in these regions, including Turkmenistan and Egypt, is irrigated

Irrigation schemes often set up a competition for water such that instream water functions such as wildlife habitat are compromised. More efficient use of water through establishing realistic water markets and pricing is one of the approaches offered in Chapter 6 to reduce this competition. Many of the experiences with water markets in the developing and developed world show that it has great potential for alleviating pressures on instream water functions.

As the world works to reduce hunger and meet the food needs of a growing population with changing food preferences, the intensification of agriculture in an environmentally friendly way can help reduce the need to convert natural ecosystems (such as forests and grasslands) to agricultural land.

Increasing crop yield through genetic manipulations is a second major intervention. (See Chapter 6.) Crop yields have increased by developing new crop varieties bred from extant genetic stock, and more recently by developing GMO crops. The introduction during the 1960s of high-yielding varieties of wheat and rice to Asian and Latin American countries gave these nations the chance to provide their people with adequate supplies of food. High-yielding varieties of other crops such as potatoes, barley, and corn were also developed from extant genetic stock. These high-yielding varieties required intensive cultivation methods, including the use of fertilizers, pesticides and machines, to realize their potential. As noted above, these interventions have both costs and benefits for the environment.

Scientists have developed GMO crops in an attempt to increase yield while reducing the need for costly inputs. Globally, cultivation of GMO crops has increased to 59 million hectares in 2002 (James 2002). GMO crops offer economic and environmental benefits (Trewavas and Leaver 2001), but also raise environmental, social, and political concerns. Dramatic increases in yields have been shown for GMO crops grown widely in several countries, including Argentina and China in the developing world. Environmental benefits include reductions in the use of pesticides. One of the major environmental concerns is that hybridization with wild relatives could cause unwanted environmental changes including negative effects on ecosystem services (Raybould and Gray 1993; Dale et al. 2002).

In Chapter 6, there is a balanced discussion of the environmental and socioeconomic benefits and risks associated with the use of GMOs. The MA stresses that our present experiences suggest that it may not be possible to evaluate the benefits and risks of GMOs in general; rather they must be addressed case by case for specific agroecological and socioeconomic conditions. That does imply that a moratorium or ban on GMO crops is counterproductive in environmental and in food production terms. In the final analysis, it may be desirable to have improved regulations that allow regionally differentiated uses of specific GMOs that add nuance to a globalized trading system.

Chapter 6 also points out that GMOs are only one of the new molecular methods for improving sustainability in agriculture. Other important tools include marker-assisted methods of breeding and molecular methods for the preservation of germplasm diversity.

Increasing the area in agriculture is a third major intervention. Currently about 11% of the terrestrial biosphere has been converted to cropland (some 36% of the world’s land base has crop production potential to some degree), and another 30% is used as grazing land. Some of the world’s food needs may be met by expanding agricultural areas, but this comes at the expense of the services provided by natural landscapes such as forests.

Deforestation is one of the world’s gravest environmental threats. Since the early 1970s, about 5,000,000 square kilometers of Amazon forest have been cleared for crops and pasture. Between the mid-1960s and the mid-1990s, all but three of the Central American countries cleared more forest than they left standing. Currently, Mexico is losing more than 10,000 square kilometers of forest a year to small farmers, and sub-Saharan Africa is losing more than 49,000. (FAO identifies deforestation during the 10-year period 1990–2000 at the following annual rate: Africa 8%, South America 4.5%, Asia 0.8%, Oceania 2%, North and Central America 1%, world 2.3%.) Forest destruction results in decreased soil fertility and increased erosion. Uncontrolled soil erosion can affect the production of hydroelectric power as silt builds up behind dams. Increased sedimentation of waterways can harm downstream fisheries, and in coastal regions can result in the death of coral reefs. Deforestation also leads to greater incidence of floods and droughts in affected regions. Clearing of forests for agricultural land contributes to loss of species, with tropical species especially vulnerable to habitat modification and destruction. The expansion of agricultural land is the most severe threat to maintaining biodiversity, and therefore sustained sophisticated intensification of the present and best lands is in fact the only realistic alternative solution (*high certainty*).

### 19.2.3 MDG 2: Achieve Universal Primary Education, Target 3

Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.

**19.2.3.1 Introduction**

The quantitative gap between the current situation and the target for 2015 is less dramatic than is the case for other targets such as hunger and poverty. In most regions of the world, the net enrolment ratio in primary education has been improving since 1990, and the values in 2000/01 were above 80% in most regions, with the exceptions of sub-Saharan Africa (57.7%) and South-central Asia (79.2%) (UNESCOa 2003; World Bank 2003). Net enrolment ratio is the number of students enrolled in a level of education who are of official school age for that level, as a percentage of the population of official school age for that level. (See Table 19.5.)

However, when the drop-out rate (as measured by the percentage of pupils starting grade 1 who reach grade 5) is factored in, the situation looks more problematic. Because of limited availability of data at the country level, regional totals cannot be calculated; country figures of pupils reaching grade 5 range from 43% to 100% (UNESCOb 2003). Table 19.6 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 3.

**19.2.3.2 Dependencies**

There are no obvious and direct dependencies on ecosystem services for achieving the goal of education, but the required buildup

of infrastructure (including building schools, roads) in the areas lacking these facilities will use land, building materials, and energy; potentially open new land to colonization; and may have varied environmental impacts.

**19.2.3.3 Interventions**

Different specific interventions will be required to reach this target by 2015. The interventions needed to reach the target include:

- building schools and accessing infrastructure. This includes building the schools, installing furniture and, in many cases in remote areas, also building and maintaining roads of access;
- providing transportation facilities, particularly in rural areas. This includes provision of transportation services, acquisition and maintenance of vehicles, building stations, and providing operational elements (fuel, tires, etc.);
- training and recruiting teachers;
- preparing and distributing teaching materials, such as textbooks, stationary, uniforms, etc.;
- providing school meals and basic health services;
- providing family subsidies, when necessary, to compensate for the child's absence from home.

**19.2.3.4 Synergies and Trade-offs**

The positive impacts of expansion of primary education on ecosystems and their services include improved ecosystems use and management in the long term, but also short-term gains if schooling addresses the needs and means for sustainable management of ecosystems and the lessons are applied in the students' homes. Environmental care and awareness should be included in school curricula to positively influence consumption behavior and natural resources management, with important long-term benefits

On the other hand, the associated infrastructure works, if not carefully done, may have negative impacts on ecosystems and their services, including in some places the fostering of habitat destruction and biodiversity loss due to the opening of areas to land colonization through the new access provided by the roads built to connect villages to the new schools. Also, building the large number of schools that will be required is likely to have some local negative environmental impacts due to disturbances associated with the extraction and processing of building materials (for example, cement factories, which also have global effects through the release of carbon dioxide to the atmosphere).

**Table 19.5. Net Enrolment Ratio in Primary Education, 1990/91 and 2000/01**

	1990/01	2000/01
<i>(primary-level enrollees per 100 children of enrollment)</i>		
World	81.9	83.6
Industrial regions	94.9	95.6
Countries in transition	88.2	90.6
Developing regions	79.8	82.1
North Africa	82.6	91.4
Sub-Saharan Africa	54.5	57.7
Latin America and the Caribbean	86.9	96.6
East Asia	97.7	93.5
South-Central Asia	73.1	79.2
Southeast Asia	92.6	91.5
West Asia	81.8	85.1

**Table 19.6. MDG 2, Target 3: Dependencies, Interventions, Synergies, and Trade-offs for Primary Education**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Primary education	land, building materials, and energy	build schools and access infrastructure provide transportation facilities, particularly in rural areas train and recruit teachers prepare and distribute teaching materials provide school meals, and basic health services provide family subsidies	adequate education can improve ecosystems use and management, in the long and short term	fostering habitat destruction through opening of remote areas to land colonization local impacts of extraction and processing of building materials

### 19.2.4 MDG 3: Promote Gender Equality and Empower Women, Target 4

Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and at all levels of education no later than 2015.

#### 19.2.4.1 Introduction

MDG 3 is directed at achieving gender equity and empowering women. It has a single target: target 4, which calls for the elimination of gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015. While it is acknowledged that this target does not adequately represent the many components of gender equity and the many interventions required in achieving it, it is a target that has direct ecosystem service links. The ecosystem services involved would be primary production, food, fresh water, fuelwood, spiritual and religious benefits, education, and cultural heritage. Women (as well as men), especially the poor, are dependent on the natural environment and the ecosystem services it provides for their health and well-being (for example, fresh water, fuel, productive agricultural land, and natural biodiversity) and on the cultural, spiritual, and religious aspects of their environments.

Achieving gender equity is an essential goal in itself and it is absolutely critical for meeting all the 2015 targets. The date set for achieving gender parity in primary and secondary education is 2005, ten years before the 2015 targets (UNICEF 2004). The issue is much more than a question of equity; the challenges facing the globe demand the utilization of all human potential. There have been notable strides but we are far from achieving that goal. Of the 876 million persons over 15 who cannot read or write, nearly two thirds are women. UNICEF estimates that there are 121 million primary-school-age children out of school, 65 million girls and 56 million boys (UNICEF 2004). For the Asia-Pacific region, in the 46 (of 58) economies for which data are available, in almost all there were moderate to severe gender disparities in primary education although the situation was somewhat better in secondary school. In China, by 2000, there were actually more girls enrolled in primary education than boys. The pattern does not hold true in secondary education, however. The situation in primary education in China is offset by disparities in South Asia (UN 2003). Gender inequity reverberates through society in complex ways, impacting not only women but also their children, their families, and their societies. The gender gap in earnings persists, and employed women have less social protection and fewer employment rights than men. Violence against women remains a serious violation of women's rights across the globe, and the majority of new cases of HIV/AIDS in the 15–24 year old age group are women.

A more comprehensive view of gender equity than that employed in the MDGs conceptualizes three main domains of gender equity, all of which are amenable to policy intervention. The first, which includes education, is enhancing women's capabilities, including health, education, and nutrition. MDG 5, improving maternal health, is related. The second domain is enhancing women's opportunities—access to assets, income, and employment. The third domain is enhancing women's agency—the ability to make choices that can alter outcomes including participating in and leading the political process. Because of the daunting nature of the problem, the prevention of violence is viewed as a separate category (Grown et al. 2003). Table 19.7 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 4.

#### 19.2.4.2 Dependencies

An ecologically balanced natural environmental base, including productive agroecosystems that support economic development will help to alleviate poverty and allow investment in girls' education. This is more than a strictly financial issue, although school fees, uniforms, books, and supplies are important concerns. In many parts of the world, one of the primary reasons that girls are not in school is because of domestic responsibilities, for example, the collection of water and fuelwood and agricultural tasks.

#### 19.2.4.3 Interventions

The specific interventions include: expanding access to safe, affordable fuel for domestic use, expanding access to improved water supply, an improved transportation infrastructure, an improved education infrastructure, the provision of information and communications, and access to technology for distance education in rural areas.

#### 19.2.4.4 Synergies and Trade-offs

The provision of additional fuel sources, especially modern liquid fuels such as liquid petroleum gas or renewable sources such as solar power and hydroelectricity would reduce stress on local forests and other fuelwood sources. Few, if any, negative impacts would be expected. In terms of HWB, if attention is paid to the fuel source and improved cooking stoves, this should also decrease women and children's exposure to indoor air pollution, an important problem in many parts of the world. The primary consequence of expanding access to a safe, potable water supply would be an increased demand for surface and groundwater, potentially affecting surface water quality and quantity. This could impact other components of the local ecosystem. If engineering solutions are applied (for example, dams or other waterworks), there could be considerable ecosystem service impacts. The corollary of improved access to safe water is improvements in sanitation (for example, lack of adequate toilet facilities is one of the reasons given for not sending girls to school). With respect to both increased access to potable water and improved sanitation, wastewater treatment needs to be addressed.

Wastewater treatment has definite benefits in terms of HWB; these include decreased exposure to gastroenteric pathogens in the water supply as well as decreased risk of exposure to pathogens while collecting water, for example, those causing schistosomiasis and leptospirosis. There would also be decreased risk of diseases related to lack of hygiene or the "water-washed" diseases. Safe water supplies may also lead to a decrease in the breeding sites for disease carrying vectors, for example, *Aedes* mosquitoes that transmit dengue fever. Improved health should have positive consequences for educational, agricultural, employment, and other endeavors for entire communities.

Both access to affordable fuel and improved water supply should free women and girls from the burdensome duties of collecting these basic domestic necessities.

An improved transportation infrastructure could have either positive or negative impacts on ecosystems, depending on planning and mitigation efforts. The construction of roads has been presented as one of the classic examples of "development" strategies that have had negative ecological impacts. Roads can threaten biodiversity, lead to the introduction of alien species, cause forest fragmentation and altered habitat as well as unplanned development. However, transportation infrastructure is critical for economic equity and development, for example, providing rural dwellers better access to health and education services as well as employment opportunities and access to markets. Improved trans-

**Table 19.7. MDG 3, Target 4: Dependencies, Interventions, Synergies, and Trade-offs for Gender Disparity**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Gender disparity in education	ecologically balanced natural environmental base, including productive agroecosystems	expand access to safe, affordable fuel for domestic use expand access to improved water supply improved transportation infrastructure (in rural areas) improved educational infrastructure—more and more well distributed schools provision of information and communication technology in rural areas/distance education	less stress on local forests and other fuelwood sources	increase demand for surface and groundwater potential impacts of water supply projects, dams, etc. threatens biodiversity introduction of alien species altered habitat forest fragmentation unplanned development local environmental impact at sites potential negative impact of new information technologies on traditional indigenous knowledge systems including ecosystem knowledge; conversely information and communication technology could enhance the preservation of this knowledge

portation infrastructure can also provide access to remote areas for environmental assessment and management. Roads provide various economic development options, for example, ecotourism that may have second order environmental impacts. In different contexts, roads may either slow or increase rural out-migration, with demographic and ecological consequences.

An improved education infrastructure including the building of new schools might have a very localized negative impact in terms of ecosystem services. Positive impacts would be second order—a more educated civil society (girls and boys, men and women) that, at least in theory, could be better stewards of the land. The infrastructure provided by the school (and schoolteachers) could be employed for education efforts aimed at ecosystem services.

There are important issues concerning the quality of the education, completion rates, grade completed, and actual learning. As noted, a major consideration, even if education is available to girls, is the financial and other costs. If girls are going to have access to education, policies will have to be put in place to assure subsidies, transfers, tuition, book fees, etc. In terms of ecosystem services, improved gender equality and education will allow access to land and other household resources increasing the likelihood of wise natural resource management decisions. If women and girls have ready access to water and fuel (some innovative schemes, site collection points near to schools) it will free their time for other activities that contribute to personal and family well-being, including education.

If women are literate, agricultural/natural resource education/outreach can be more easily targeted at women to enhance sustainable agricultural practices. Education provides opportunities

for capacity building and women can be effectively engaged in local level environmental management. Education may also increase women’s access to (micro) credits. While the uses to which these credits are put could have negative as well as positive impacts on ecosystem services, there are numerous examples of environmentally sensitive entrepreneurial activities undertaken by women.

Education is not only a building block for reaching the other MDGs, it is also a foundation for achieving other aspects of empowerment. Two of the indicators used for measuring progress toward MDG 3 are the share of women in wage employment in the non-agricultural sector and the proportion of women holding seats in the national parliament. Educated women benefit all of society. Hill and King (1995) found that of the countries in which the ratio of female to male enrollment in primary and secondary schools is less than 0.75, you can expect levels of GDP that, all other things being equal, are lower than where there is less discrimination in education.

The topic of women’s relationship to and stewardship of the environment has been the subject of broad debate in the literature on ecofeminism. (Jackson 1993, Chapter 2, and elsewhere.) Without arguing that women are naturally attuned to making wise environmental choices, educated and empowered women in developing countries are much less likely to find themselves in circumstances that lead to unwise ecological choices. For example, the women’s association of traditional healers called WAINIMATE (The Women’s Association for Natural Medicinal Therapy) has ensured women in Fiji and in other parts of the Pacific traditional medicines that are most effective and safe for treating diseases (Tabunakawai 1997, Chapter 2). As well, women who do

achieve local, regional, and national office can contribute to wise policy decisions with respect to ecosystem services.

In conclusion, it is worth noting that if all aspects of empowering women were adequately treated in this discussion, it would be a much more complex and nuanced discussion with regard to ecosystem services. Furthermore, a review of the chapters of *MA Current State and Trends* indicated that there were very few references to gender or women (often none). Chapter 3 on drivers is the exception, but most references to women were with regard to fertility. Chapter 5 on HWB does point out that women can be either winners or losers with respect to trade-offs. Even in Chapter 14 on health, women were mentioned only once and that was in the context of their vulnerability to malaria. Lastly, one might ask how well other “differences,” for example, socioeconomic status or indigenous peoples are dealt with in the MA.

### 19.2.5. MDG 4: Reduce Child Mortality, Target 5

Target 5: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.

#### 19.2.5.1 Introduction

For more than 25 years, the prevention of child mortality has been one of the leading priorities for the international health community. Despite progress made in reducing child mortality in children less than five years old, more than 10 million of them still die each year, almost all in poor countries (Black et al. 2003). In many countries, infant and childhood mortality rates are falling more slowly than before and, in some, they have stagnated or are on the rise (UNICEF 2004). The infant mortality rate has been highest in sub-Saharan Africa, and the region has shown the slowest decline (Ahmad et al. 2000). Despite a 50% drop in South Asia’s mortality rate, almost one in ten children in the region still dies before his/her fifth birthday (Ahmad et al 2000). Pneumonia, diarrhea, and neonatal disorders are predominant causes of infant deaths worldwide. In sub-Saharan Africa, malaria additionally plays an important part in child mortality in many countries of the region.

Undernutrition is the underlying cause of a substantial proportion of all child deaths that arise from factors—including socioeconomic factors such as income, social status, and education—that work through an intermediate level of environmental and behavioral risk factors (Mosley et al. 1984). Better information and determinants of undernutrition remains a daunting challenge and so is the development of effective and affordable health intervention measures that could facilitate the reduction of the under-five mortality rate by two thirds between 1990 and 2015. Ecosystems information provided by the MA will have indirect impact on the under-five mortality rate reduction through maternal nutrition improvement as well as healthier prenatal and postnatal care. Table 19.8 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 5.

#### 19.2.5.2 Dependency on Ecosystems and their Services

Unhygienic and unsafe environments place children at high risk (*high certainty*). Ingestion of unsafe water, inadequate water for hygiene, and lack of access to sanitation contribute to millions of deaths among children, a significant portion of which are from diarrhea (WHO 2002), as are the malaria and dengue outbreaks, particularly in developing countries, that have afflicted young children. Underweight status and micronutrient deficiencies among children that decrease their immune and non-immune host defenses have made many of them more vulnerable to infectious diseases. The causal link of the latter to ecosystems and their

services are complex and they are seen most clearly among impoverished communities that lack the buffers that the rich can afford. (See Chapter 16.) For example, climate change that affects food production has an impact on malnutrition that can aggravate many other health problems, particularly among the poor; small children are primarily jeopardized (*medium certainty*). The alterations of land cover have produced insects and pests that transmit diseases detrimental to children’s health. Degraded ecosystems, especially those that allow considerable amount of standing water, are excellent sources of waterborne diseases (like malaria, dengue, diarrheal diseases) to which children are susceptible.

Where ill health is caused, in large part, by excessive consumption of ecosystem services, then substantial reduction in overconsumption would have major health benefits, among both adults and children (*high certainty*). Conversely, healthy children are in a better position to positively influence other aspects of well-being, especially their parents’ and their closest kin in terms of reducing pressure on financial resources and on other life-support systems. (See Chapter 16.)

#### 19.2.5.3 Intervention Measures

Some intervention measures to improve human health and reduce the under-five mortality rate come from the health sector and others from outside it. The case of reduced nutrition in a community, as a result of food scarcity resulting in turn from a changed ecosystem, is one example of the latter. Malnourished children are more prone to life-threatening diseases including diarrhea, acute respiratory infections, malaria, and measles. Intervention measures that seek to sustain food production increases and to improve accessibility to food by the poor will help facilitate the under-five mortality rate reduction (*high certainty*). Provision of livelihood activities, especially to poor households, will help improve access to food but also to other amenities in life that could elevate nutritional status (*high certainty*). Another intervention relates to the need to increase awareness, monitoring and reporting not only among health personnel but also other authorities as well as the general public on the incidence or possible incidence of a disease (*medium certainty*). Increasing mother’s knowledge of diseases and their prevention through rigid extension campaign and training could result to considerable disease prevention and to more healthy children (*high certainty*).

Strong community participation and support, supplemented with appropriate regulation measures, are essential to the attainment of safe and good quality water (for example, clean river or watershed catchment), clean air (for example, reduced used of wood fuel for cooking), and healthy environment (for example, regular maintenance of canals, areas where water stagnates, etc.) (*medium certainty*). The latter will necessarily involve the provision of appropriate infrastructure facilities, especially those that would facilitate the achievement of a cleaner environment.

Interventions from within the health sector are curative in nature to save children dying from diseases. As such, health care systems should be technically and financially equipped to deliver necessary and effective services to all, especially the poorer segments of the society (*medium certainty*). Infrastructure facilities are also needed to facilitate the access of such health facilities and services by the all constituents (*medium certainty*).

It should be noted that health intervention measures should have spatial and temporal dimensions and should take into consideration other factors such as the social, economic, and demographic characteristics of their target group beneficiaries, as knowledge of these variables could facilitate their spread and adoption. Prior to all these, however, is the need for a realistic

**Table 19.8. MDG 4, Target 5: Dependencies, Interventions, Synergies, and Trade-offs for Child Mortality**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Child mortality	<p>healthy ecosystems and ecosystem services reduces the incidence of endemic and emerging diseases that affect the lives of children</p> <p>healthy ecosystem that provides options to improve means of livelihood will promote well-being of children.</p>	<p>better understanding of epidemiological profile and the capabilities of the health system in order to be able to identify:</p> <ul style="list-style-type: none"> <li>• more efficient and equitable delivery of health care services</li> <li>• infrastructure facilities needed to facilitate access to health services</li> <li>• improved delivery/access to clean water</li> <li>• improved sanitation including proper waste disposal practices</li> </ul> <p>increased awareness and more efficient monitoring and reporting of health personnel on the incidence or possible incidence of disease.</p> <p>increased livelihood opportunities, especially for the poor</p>	<p>reduced pressure on ecosystems</p> <p>reduced use of wood fuel</p> <p>less pressure on the regulatory services of ecosystem promotes better ecosystem management</p>	<p>increased population that could put pressure on the use of ecosystem services, particularly on its provisioning services</p> <p>may involve land use change (also demographic changes) that could have negative impact on ecosystems</p> <p>land use change from increased as well as shifts in demand due to economic growth</p> <p>competition for resources; increased demand for surface/groundwater</p>

picture of the country’s epidemiological profile and the capabilities of their health systems to be able to design and implement the appropriate public health interventions.

**19.2.5.4 Synergies and Trade-offs**

All these interventions have positive and negative impacts on the ecosystem. Positive impacts, as already mentioned, relate to the fact that healthy people, especially children, save families from spending money on medicines, hospitalization, etc.; these savings can then be invested in productive activities to improve economic well-being. Better-off farm families have the tendency to put fewer burdens on their children to be involved in household chores, especially in collecting woodfuel and fetching clean water. Mothers, too, can have the luxury of more modern appliances or delegating household chores to others and thus gaining more time to take care of their children. The negative impacts, on the other hand, relate to the externalities that result from an increase in population as mortality rates are reduced (but which can be neutralized by lower fertility rates as households start to appreciate smaller family sizes) as well as from shifts in demand due to economic growth and as poverty is reduced that may involve environments to be disturbed. Examples include the change in land use to cater to more diversified production activities, diversified demand for food and other commodities, and increased demand for services and other amenities.

**19.2.6 MDG 5: Improve Maternal Health, Target 6**

Target 6: Reduce by three quarters, between 1990 and 2015, the maternal mortality rate.

**19.2.6.1 Introduction**

A report of the International Conference on Population and Development, endorsed by 179 countries, states that women, including their health and well-being, are valuable as people and citizens (ICPD 1994). Currently, some 350 million women have no ac-

cess to safe and affordable contraception, contributing to undesirable fertility for women, and half a million deaths occur per year during pregnancy and childbirth, particularly in sub-Saharan Africa, where maternal deaths account for 53% of all deaths. A woman’s risk of death during pregnancy and childbirth varies greatly between industrial and developing countries. The risk of dying from pregnancy in Africa is 1 in 16; in Asia, 1 in 65; and in North America, 1 in 3,700. The overall risk for developing countries is 1 in 48, whereas in industrial countries the risk is 1 in 1,800 (ICPD 1994). Providing conditions that enable women to have a healthy pregnancy and childbirth is, as agreed by the ICPD, a fundamental right. Their involvement and decision on when to have children, and how many to have, is dependent on information access to reproductive health and society’s commitment to gender equity.

Many health problems incurred by women during pregnancy are a result of complications arising from but not limited to HIV/AIDS, sexually transmitted disease, respiratory infections, and malaria. These problems can be lessened through investment in economic and social infrastructure such as access to health aids and facilities, and also through the development and conservation of ecosystem services. Decreasing maternal mortality, however, requires a focus on preventative care since there are no direct links with ecosystem services and maternal deaths (MA Scenarios, Chapter 7).

To decrease maternal mortality, improvements to women’s health during pregnancy and throughout the post-natal years are critical, as these periods in a woman’s life are essential to her well-being. The Millennium Project Task Force on Child Health and Maternal Health identifies where there are low maternal mortality rates in particular countries it is primarily due to the availability and access to skilled attendants, emergency obstetric care, and referral systems, so that women can reach emergency obstetric care for life saving situations (Freedman et al. 2003). As short-term solutions, these services are extremely important in reducing ma-

ternal mortality. By ensuring access to and providing safe water, soils, and food, policy-makers can ensure long-term benefits. Pregnant mothers will have better chances at having healthy children and economic spending can be put toward improving health services and strengthening the entire health system. Table 19.9 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 6.

### 19.2.6.2 Interventions

Improving infrastructure, that is, provision of high-quality and accessible medical care and information, in clinics and hospitals located for easy access to women can result in habitat modification and water use locally. Transportation and road development is also necessary to ensure that medical emergency services can reach their destinations efficiently and women will have the opportunity to access transport to clinics or hospitals. Providing emergency care services will dramatically reduce the maternal mortality rate (Freedman et al. 2003).

Improving access to nutrition through food quality and quantity places demand on land and aquatic habitats for agricultural land of higher soil fertility, for chemicals to increase plant productivity. Alternatives to chemical usage such as natural pest control can be considered.

Increasing health and gender equity through provision of knowledge about reproductive alternatives, nutrition, and disease can lead to healthy pregnancies and choices about reproductive health. Gender equity can broaden appreciation of educational and cultural services, indirectly leading to wise use of ecosystems and services. As already noted, empowering women through training and education will allow them to manage resources wisely for themselves and their families).

### 19.2.6.3 Trade-offs

Where there is a need for economic development such as building and improving infrastructure to improve access to emergency obstetric care, achieving the maternal health goal may require converting natural ecosystems resulting from an increased demand on land, water and biodiversity. This is the single most relevant trade-off concerning maternal mortality. There is a need for more medical facilities that offer emergency care, roads, and transport for women to access them.

## 19.2.7 MDG 6: Combat HIV/AIDS, Malaria, and Other Diseases, Targets 7 and 8

Target 7: Have halted by 2015, and begun to reverse, the spread of HIV/AIDS.

Target 8: Have halted by 2015, and begun to reverse, the incidence of malaria and other major diseases.

### 19.2.7.1 Introduction

Health, defined differently in different cultures, is fundamental to HWB. It is also both a cause of well-being and a consequence. In Chapter 16, the links between health and ecosystem services are listed as biodiversity, food, fresh water, wood, wood fuel, fiber, nutrient management, waste management and detoxification, flood and storm regulation, and cultural services. To these could be added climate regulation. This long list is indicative of the complex relationship between human health and well-being and ecosystem services. Related MDGs are goal 4, Reducing Child Mortality, and goal 5, Improving Maternal Health. Even taking these three goals together captures only a portion of the complex relationship between health and ecosystem services. The United Nations and the World Health Organization have identified HIV/AIDS, malaria, and tuberculosis as major threats to health across the globe. MDG 6 explicitly addresses HIV/AIDS and malaria and reduction in the prevalence of and death rates associated with tuberculosis, which are used as a measure of the success in meeting this goal.

For HIV/AIDS (primarily a sexually transmitted disease, although also transmitted perinatally and by intravenous drug use and blood transfusions) and TB (a communicable disease), most of the interventions are in the realm of public health, medicine, education, and politics and are not directly related to ecosystems. Malaria is the most serious and common vector-borne disease in the world, responsible for 2 million deaths a year, 90% of which occur in sub-Saharan Africa, the majority in children under five. Transmitted by the *Anopheles sp.* mosquito, malaria provides a classic example of the relationship between vector-borne disease and ecosystem services. Malaria epidemics are often the result of changes in the eco-epidemiological system, for example, abnormal meteorological conditions (WHO 2000) or deforestation. Other globally important vector-borne diseases include dengue, filariasis, schistosomiasis, and yellow fever.

Another important group of ecosystem sensitive diseases are those that are related to water supply and sanitation, for example, those such as cholera that are waterborne or those related to poor personal hygiene, that is, the “water-washed diseases.” MA *Current State and Trends*, Chapter 14, addresses the role of altered ecosystem and emerging and re-emerging infectious disease. Food production, an ecosystem service, and availability are directly related to human health and there is a synergism between malnutri-

**Table 19.9. MDG 5, Target 6: Dependencies, Interventions, Synergies, and Trade-offs for Maternal Health**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Maternal health	There are not direct links to ecosystem services. Maternal mortality is caused by complications at birth and the lack of access to skilled birth attendants and other health services.	build medical facilities and emergency care facilities provide transportation facilities, particularly in rural areas for women train and recruit medical professionals for preventative care	no direct benefits to ecosystem services; access to medical care will improve maternal health	alternating natural habitats for infrastructure development local impacts of extraction and processing of building materials

tion and infection, especially in children. Overnutrition, as well as some other ecosystem-relevant factors, for example, exposure to carcinogens, are implicated in the increase in noncommunicable diseases, for example, cardiovascular disease, cancer, hypertension, and diabetes. These are becoming increasingly prevalent not only in the developed world but also in the developing world, resulting in what some refer to as developing countries' "double burden of disease."

**19.2.7.2 Dependencies**

For target 7, halting and beginning to reverse the spread of HIV/AIDS by 2015, the direct links between intervention strategies that are largely aimed at behavior and ecosystem services are not evident. In a very general sense, to the degree that countries will need to rely on their own national fiscal resources to fight the spread of HIV/AIDS, ecosystem services that support sustainable development will allow resources to be targeted at the HIV/AIDS epidemic. On a community level, as fewer and fewer individuals are living in poverty, individuals will not have to resort to livelihood strategies (for example, prostitution and male migration) that increase risk of HIV/AIDS. In those countries where the HIV/AIDS epidemic is acute, as in sub-Saharan Africa, HIV/AIDS has a direct impact on ecosystem services. With a considerable segment of the population too ill to work, subsistence production and agricultural activities decline as too few hands are available for weeding and other agronomic activities. In terms of the natural environment, this could have positive or negative effects, but in terms of human health and well-being the implications will be disastrous. Table 19.10 summarizes the dependencies for HIV/AIDS, as well as interventions, synergies, and trade-offs.

An estimated 29.4 million (of a global total of 42 million) persons are living with HIV/AIDS in sub-Saharan Africa, and 3.5 million new infections occurred in 2002. Prevalence rates vary across the continent but reach 20% of the adult population in South Africa and Zambia.(UN AIDS 2003). HIV/AIDS is a threat to reaching the MDGs on the African continent. However, while more than half of the HIV/AIDS cases occur in sub-Saharan continent, there is no reason for complacency elsewhere. Over seven million people are living with HIV/AIDS in Asia and the Pacific and while rates may be low (0.1% in China and 0.6% in India,) this represents 8,500,000 and 4,000,000 persons, respectively (UNDP 2003). If appropriate policies are not put into

place, there is reason to be very concerned about the epidemic in Asia, although countries like Thailand and Cambodia have made great strides in stemming the epidemic (Brown 2003).

Malaria is endemic in over 100 countries and two and a half billion people are at risk. Malaria is responsible for 11% of the disease burden in Africa, and countries with high rates of malaria have income levels averaging 33% of those without malaria. (See Chapter 12.) Malaria is caused by four species of the plasmodium parasite; *Plasmodium vivax* is most widely distributed and *Plasmodium falciparum* is the most clinically dangerous. Both of these are becoming increasingly drug resistant and the anopheline species that transmit malaria are becoming increasingly resistant to pesticides as well. There are a complex of socioeconomic, geographic, and ecological conditions that are conducive to the transmission of malaria. As with HIV/AIDS, high rates of malaria endemicity have serious social and economic impacts.

The vectors are sensitive to temperature, precipitation, and extreme weather events. Relative humidity becomes important at higher temperatures. The extrinsic incubation cycle of the plasmodium is also sensitive to temperature and this can serve as a limiting factor in disease transmission. Temperature is important with respect to the survival of both the vector and the parasite and precipitation directly influences both the abundance of breeding sites and vector densities (McMichael et al. 1996). Deforestation and irrigation schemes can lead to increased malaria transmission. The presence or absence of alternate hosts can also be important. There is concern that with global warming some vector species will increase their range. In Papua New Guinea, for instance, if temperatures in the relatively densely populated highlands were to increase allowing vector species to populate higher altitudes, a large population with no immunity would be at risk. Typically populations on the margins of endemic areas are at the greatest risk.

**19.2.7.3 Negative Impacts**

The impacts of HIV/AIDS on ecosystem services are mediated through the devastating impact on the human population, on families, on the social fabric, and on the economy. In many countries, AIDS is erasing decades of progress. Families are losing income earners. Many of those who die leave behind HIV-infected partners, and when they die, orphans. Children of HIV-positive mothers may well be infected themselves. Children of

**Table 19.10. MDG 6, Targets 7 and 8: Dependencies, Interventions, Synergies, and Trade-offs for HIV/AIDS, Malaria, and Other Diseases**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
HIV/AIDS	no direct links evident; intervention strategies are aimed at behavior	public health interventions aimed at high risk populations/behavior modification public policy interventions in support of affected families and children	in parts of southern Africa where HIV/AIDS rates are extremely high, reducing rates may allow better ecosystem management	
Malaria and other major diseases		larval and adult spraying drainage intermittent irrigation impregnated bednets		alterations in natural ecosystem with larval spraying drainage could cause alteration or destruction of wetlands

the ill take on more and more responsibility and fewer families have the resources to send their children to school. The vast majority of those with HIV/AIDS are between the ages of 15 and 49, in the prime of their working lives. HIV/AIDS has a direct impact on the economy by lowering production and earnings and hence taxes, and the resources demanded to deal with the epidemic are a further drain on the economy. Direct impacts on ecosystem services are probably most prominent in the agricultural sector and could be either positive or negative with respect to ecosystem services, as noted above, but are definitely negative in terms of food production and the fight against hunger. It is estimated in Burkina Faso, that 20% of rural families have reduced their agricultural work or even abandoned their farms because of HIV/AIDS. In Ethiopia, AIDS-affected households were found to spend 11–16 hours per week performing agricultural work, compared with an average 33 hours for non-AIDS-affected households (AVERT 2003).

HIV/AIDS-affected families have fewer resources to devote to their agricultural pursuits. This could, on the one hand, mean that, for example, fewer pesticides are used or on the other that ecologically unsound practices are used to try to increase production. Abandoned land might revert to second growth or, especially if soil erosion is a problem, become further degraded. With high mortality rates, some indigenous traditional, ecological, and agricultural knowledge may also be lost. It is worth noting that other important endemic diseases, including malaria, that affect a notable proportion of the population can have similar, if not as extreme, effects.

#### **19.2.7.4 Interventions**

The interventions for HIV/AIDS and TB are not primarily environmental. The main interventions for malaria include the prevention of mosquito bites including the provision and distribution of insecticide-treated bednets and other materials, indoor residual spraying only in well-defined high-risk or special situations, the prevention of infection by chemoprophylaxis particularly in pregnant women, the treatment of clinical episodes, and surveillance and rapid response (WHO 2000). Some of these, as the interventions for HIV/AIDS and TB, are in the realm of medicine, public health, and behavior. However, there are important environmental interventions for malaria including selective environmental management, drainage, and intermittent irrigation that are important in helping to control malaria. (See Chapter 12 for a discussion of the importance of integrated vector management.)

There have been many examples of the misuse of dichloro diphenyl trichloroethane (DDT) and other pesticides, particularly in the agricultural sector. While DDT is being phased out in many locations in favor of pyrethroids, WHO still recommends its use in indoor residual spraying in special situations (WHO 2000). The recent resurgence in malaria has been blamed on the bans on the use of DDT in many regions of the world. Inappropriate use of pesticides can have severe impacts on many ecosystem services, although the application of pesticides plays an important role in disease control in many parts of the world. Drug resistance in parasites and pesticide resistance in vectors is becoming an increasing problem. The chemicals may have negative impacts on other organisms, on groundwater, etc. In addition, it is worth noting that specific interventions for one vector may differ radically from those used for other vectors, for example, different genera of mosquitoes. The impact of drainage and intermittent irrigation strategies would be site specific. In a degraded ecosystem, with no endangered species, it could be positive, whereas in a natural wetland, it would be negative.

#### **19.2.7.5 Conclusion**

This discussion of HIV/AIDS and malaria only begins to explore the complex relationship between human health and ecosystem services. An important link that is now receiving considerable scientific attention is the relationship between human and ecosystem health and climate variability and climate change. Emerging and re-emerging infectious diseases may have a direct link to alterations in ecosystem services, for example, Lyme disease or West Nile virus. Wise management of the environment, for example, river catchments, positively affects environmental and socioeconomic determinants of health. The complexity of the relationships between human health and ecosystem services demands interdisciplinary and cross-sectoral collaboration in addressing them. In trying to assess the impact of any given set of conditions on human health, we need to understand the current vulnerability of the population affected and their future adaptive capacity. The relationship is often inverted. As in the case of sub-Saharan Africa, the links between ecosystem change and human health are seen most clearly among impoverished communities who lack the “buffers” the rich can purchase.

A recent multiyear study, under the auspices of the WHO Global Burden of Disease project, developed projections of mortality and disability for each five-year period from 1990 to 2020 (Harvard 2003). HIV/AIDS, malaria, and TB are major global problems, and there is the possibility of new communicable diseases as we were reminded by the Severe Acute Respiratory Syndrome outbreak in 2002/3. In the GBD projections, deaths from communicable, maternal, and prenatal conditions and nutritional deficiencies are expected to fall from 17.3 million in 1990 to 10.3 million in 2020. Deaths from noncommunicable diseases are expected to climb from 28.1 million deaths in 1990 to 49.7 million in 2020, an increase of 77%. Much of this increase will occur in the developing world. The important two driving forces behind these changes are population aging and the use of tobacco. As we think about ecosystem services and human health, it would be a mistake to ignore the links to noncommunicable disease. Certainly not the only, but a very important, link is through food supply and nutrition, very closely linked to ecosystem services. It is also important to remember that modern or Western conceptions of health that are largely based on physical evidence of bodily structure and function may differ greatly from indigenous conceptions based on common heritage and union with the environment.

### **19.2.8 MDG 7: Ensure Environmental Sustainability, Target 9**

Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.

#### **19.2.8.1 Introduction**

MDG 7 contains three targets, of which target 9 refers specifically to ecosystem services. This target can clearly be subdivided into two components: (1) integration of the principles and (2) reversal of environmental loss, requiring different types of interventions and having differentiated implications for ecosystems and their services.

*Target 9a: Integrate the principles of sustainable development into country policies and programs*

The principles of sustainable development referred to in target 9 have been officially agreed at the Earth Summit of 1992, and defined in the Rio Declaration on Environment and Develop-

ment (UN 1992). The twenty-seven principles internationally agreed are reproduced in Box 19.1.

Lack of integration in planning and policy-making has long been recognized as one major obstacle to progress toward sustainable development (UNCSD 1995). While sectoral plans and approaches have the advantages of being unambiguous, with clear objectives and a good correspondence to the specialized institutions responsible for implementation, they have the disadvantage that the assortment of plans and regulations across sectors may have inconsistent and incompatible objectives, and often the issues of integration and coordination fall between the gaps. (See Chapter 14.) Table 19.11 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 9a.

**19.2.8.2 Dependencies**

The fulfillment of target 9a does not exhibit any obvious direct dependencies on ecosystems for achieving it, as it implies mainly institutional changes.

**19.2.8.3 Interventions**

Among the interventions required, the most important are:

- reinforce environmental policies;
- introduce environmental principles in economic and social policies;
- reinforce and enforce environmental legislation at various scales;
- train and build capacity on sustainable development in the public and private sectors;
- establish economic and social incentives for the contribution of the private sector to the integration and implementation of the principles;
- support research and development on methodologies and techniques for integrated planning and policy-making and develop national information strategies for sustainable development;
- establish effective and integrated legal and normative frameworks for economic planning, market instruments, and regulatory instruments; and

- define and implement and ensure compatibility/alliance with country strategies such as country sustainable development strategies.

**19.2.8.4 Synergies and Trade-offs**

Most of these will have a positive impact on ecosystems and their services, as they are specifically focused on improving environmental sustainability. The increased integration of the principles of sustainable development into policies and programs will considerably reduce the negative ecological impacts of economic and social policies and actions. No direct negative impacts on the ecosystems are likely to result from those actions.

*Target 9b: Reverse the loss of environmental resources*

The loss of environmental resources is a serious problem abundantly documented by many studies, and full details can be found in various chapters of this and other MA volumes. As demonstrated several times, this process amounts to erosion of the ecological basis for development and directly threatens HWB. For example, an important ecosystem service provided by intact vegetation is the stabilization of landscapes against wind, soil, and water erosion. The clearing of forests and other types of vegetation in hilly and mountainous regions of the world has diminished the capacity of the land as a habitat for people and in some cases led to the death of thousands of people in mudslides associated with extreme rainfall. Intense rains falling on steep slopes cleared of forests in Caribbean and throughout Central and South America have resulted in thousands of people dying in massive mudslides in recent decades, including those resulting from Hurricane Mitch in 1998. Large-scale mudslides became the signature of Hurricane Mitch, a storm that grew to become the Atlantic basin's fourth strongest hurricane ever with sustained winds of 180 mph for more than 24 hours. Hurricane Mitch stalled off the coast of Honduras from late on October, 27, 1998, until the evening of October 29, dropping up to 25 inches of rain in one six-hour period in some places. The heavy rain led to widespread flooding and mudslides that killed at least 10,000 people.

The specific indicators identified for target 9b so far (proportion of land area covered by forest, land area protected to maintain

**Table 19.11. MDG 7, Target 9a: Dependencies, Interventions, Synergies, and Trade-offs for Integrating Principles**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Integrate principles into policies and programs	none	environmental policies introduce environmental principles in economic and social policies environmental legislation train and build capacity incentives for private-sector contribution support R&D on methods for integration and develop national information strategies establish integrated legal and normative frameworks implement country sustainable development strategies	reduced negative impacts of ecosystem services	none

biological diversity, energy used per unit of GDP, per capita carbon dioxide emissions and consumption of ozone-depleting chlorofluorocarbons, and population using solid fuels) are, from the viewpoint of ecosystem services, far from complete for this component of the target. Table 19.12 summarizes the dependencies, interventions, synergies, and trade-offs for MDG target 9b.

#### 19.2.8.5 Dependencies

The fulfillment of target 9b does not show obvious dependencies on ecosystem services, except that, in some cases, the damage to ecosystem services may already be irreversible or too costly to revert, and the reversal of the loss of environmental resources may no longer be possible.

#### 19.2.8.6 Interventions

A number of different types of will be necessary:

- increase expenditure on environmental sustainability. In many countries, the current level of public and private expenditures on the sustainability of the environment is insufficient to markedly reverse the losses;
- increase resources allocated to R&D on ecosystems and their services, and new eco-technologies;
- implement programs of ecosystem restoration and rehabilitation and ecological engineering (for watersheds, agricultural land, deforested areas, polluted aquatic ecosystems, etc).
- develop economic incentives and regulatory instruments directed to the sustainability of ecosystems services (for example, reduce the energy intensity of the economy). A number of policy instruments are available, ranging from voluntary compliance to pollution taxes and environmental protection laws. The appropriate mix will vary with the country institutional system;
- introduce the principles of sustainable development in education curricula and implement programs for raising public awareness. This is an intervention that will take some time to show its effects, but that is likely to have a long-term positive impact on ecosystem services.
- introduce environmental sustainability considerations into international trade and cooperation agreements at various scales; and

- protect areas and ecological corridors or networks essential to maintain biological diversity.

#### 19.2.8.7 Synergies and Trade-offs

Meeting the target will have a number of positive ecosystem impacts. First, the economic impacts of economic and social policies and actions will be reduced. This is probably the positive impact that will be most important in quantitative terms, as usually the negative ecological impact of economic actions such as investment in public works, industry allocation, resettlement of population and land colonization, etc., far exceeds the positive impacts of specifically environmental policies. Second, improved management of ecosystems will contribute to enhance ecosystem services and thus help to fulfill the other goals. Third, restoration and rehabilitation of degraded ecosystems will increase the ecological basis for development. Fourth, increased understanding of ecosystem functions will provide novel management technologies and identify new productive and sustainable uses for ecosystem services.

There are no obvious negative ecosystem impacts of the interventions. However, it is known that ecosystems managed for maximum productivity or yield, without maximizing ecological (self) regulation mechanisms, may lose their resilience in the long term and they may even collapse (Holling and Meffe 1996).

### 19.2.9 MDG 7: Ensure Environmental Sustainability, Target 10

Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.

#### 19.2.9.1 Introduction

The baseline year for estimating the targets is 1990. Unfortunately, the terminology chosen for defining the targets does not conform with the classification adopted by the WHO/UNICEF Joint Monitoring Program, which collects official data on “improved” access to water supply and sanitation. The distinction between “improved” and the more stringent definition of “adequate” access is very important. For example, the availability of a shared toilet in an urban settlement is termed as “improved” ac-

**Table 19.12. MDG 7, Target 9b: Dependencies, Interventions, Synergies, and Trade-offs for Reversing the Loss of Environmental Resources**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
reverse loss of environmental resources	no obvious dependencies	increase expenditure on sustainability increase resources implement ecosystem restoration, rehabilitation, and ecological engineering develop economic incentives and regulations introduce the principles in education curricula and raise awareness introduce environmental sustainability into trade and cooperation protect areas	enhanced ecosystem services increased ecological basis for development novel management technologies and new productive uses	ecosystems managed for maximum productivity may lose their resilience in the long term

## BOX 19.1

**The Principles of Sustainable Development from the Rio Declaration (UN 1992)**

Principle 1. Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3. The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5. All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6. The special situation and needs of developing countries, particularly the least developed, and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7. States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8. To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9. States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10. Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11. States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the

environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12. States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13. States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14. States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15. In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16. National authorities should endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17. Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18. States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19. States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20. Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21. The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

**BOX 19.1** *Continued*

Principle 22. Indigenous people and their communities, and other local communities, have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23. The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24. Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25. Peace, development and environmental protection are interdependent and indivisible.

Principle 26. States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27. States and people shall cooperate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

cess to sanitation without taking into account the number of people who may need to share the facility. Likewise the presence of user fees and their affordability to the poor are not taken into consideration. As a result, “improved” access to water supply and sanitation does not necessarily imply effective or “adequate” access, since users may be prevented from using the facilities by high fees or overcrowding. These problems are particularly acute in urban areas (Bartlett 2003). In fact it has been shown that “improved” sanitation does not “greatly reduce the risk of oral-fecal diseases” (Pruess and Fewtrell 2002).

In the absence of data on “adequate” or “basic” access, we use the data on “improved” access provided by the JMP. The JMP definition is in line with the U.N. Secretary-General’s Report on the MDGs, but will underestimate the number of people who do not have effective access to clean water and sanitation—particularly in urban areas. Based on the JMP data, a considerable expansion of infrastructure services is required in developing countries to meet the needs of 1.2 billion people in developing countries for improved access to drinking water and 1.8 billion people who need to be connected to sanitation by 2015. Each year until 2015, it will be necessary to provide access to water and sanitation to 100 million and 140 million people, respectively. In comparison, an average of 85 million additional people per year received access to water and sanitation facilities during the 1990s. Hence considerable additional investments will be required to increase the pace of providing water and particularly sanitation facilities in developing countries. (See Table 19.13.)

**19.2.9.2 Dependencies**

Achieving the water and sanitation targets will depend on a number of ecosystem services. Table 19.14 summarizes the impact of meeting the targets on ecosystems.

**Table 19.14. Ecosystem Services Contributing to the Water and Sanitation Targets**

Ecosystem Services Contributing to Meeting the Water and Sanitation Targets	Ecosystems Directly Influenced by Progress toward the Water and Sanitation Targets
provisioning services • provision of fresh water	freshwater ecosystems and wetlands (through increased water withdrawal and pollution)
regulating services • water flow regulation (to ensure sufficient and regular supply) and aquifer recharge • water filtration and purification	coastal and marine ecosystems (through increased water withdrawal and water pollution)
supporting services • water cycling	agroecosystems (through increased demand for water) urban ecosystems through increased or reduced fecal pollution (depending on sanitation and water treatment technologies) drylands, forests, and other ecosystems that compete with humans over water

From an ecosystem perspective, meeting MDG target 10 and the WSSD sanitation target poses two related challenges. One necessary, but not sufficient input into achieving the target is the provision of sufficient quantities of clean water through ecosystem services. In addition, rising water pollution through domestic

**Table 19.13. Access to Improved Water Supply and Sanitation in Developing Countries.** This table illustrates improved access to water supply and sanitation between the years 1990 and 2002. Despite the increases, there still remains an additional 6% and 21% of the growing population that will require additional investments in improved water supply and sanitation, respectively, in developing countries. (UNICEF/WHO 2000)

	Population (billion)	Access to Improved Water %	Access to Improved Water (billion)	Access to Improved Sanitation %	Access to Improved Sanitation (billion)
1990	4.1	71%	2.9	34%	1.4
2000	4.9	79%	3.9	49%	2.4
MDG 2015 Targets	6.0	85%	5.1	70%	4.2
Difference, 2015–2000	1.1	6%	1.2	21%	1.8

and industrial effluents must be managed to protect ecosystem services and to improve human health. These two challenges are discussed in detail here. Table 19.15 summarizes the dependencies, as well as interventions, synergies, and trade-offs for MDG target 10.

19.2.9.2.1 Water quantity

As described in MA *Current State and Trends*, Chapter 7, fresh water that is readily accessible for human use is limited to approximately 9,000 cubic kilometers a year with an additional 3,500 cubic kilometers stored by dams and reservoirs. Currently, humans consume about 50% of the combined 12,500 cubic kilometers of fresh water that are readily available each year.

To ensure basic needs for drinking, food preparation, and personal hygiene, a minimum of 20 to 50 liters of water free from harmful contaminants is required per person every day. Assuming an incremental consumption of 50 liters per day, the 1.4 billion people who need to be provided with access to improved water supply to meet target 10 would require a total of 0.07 cubic kilometers of water, or less than 0.001% of readily available fresh water. Since many of the 1.4 billion people currently without access to improved water supply already consume some fresh water, this overestimates the additional demand for water to meet basic human needs. Hence at the global level, overall fresh water availability does not appear to represent a binding constraint on providing access to the minimum amount of drinking water that is required to achieve the water and sanitation targets.

To underline this point, Figure 19.1 and Figure 19.2 provide simple plots of available water resources per capita and access to improved water supply and sanitation, respectively, showing no discernible correlation between access to water or sanitation and

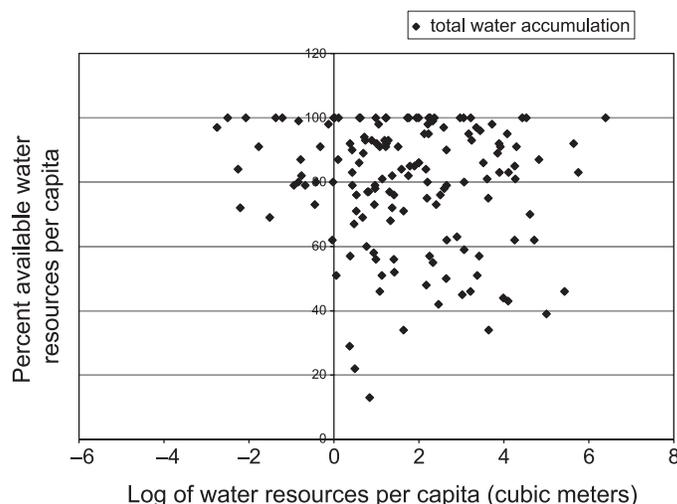


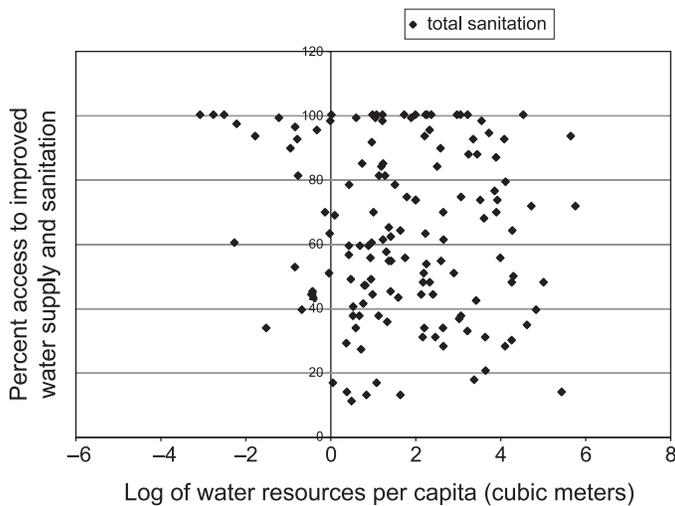
Figure 19.1. Percent Access to Water Supply against Log of Per Capita Water Resources in 2000 (FAO Aquastat; UNICEF/WHO 2004)

overall per capita water availability. This finding is too robust to control for per capita income and regional effects.

However, domestic per capita consumption of fresh water tends to rise considerably beyond the minimum needs of 50 liters per day once access to water supply has been established. Coupled with increased agricultural and industrial demand for water, water withdrawals increase much faster than populations. For example, between 1900 and 1995, water withdrawals increased by over six

Table 19.15. MDG 7, Target 10: Dependencies, Interventions, Synergies, and Trade-offs for Access to Water

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Access to water and to sanitation	freshwater ecosystems and wetlands coastal and marine ecosystems agroecosystems urban ecosystems drylands, forests, and other ecosystems that compete with humans over water	expand access to improved water supply expand access to improved sanitation greywater treatment and disposal industrial wastewater treatment additional water storage for provision of drinking water	improved sanitation systems can reduce local microbial pollution and total nutrient load by using improved technologies (for example, lined pits or improved sewer systems) reduces microbial water pollution as well as nutrient loads. reduces chemical water pollution	will increase demand for surface and groundwater can lead to a dramatic increase in demand for water, particularly if traditional sewer technology is used unless accompanied by wastewater treatment, increased access to (urban) sewers can lead to an increase in microbial, nutrient and other pollution of freshwater ecosystems in some areas, improving access to water supply may require additional water storage capacity, which can have negative impacts on ecosystems and their services



**Figure 19.2. Percent Access to Sanitation against Log of Per Capita Water Resources in 2000** (FAO Aquastat; UNICEF/WHO 2004)

times, more than double the rate of population growth (MA *Current State and Trends*, Chapter 7). If this trend continues unabated, human consumption of fresh water at the global level may soon be constrained by the availability of fresh water.

Importantly, global averages hide important regional variations in terms of demand for water as well as fresh water availability. As described in MA *Current State and Trends*, Chapter 7, prior assessment (Revinga et al. 2000) shows that, as of 1995, some 41% of the world's population, or 2.3 billion people, were living in river basins under water stress, with some 1.7 billion of these people residing in highly stressed river basins. Another 29 basins will descend further into scarcity by 2025. This problem is exacerbated by the fact that a large part of the expected increase in human population will occur in regions where water is already scarce and/or erratically available. Any changes to ecosystem services resulting from increased demand for water will have a disproportionate impact on the poor who depend most on ecosystem services for well-being.

In summary, the availability of fresh water at the global level is unlikely to prevent low- and middle-income countries from achieving the targets on water and sanitation, since the minimum per capita needs addressed by these targets are very low compared with current total consumption, which is dominated by agricultural and industrial water demand. However, water scarcity at the catchment level may occur in some areas where demand for water can exceed the readily available freshwater resources. This is particularly true for some of the rapidly growing cities in low-income countries, which may experience water shortage or need to import water from other catchment areas. A particular area of concern in some of the fastest growing cities is the growing mining of groundwater resources beyond sustainable levels.

In most cases, though, water shortages are the result of excessive water consumption for agricultural and sometimes industrial use rather than domestic consumption. In such cases, water consumption for non-domestic use may need to be balanced with need through ecosystem-wide integrated water resources management to meet the water and sanitation target. Consequently, the Johannesburg Plan of Implementation urges all countries to adopt IWRM plans by 2005. That also implies a substantial increase of water use efficiency in agroecosystems.

#### 19.2.9.2.2 Water quality

Increased access to water and sanitation may have notable impacts on surface water quality and affect groundwater in areas where the water table is high. The extent and direction of this effect can depend on the types of technologies used. In general, properly constructed and maintained sanitation systems can reduce water pollution through human waste. For example, improved double-pit latrines or septic tanks can process domestic wastewater to avoid any adverse impact on surface and groundwater. The same applies to water-borne sewers, provided they are equipped with appropriate water treatment systems that can remove microbial pollutants and reduce nutrient load.

On the other hand, sewer systems that lack appropriate trunk infrastructure and water treatment facilities can lead to high levels of microbial pollution with potentially adverse impacts on human health through the spread of infectious diseases. In some ecosystems such as lakes, the increased inflow of nutrients can lead to eutrophication with important consequences for ecosystem services. Since septic tanks and bore sewers are often not properly operated and maintained, they cannot remove solid particles or microbial pollutants and thereby contribute to the pollution of water systems.

These problems are particularly acute in developing countries where an estimated 90% of wastewater is discharged directly to rivers and streams without any waste processing treatment (WMO 1997, p.11). Threats of water quality degradation are most severe in areas where water is scarce because the dilution effect is inversely related to the amount of water in circulation. (MA *Current State and Trends*, Chapter 8). In these areas, achieving the MDGs on sanitation without parallel investments in water treatment can threaten fresh water and coastal ecosystems and the services they provide.

In many parts of the world, agricultural inputs such as fertilizers and pesticides, as well as accelerated soil erosion from faulty land management practices can degrade surface and groundwater quality. A broad range of site-specific interventions is required to minimize the use of agricultural inputs and to improve soil management. The World Overview of Conservation Approaches and Technologies has an extensive database of such interventions.

#### 19.2.9.3 Interventions

Critical interventions for achieving the water and sanitation targets include the expansion of appropriate water and sanitation infrastructure services accompanied by improved hygiene education. In particular, the design standards for sanitation infrastructure used to achieve the 2015 target can have a substantial impact on the extent to which ecosystems and their services are affected. Conventional waterborne sewers can dramatically increase per capita demand for water and thereby exacerbate water stress in some areas. If untreated, sewer systems can further lead to increased water pollution.

In many regions where access to water supply is currently very low, there may be a need for additional water storage capacity to ensure a steady and perennial supply of fresh water. Dams can have severe adverse impacts on fresh water and other ecosystems (MA *Current State and Trends*, Chapter 7; World Commission on Dams 2000). The WCD has laid out detailed guidelines that can help prevent unnecessary degradation of ecosystems. Adequate water demand management can further reduce the need for additional storage capacity.

#### 19.2.9.4 Conclusions

On balance, achieving the water and sanitation targets will require an ambitious increase in the number of people provided with

access to water supply and sanitation each year. The provision of clean water depends on a number of provisioning and regulating ecosystem services that will need to be protected in order to ensure a regular supply of clean water.

While water scarcity is likely to worsen in some areas, global freshwater ability appears to be sufficient for achieving the water and sanitation targets. The overall impact that achieving the 2015 targets may have on water demand and quality depends critically on appropriate water demand management policies such as pricing that can help contain demand for fresh water beyond the minimum basic needs of 20–50 liter per capita. In addition, integrated governance and institutional frameworks such as basin management authorities, IWRM, and other multisectoral approaches to managing water needs, can reduce pressure on ecosystems and their services. Finally, the nature of sanitation technologies and the extent to which they are properly operated can help mitigate adverse impacts on water quality.

### 19.2.10 MDG 7: Ensure Environmental Sustainability, Target 11

Target 11 has two components. The first focuses on slum upgrading as stated in the text of the MDG Target, “By 2020, to have achieved significant improvement in the lives of at least 100 million slum dwellers.” The second component concentrates on prevention by stopping the formation of slums by 2006 as stated by the Cities Alliance for Cities without Slums (UN 2000; Annan 2000).

#### 19.2.10.1 Introduction

Today 3 billion people live in urban areas (United Nations 2002), which is close to 50% of the world’s population, compared with only 15% in 1900 (Graumann 1977). Urbanization is fundamentally transforming the world: most of the world’s largest cities are now in Asia, not in Europe or North America. U.N. projections suggest that urban populations are growing so much faster than rural populations that 85% of the growth in the world’s population between 2000 and 2010 will be in urban areas and virtually all of this growth will be in Africa, Asia, and Latin America. Moreover, most of these new urban dwellers are likely to be poor, resulting in the increasing urbanization of poverty. Slums are a physical and spatial manifestation of increasing urban poverty and intra-city inequality.

Slums, like poverty, are multidimensional in nature. Some of the characteristics of slums, such as access to physical services or density, can be clearly defined, while others such as social capital cannot. UN-Habitat proposes that a person whose living conditions suffer from at least one of the following five characteristics is be considered a “slum dweller”:

- inadequate access to safe water,
- inadequate access to sanitation and other infrastructure,
- poor structural quality of housing,
- overcrowding, and
- insecure residential status.

Based on these criteria, it is estimated that currently over 900 million people—roughly one third of the world’s urban population—live in slums. More than 70% of the urban population in least industrial countries and sub-Saharan Africa (UN-HABITAT 2003) lives in slum-like conditions. This number is set to increase to roughly 2 billion by 2020 unless current trends change substantially. The challenge is particularly acute in sub-Saharan Africa, where urbanization proceeds at a very high pace.

Of course, these projections are fraught with uncertainty, but they suggest that in addition to improving the lives of 100 million

slum dwellers an incremental urban population of up to 1.1 billion who may otherwise end up living in slum-like conditions will need to gain access to decent housing, adequate infrastructure, and basic services. While achieving this target can have important benefits for HWB in urban areas, it is not clear to what extent it will have an impact on the rate of urbanization. On balance, it seems most likely that cities will continue to grow rapidly, so that by 2020, approximately 4.2 million people corresponding to 56% of the world’s population will live in urban areas (UN 2001; UN 2002).

#### 19.2.10.2 Dependencies

An analysis of the linkages between slum formation or urbanization more broadly and ecosystem services is best disaggregated according to spatial dimensions. MA *Current State and Trends*, Chapter 24, distinguishes interactions between urban systems and (1) ecosystems contained within the urban areas; (2) adjoining non-urban ecosystems; and (3) distant ecosystems. Urban systems including slums depend on a number of ecosystem services, which they consume. In turn, urbanization and the achievement of the slum dwellers target will impact on ecosystems, as summarized in Table 19.16.

As shown in MA *Current State and Trends*, Chapter 24, urbanization is not inherently bad for ecosystems. For example, urban centers can facilitate human access to ecosystem services through, for example, the scale economies of piped water systems. While urban demographic and economic growth increases pressures on ecosystems globally, the same demographic and economic growth would probably be even more stressful if the same people, with similar consumption and production patterns, were dispersed over the rural landscape. Urbanization usually reduces the demand for land relative to population. Indeed, the world’s current urban population, corresponding to half the total population, would fit into an area of 2,000,000 square kilometers—roughly the size of Senegal or Oman—at densities similar to high-class residential areas in European cities (Hardoy et al. 2001).

The relatively lower per capita demand for ecosystem services of people with a given consumption and production pattern tends to have the highest effect on distant ecosystems. Meanwhile, adverse environmental impacts of urban systems are mostly confined

**Table 19.16. Ecosystem Services Contributing to Improving the Lives of Slum Dwellers**

Ecosystem Services in and around Urban Areas Contributing to Meeting the Slum Dwellers Target	Ecosystems Directly Influenced by Improving the Lives of Slum Dwellers
provisioning services • provision of food, clean water, construction materials, and other ecosystem services	ecosystems within urban areas (for example, grasslands and freshwater ecosystems)  freshwater, coastal, and marine ecosystems (through increased water withdrawal and water pollution)
regulating services • alter filtration and purification • provision of clean air • provision of a healthy urban environment	ecosystems adjoining urban areas (through urban expansion, water and air pollution)
cultural services • recreational • cultural heritage	agroecosystems and other ecosystems further away from urban systems (through demand for food and other ecosystem services)

to ecosystems within cities and towns as well as the immediate hinterland. In general, the most critical environmental burdens of slums and cities tend to be local, such as inadequate and unsafe piped water supply, lack of proper sewerage and storm water drainage, insufficient garbage collection and disposal, indoor air pollution that results from burning biomass, poor health care services, etc. (Bartone et al. 1994; McGranahan and Songsore 1994). As a result, adjoining ecosystems and those contained within urban systems experience increased pressure and stress with rising urbanization and slum formation. For example, increased demand for water and rising levels of water pollution caused by cities and slums in particular have adverse effects on freshwater and coastal ecosystems surrounding urban centers.

The most extreme forms of environmental degradation tend to be found in slums. Chronic pollution of water sources, high disease prevalence and deterioration of public health conditions are common features in many of these illegal urban settlements. In addition, many slum dwellers reside in protected and/or fragile areas such as protected watersheds, wetlands located next to rivers and lagoons, steep hillsides vulnerable to landslides and soil erosion, and mangroves and valleys subject to flooding or tidal inundation. Table 19.17 summarizes the dependencies, as well as the interventions, synergies, and trade-offs for MDG target 11.

### 19.2.10.3. Interventions

Meeting target 11 will require a combination of slum upgrading and prevention of the formation of new slums. Slum upgrading refers to the provision of basic services such as solid waste disposal, improved infrastructure including water supply and sanitation, and improvements in housing. In many cases, successful slum upgrading requires considerable improvements in the security of tenure extended to and perceived by the slum dwellers. In addi-

tion to producing dramatic improvements in HWB, slum upgrading can lessen pressure on freshwater ecosystems, grassland, forests, and other ecosystems found within urban areas. As a result, critical ecosystem services such as water purification and disease control can be maintained and will contribute to improved human health.

In some instances, improving the lives of slum dwellers may require the negotiated relocation of urban populations away from fragile land such as steep slopes or floodplains and other vulnerable or protected ecosystems within urban areas. Such carefully planned interventions can generate important improvements in HWB within cities provided that the communities concerned are closely involved in the preparation, negotiation, and execution of resettlements.

Preventing the formation of new slums will require a broad range of interventions targeted at making land available at minimal cost to low-income households, improving urban planning and design, and providing adequate access to basic services as well as infrastructure for transport, energy, water supply, and sanitation. Managing the spatial layout and design of urban agglomerations can help reduce pressure on vulnerable ecosystems such as adjoining wetlands, riverbanks, or steep slopes.

### 19.2.10.4. Conclusions

On balance, meeting target 11 will have profound and positive effects on ecosystems and their services found within and adjoining to urban areas. Further preventing the formation of new slums is likely to have an even greater impact on ecosystems and their services through improving the urban environment and reducing pollution of water and air. The overall impact of target 11 on rates of urbanization and total urban demand for ecosystem services is likely to be limited since the targeted 100 million slum dwellers

**Table 19.17. MDG 7, Target 11: Dependencies, Interventions, Synergies, and Trade-offs for Improving the Lives of Slum Dwellers**

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Improving the lives of slum dwellers	no dependencies exist	provision of secure tenure extension of urban infrastructure provision of basic services (for example, solid waste disposal, transportation, protection services) improved and strengthened institutions for urban management and planning	slum dwellers will have stronger incentives to invest in the improved management of the urban ecosystem (for example, through improved sanitation) improved sanitation combined with water treatment can help control water pollution improved waste disposal can reduce pressure on urban and related water ecosystems improved institutions for urban management will strengthen slum dwellers' voice in local decision-making; as a result local deterioration in ecosystem services will figure more prominently in decision-making	impact of urban infrastructure (for example, transport and energy) depends critically on design and implementation; negative impacts can occur if environmental needs are not taken into account at the outset reduced availability and higher prices for the local poor

account for only a relatively small share of the total urban population.

### **19.2.11 MDG 8: A Global Partnership for Development, Targets 12–15**

#### **19.2.11.1 Introduction: The Link between MDG 8 and Ecosystems**

The MDGs are meant to address the central challenge we face today—“to ensure that globalization becomes a positive force for all the world’s people.” Globalization is a multifaceted collection of processes, a central part of which is the expansion of world trade and technology. A more open and fair trading system can expand developing countries’ growth rates, providing revenues needed to finance MDGs 1 through 7. But least industrial countries, including many landlocked, small island, and highly indebted nations, lack the basic health, education, and infrastructure capacities needed to adequately access expanded markets and make the most of more open trade regimes. Table 19.18 summarizes the dependencies, interventions, synergies, and trade-offs for targets 12 through 15.

#### **19.2.11.2 Target 12: Develop Further an Open Trading and Financial System: Including a Commitment to Good Governance, Development, and Poverty Reduction, both Nationally and Internationally**

What do ecosystems have to do with this? How are ecosystem services essential to reaching MDG 8, and how may achieving MDG 8 affect ecosystems? Of the 1.2 billion people living in extreme poverty on less than \$1 per day, approximately 900 million live in rural areas and are thus highly dependent on primary sector economic activities such as agriculture, forestry, and fisheries. Access to markets and expanded trade can lead to increased incomes for these communities, and greater revenues for developing countries to achieve MDGs 1 through 7. Meanwhile, high agriculture subsidies in the industrialized world continue to distort global market dynamics and promote unsustainable forms of agriculture in many developing countries, instigating a cycle of land degradation and loss of ecosystem functions.

But the critical link between MDG 8 and ecosystems is by no means limited only to those in extreme poverty. There is no question that further increases in growth and trade expansion is required to raise the incomes needed for poverty reduction, food security, etc., particularly in least developed, landlocked, and small island nations. However, the aggregate consumption levels of an expanded global consumer society could soon push critical aspects of the planet’s life support system over an “ecological cliff.”

Equal attention should be placed on countries that may be progressing well toward the MDGs’ social and economic development goals, but in the process are having a relatively larger impact on global ecosystem functioning. Areas of high biodiversity and critical global ecosystem functions are often located in or severely affected by such countries. The industrial and developing countries within WTO that are involved in expanding global trade patterns, including Brazil, China, the European Union, India, Indonesia, Japan, Russia, the United States, and various other countries increasingly drive global ecological change through their trade policies.

##### *19.2.11.2.1 Policy interventions to achieve target 12 and maintain ecosystem services*

The main factor for understanding the link between trade and ecosystem services relates to the problem of scale. Unchecked,

today’s global economy may be five times bigger only one generation or so hence. Our challenge today is to expand international trade in a way that does not cause irreparable harm to global ecosystems. Notable improvements in the efficiency of production and consumption patterns will be necessary, in both industrial and developing countries.

The focus of target 12 is not only on more open trade but also on the rules required to manage such trade with equity and sustainability, through a process of good governance. What communities need is the space to shape their own path to HWB. The drive toward expanded growth and trade brings marked changes to local culture, often relegating traditional local knowledge of HWB and ecosystems to the background. The ability to engage excluded communities in the process of globalization will largely depend on means by which traditional knowledge systems can be integrated into local growth and human development strategies. It will also involve greater engagement of the private sector in this process of creating an inclusive form of globalization, as market-based development becomes an increasing reality.

##### *19.2.11.2.2 Trade-offs between human development and ecosystem services*

The extent to which ecosystems services are disrupted is an outcome of policy options, clear trade-offs, and choices. The expansion of trade is often based on the assumption that environmental impacts will be corrected for as affluence and investments in sustainability increase. But direct links between rising incomes and improved environmental protection is only relevant for certain types of pollution, and does not apply to many critical ecosystem services such as biodiversity and climate regulation, both of which appear to be proportional to rising consumption levels. In this regard, proactive regulation is needed to avoid undesirable ecological feedbacks, recognizing the value of such services for underpinning human welfare. Recent estimates place the value of the world’s ecosystems to be more than the total value of the world’s economy. There is a need to use ecological valuation methods to account for the economic values of ecological services ignored by markets.

Where trade-off mechanisms fall short, the challenge is to ensure that a minimum level of “ecological security” is maintained, based on scientific knowledge of HWB/ecosystem service linkages, and preserved without trade off. This would be critical to ensure a long-term, minimum level of ecological stock to meet basic human development. Such an ecological security system could be integrated into trade and finance policies.

#### **19.2.11.3 Targets 13–15: Address the Special Needs of Least Developed Countries, Landlocked and Small Island Developing States, and Heavily Indebted Poor Countries**

Most least developed countries rely heavily on agriculture for their socioeconomic well-being, making them directly dependent on ecosystem services, particularly land and water sustainability. Many least developed countries suffer from a lack of options beyond improving agriculture due to various barriers—inaccessible markets, lack of infrastructure, lack of private investment, and underdeveloped value-added industries, to name a few.

Achievement of targets 12 through 15 would reduce tariffs and subsidies in agricultural products, but even with more open markets, many communities may well remain excluded from the losses and benefits. Least developed countries, particularly landlocked and small island states, are geographically isolated from large markets, and lack the infrastructure needed for expansion. Furthermore, many least developed countries now suffer from se-

Table 19.18. MDG 8, Targets 12–15: Dependencies, Interventions, Synergies, and Trade-offs for Global Partnerships

Target	Dependencies on Ecosystems for Achieving Target	Interventions	Links to Ecosystems and Ecosystem Services	
			Synergies (benefits to ecosystems/ecosystem services)	Trade-offs (threats to other types of ecosystems/ecosystem services)
Rule-based trading and financial system	<p>global trade includes significant level of products and services derived directly or indirectly from ecosystem goods and services</p> <p>global growth depends heavily on carrying capacity of planet and ability of trading system to adapt to temporary or permanent disruptions in ecological goods and services</p> <p>negative feedbacks can damage sustainability of such systems, thereby jeopardizing long-term global economic system</p> <p>global, regional, national, and local trade flows are dependent on natural flows of ecosystem goods and services, both of which are changing rapidly</p> <p>many developing countries rely increasingly on foreign direct investments for growth in trade and finance</p> <p>multinational corporations have an increasing dependence on ecosystem services that may affect the sustainability of the goods or services they produce or trade</p> <p>with increasing role in global and national governance processes, multinational corporations also play a significant role in making trade-offs between commercial and ecological values</p>	<p>global and national decision-making processes whereby more just and effective trade-offs can be made between socioeconomic and ecological values, including expanded role for civil society in decision-making processes</p> <p>include use of ecological valuation methods for making trade-offs in decision-making processes</p> <p>integrate an ecological security system, whereby minimum required level of ecosystem services can be protected without trade-off, to ensure basic human well-being in long-term</p> <p>include approaches to map trade flow–ecosystem service flow links and areas where high trade growth rates collide with critical ecosystem services</p> <p>build partnerships among business, government, and civil society to integrate ecosystem approach into investment planning at macro (industrial trade policy) and micro (foreign direct investment project) levels.</p> <p>establish local learning forums among businesses and partners to develop and use benchmarks and indicators for monitoring ecosystem service issues and exploring lessons for achievement of human well-being</p>	<p>improved well-being in terms of non-income aspects of poverty related to exclusion</p> <p>provides decision-makers with quantitative ability to compare choices with resulting increases chance of preserving critical ecosystem services in the long-term</p> <p>trade-offs and choices may well lead to degradation of ecosystem services; however, core ecosystem services can be preserved</p> <p>addresses fact that ecosystems know no political and trade boundaries so that decisions may be taken with reference to local and global scales of ecosystem service and impact</p> <p>reduces risk of conflict among business and civil society if ecosystem services valuable to their well-being are sustained</p> <p>ability to gauge drop in ecosystem services related to business decisions and take corrective actions</p>	not applicable
Special needs of least developed countries	LDCs, including landlocked and small island states, have high dependence on agriculture and related ecosystem services	synergies in official development assistance and debt relief programs to ensure ecosystem approach for infrastructure and agricultural expansion initiatives, including strategic ecological assessment methods for infrastructure, and sustainable land management measures to ensure sustained productivity to stay out of debt traps.	prevention of costly or irreparable change to least developed country ecosystems	not applicable
Landlocked countries, small island countries	these countries lack infrastructure (irrigation, energy, roads, etc.) needed to take advantage of expanded markets from a drop in tariffs and subsidies in industrial countries	integrate ecosystem approach into other macro (structural adjustments, poverty/human development strategies) and micro-level (local ODA projects) interventions	more sustainable land and water use has benefits related to other ecosystem services as well.	
Debt sustainability	these countries are burdened by land and water stress caused by unsustainable agriculture from decades of low market access			

rious land and water stresses, and these may well increase should the pace of global change increase. And open markets are not enough—increased official development assistance and real debt relief are required to help finance new infrastructure, and address land and water issues. Considerable opportunity now exists to synergize new ODA, debt relief, and innovative “debt for MDG” swaps to ensure that these issues are addressed side by side.

MDG 8 serves to re-focus attention on rural agriculture as a vital part of achieving human development. This includes increased coordination of ODA to nationally designed and executed MDG programs. Such programs should use strategic ecological assessment methods to improve the likelihood of long-term benefits. This would be relevant at macro- (national structural adjustments and poverty reduction/human development strategies) and micro-levels (local ODA-financed projects).

ODA should focus on agricultural sustainability, as well as infrastructure needed in least developed countries to take advantage of increased market access. New infrastructure will be required, but should be developed in a way that integrates ecosystem approaches into grant and lending processes through strategic ecological assessment methods. Sustaining agricultural outputs will depend on sustainable land and water use, in turn depending on an array of governance issues—secure access to land, water, and local markets; access to market information; rural enterprise development and credit; and safety-net policies to adapt to market reform.

### 19.3 Multi-goal Analysis

The Millennium Development Goals strive to improve human well-being. Ecosystems provide many of the services needed to meet these goals, and many ecosystem services and MDGs are interlinked and interdependent. The previous section considered a goal-by-goal analysis. Here we consider a multi-goal analysis. Table 19.19 illustrates all MDGs and targets, and the ecosystem services needed to achieve those targets. Where there exists a positive or negative impact, each cell is highlighted in black. General trade-offs and synergies associated with achieving the 2015 target are analyzed.

#### 19.3.1 Crosscutting Analysis

##### *How does meeting the target of one or more of the MDGs affect the ability to meet all 2015 targets?*

Achieving target 9 is essential to simultaneously achieving targets 1, 2, 5, 7, 8, and 12–15, as depicted in Table 19.19. Target 9’s emphasis on integrating principles of sustainable development corresponds with direct investment in supporting, provisioning, regulating, and nonmaterial services. Ultimately, simultaneous contributions will occur with reduced hunger, child deaths, and disease, and an increase in income levels, trade, and reduced debt.

##### *Can all the targets be met simultaneously?*

Meeting all the targets simultaneously may be possible if ecosystem services are maintained and/or protected (in particular provisioning, supporting, and regulating services) and if institutional capacity building and good governance are initiated. Capacity building and good governance are essential in achieving the 2015 targets and, in particular, essential to those targets not directly related to ecosystem services. These targets include gender, education, maternal mortality, youth employment, and access to medicines and technology. By incorporating principles of sustainable development into national policies and by integrating MDG

programs into country strategies such as poverty reduction strategy papers, institutions can be created to address the above targets.

##### *How dependent are the 2015 targets on ecosystems and ecosystem services?*

Targets 1, 2, 5, 7–9, and 12–15 are directly dependent on ecosystem services. It is well-established that these targets cannot be met without essential ecosystem services such as primary production and nutrient cycling, food, water purification and regulation, and erosion control. These benefits and more are the very basics of survival.

By investing primarily in provisioning, supporting, and regulating services, the targets most likely to be achieved simultaneously by 2015 are targets 1, 2, 5, 7–9, 12–15. The synergistic effects of investing in these three ecosystem services are noted among reducing poverty, hunger, child mortality, disease, opening trading systems, least developed countries, land locked/small island states and LDC debt. In terms of MDG 1 (eradicating extreme hunger and poverty), expanded agricultural production, more inputs, and new technologies such as precision farming will be required to increase crop yield and promote rural and non-rural employment. Achieving target 9 requires incorporating sustainable agricultural policies in areas of international trade and restoration and rehabilitation, and training programs to yield greater productivity. With investment in supporting, provisioning, and regulating services, this will ensure ecosystems are maintained to provide resilience and production while increasing quality of life.

Targets 4, 6, 7, and 12–15 require financial and institutional investment in supporting, provisioning, and regulating services. The synergistic effects of establishing such investment involves increasing life expectancy, establishing new markets, reducing debt and increasing financial instability and contributing to capacity building for decision-making.

The trade-offs incurred by investing in supporting, provisioning, and regulating benefits include fewer initiatives in policies and programs that would be created for nonmaterial benefits. Nonmaterial benefits provide important meaning to many individuals in society. In addition, employment is generated through such services as recreation and ecotourism. In achieving the 2015 targets, however, priority in provisioning, supporting, and regulating services may be substantial in achieving the 2015 targets. These services are essential to the poor for ensuring entitlements.

A major trade-off is also incurred in infrastructure development. Most developing societies will require infrastructure to ensure public facilities, distribution channels including roads and ports, and other building structures. Policies targeted at infrastructure development may alter natural ecosystems and decision-makers will have the difficult task of ensuring sustainable principles and practices are captured.

##### *How can knowledge of the dependency on ecosystems to provide the services help to achieve the 2015 targets?*

Decision-makers have a challenging task of ensuring that the products and services that the ecosystem provides are constantly available and maintained while ensuring good governance and institutional capacity building. Understanding the benefits and the roles of regulating, provisioning, and supporting services provides decision-makers with the opportunity to:

- maintain natural ecosystems through sustainable practices to ensure food and water are readily available for distribution;
- invite new institutions and organizations to aid in the maintenance of ecosystem services and institutional capacity building;





- create new markets for local and foreign investors and create employment for rural and non-rural people;
- ensure the protection of ecosystems such as watershed protection to contribute to disease regulation and fresh water so that children in particular will live much longer to contribute to their developing societies;
- invest in technologies that are efficient, nonpolluting, and cost-effective, such as wastewater treatment technology and solar and wind technology;
- initiate policies and programs that provide fuel such as biogas that will benefit women through less physical labor and provide more access to communication systems;
- initiate policies and programs that reduce deforestation through agricultural intensification and invest in nursery planting and restoration programs to achieve a multitude of benefits including climate regulation and medicinal products.

#### ***What are the respective roles and responsibilities of industrial and developing countries in achieving the 2015 targets?***

Principle 7 of the Rio Declaration identifies that the industrial world must acknowledge its considerable consumption and exploitation of natural resources. The industrial world, therefore, can initiate policies and plans that acknowledge its role in minimizing ecosystem services and identify strategies to achieving the 2015 targets. This will include contribution to monitoring, research, and analysis in both industrial and developing countries, which can be conducted through existing institutions and governance structures.

Developing countries will benefit in achieving the 2015 targets by ensuring plans and policies geared at achieving the 2015 targets are integrated vertically and horizontally into national policies such as PRSPs and within governance (*high certainty*).

#### **19.3.2 Trade-offs and Synergies**

Meeting the MDGs by 2015 may cause time trade-offs. The trade-offs listed below are more concerned with achieving the 2015 deadline than with ensuring sustainable methods of achieving the MDGs. The trade-offs include:

- As identified above, meeting the food target for MDG 1 by 2015 through unsustainable changes in production such as the increase in use of pesticides and rapid agriculture intensification may meet the target; however, there will be more stress on the environment and people's livelihoods. Therefore, "leapfrogging" toward sound ecological sound production techniques and approaches is needed.
- Plans to achieve all the MDGs by 2015 could be "rushed," requiring decision-makers to look for policies that are "one size fits all." Policies will differ according to the regions in question and therefore a "one size fits all" approach could be detrimental to specific ecosystems.
- Plans to achieve MDG 1 through increasing fish aquaculture by 2015 is one way of increasing fish stocks and reducing hunger; however, it may also lead to the depletion of various fish species since aquaculture breeding requires fish as a food resource.

Correspondingly, general synergistic effects include:

- Investing in watershed protection means benefits to drinking water and less water-borne disease such as malaria, etc.
- Intensification instead of extensification of agriculture means reducing expansion of agriculture into forests and the benefits of doing so include maintenance of resources such as medicine and other services such as climate regulation.

- Providing fuel such as biogas for households will benefit women through less physical labor, as there will be less indoor and outdoor pollution.
- Increase in access to safe water means healthy and more hygienic environments and people.

#### **19.3.3 Direct and Indirect Impacts**

The fulfillment of the 2015 targets (more specifically, of the interventions made to reach the specified targets for each goal) will have varied impacts (positive and negative) upon ecosystems and their resources. Conversely, the current state of the ecosystems and the availability in quantity and quality of their services may put additional constraints to, as well as provide opportunities for, the achievement of the 2015 targets.

The impacts of achieving the 2015 targets upon ecosystems and their services well include *direct effects* of the interventions made, for example, to build schools or apply agrochemicals) but also a plethora of *indirect effects* associated with more diffuse processes (such as capital investment and redistribution, changes in trade, transportation, economic growth, changes in expectations), potentially affecting the fulfillment of all goals and the state and dynamics of many ecosystems and resources. These processes are also likely to imply a higher throughput of materials through the world economy, as well as increased energy consumption, resulting in higher demands for ecosystem services.

While the specification of the indirect impacts is not feasible within the time and resource constraints of the MEA (and perhaps also in principle), those impacts will be very real and must be included as part of the ecosystem implications of fulfilling the target. Target 8, in particular, will have mostly indirect impacts upon ecosystem services.

Regarding the direct impacts, it is important to note that in general they are not defined by the goals themselves, not even by the targets, but by the specific menu of interventions chosen to fulfill them. In other words, for many goals, there are degrees of freedom in the selection of interventions and their relative weight; therefore, different strategic choices will have different balances of negative to positive impacts. In the same vein, different regional and local contexts will require different combinations of interventions to fulfill the goals. In general, it is possible to organize in all ecosystems interventions such that win-win situations are attained. Sustainable intensification may explicitly address MDG 1, targets 1 and 2 has neutral effects on MDGs 2 through 6, and will have positive effects on MDG 7. It is possible to look explicitly for such situations and reduce or limit negative effects on ecosystems.

### **19.4 Discussion**

Clearly, achieving each 2015 target requires a multitude of inputs, while in turn each input can contribute to more than one goal. In their current formulation, the MDGs do not set explicit targets for several broad categories of inputs that are critical for their achievement. Examples include good governance, secondary education, and energy and transport services. Since the latter two exhibit strong dependencies and trade-offs with ecosystem services, they are discussed briefly here.

#### **19.4.1 Energy Services**

Improved energy services are a necessary input for achieving most MDGs. In many cases a shift toward modern sources of energy such as clean fuels for cooking and space heating, as well as electricity, is required for meeting the following goals: 1 (eradicating

extreme poverty and hunger), 3 (promoting gender equality and empowering women), 4 (reducing child mortality), 5 (improving maternal health), and 7 (ensuring environmental sustainability).

At the household level, clean energy can improve health and general well-being, particularly of women and children, by lowering indoor-air pollution levels associated with the use of biomass and solid fuels, which currently account for 1.6 million deaths each year—a death toll that exceeds the global health burden caused by malaria (WHO 2002). Improved energy services also reduce the burden on women and young girls who often spend several hours each day gathering biomass for cooking and thus free up time for their participation in education and income-generation activities. It follows that energy services are central to the achievements of the 2015 targets even though no individual goal addresses them explicitly.

Energy supply in low-income countries depends critically on the provisioning services such as primary production of firewood and other biomass, provided by a broad range of ecosystems including drylands, forests, and cultivated ecosystems. Worldwide, 2.4 billion people burn wood, charcoal, dung, or crop residues for cooking and heating (International Energy Agency 2002). In many poor countries, biomass accounts for 90% of household energy consumption. Hence, ecosystem services not only sustain energy supply in low-income countries, but they are also critically affected by the predominant choice of energy carrier and aggregate consumption levels.

A lot of controversy has surrounded the link between fuelwood use and deforestation (MA *Current State and Trends*, Chapter 9). While the relationship between both is extremely complex and data continue to be sparse, recent evidence suggests that the extent of deforestation caused by wood-based energy services is less severe than thought in the past (Arnold et al. 2003). Global demand for fuelwood appears to have peaked, while demand for charcoal continues to grow in many areas. In Africa and South America, the combined per capita consumption of wood and charcoal is stagnating while it is declining in most parts of Asia (Arnold et al. 2003).

These aggregate figures, however, mask important local variation. Particularly in the vicinity of urban areas, where total consumption of charcoal and wood is high and continues to increase in line with rapid population growth, the impact on ecosystems and the services they provide can be very severe. In light of rapid growth of urban populations in Africa and most other parts of the developing world, this problem is likely to be exacerbated over the coming years.

To meet the 2015 targets, access to improved cookstoves and adequate ventilation of homes and kitchens will need to be improved. In the medium term, the transition from biomass and other solid fuels toward improved fuels or solar efficient technology will need to be accelerated through improving access to liquid petroleum gas and other fuels that result in lower indoor air pollution. This shift will be necessary to meet several 2015 targets, including the ones on health, gender equality, and environmental sustainability, while at the same time providing a sufficient energy supply for expanding per capita consumption as incomes and rates of urbanization continue to grow on low-income countries. Critically, moving up the energy ladder will lessen the growing pressure on ecosystems that provide fuel for rapidly growing cities.

Perhaps the most important global impact of energy consumption is long-term climate change caused by unsustainable emission levels of greenhouse gases. While most of these emissions are caused by rich countries, emission levels in many developing countries are growing rapidly. However, per capita energy consumption in the “top priority” and “high priority” countries

identified in the *Human Development Report 2003* continues to be only a fraction of rich countries’ consumption levels (UNDP 2003). Shifting toward fossil fuels in these countries, though not desirable in the long term, will not have any substantial effect on global emissions of greenhouse gases. In cases where renewable non-biomass energy sources such as solar or hydro are not available and commercially viable, the shift away from biomass toward cleaner fossil fuels for cooking and heating in low-income countries can help reduce pressure on ecosystems.

#### 19.4.2 Transport Services

Improvements in transport services such as road and rail transport, shipping services, as well as air transport, play an important role in meeting the 2015 targets. These services are required to provide effective access to social services such as emergency obstetric care; lower the household transport burden and reduce time poverty, especially of women and young girls; reduce the cost of agricultural inputs and raise farmgate prices for produce; facilitate the creation of export-based manufacturing and service industries including tourism; and increase the size of the captive market for the local private sector by lowering transport costs. In summary, improved transport services are necessary for achieving the 2015 targets including target 1, reducing income poverty.

It is no coincidence that many of the regions that are furthest away from meeting the 2015 targets also have extremely low levels of transport infrastructure. For example, sub-Saharan Africa has a mere 0.23 kilometers of paved roads per 1,000 people, while the average road density for South Asia is 1.08 kilometers per 1,000 people. Combined with the small size of African vehicle fleets, this results in transport costs that are much higher than in typical Asian countries and constitutes a major obstacle to reducing poverty.

Improving transport services to meet the 2015 targets will require substantial public investments in transport infrastructure, including roads, ports, and rail networks. Such investments will need to be complemented by policies and institutions that promote the promulgation of motorized vehicles and intermediate means of transport such as bicycles, animal carts, etc. For example, effective access to microcredit can play a critical role in improving access to means of transport.

However, improved transport infrastructure can have adverse impacts on ecosystems and the services they provide through ecosystem fragmentation, the opening of ecosystems to human settlement and exploitation, or increases in transport-related emissions of greenhouse gases. In particular, the construction of new road networks into areas of high biodiversity with very low human population densities (for example, tropical forests in the Amazon, Congo basin, Borneo, etc.) is likely to lead to an accelerated degradation of these ecosystems and their services. In comparison, the upgrading of roads in relatively densely populated areas consisting predominantly of cultivated ecosystems is likely to have limited adverse environmental impacts.

In all likelihood, this trade-off between HWB and the protection of ecosystems cannot be easily overcome and therefore needs to be managed appropriately to balance between the competing needs of humans and the environment. One way of achieving this is through environmental impact assessment in which the trade-offs of construction and upgrading of transport infrastructure is examined. This can be achieved through subjecting the construction and upgrading of transport infrastructure to environmental impact assessments.

#### 19.4.3 Strengthening Capacity for Policy-making

Response options in this chapter have been identified as interventions under each goal. Essentially they are interventions that en-

courage education and knowledge sharing and direct investment or expenditure. In conjunction with those interventions identified by the United Nations Millennium Project, each will depend on the capacity of local and national governance and institutions to execute them (Chapter 4).

An important finding of the MA *Scenarios* is that while ecosystem goods and services will decrease globally, HWB will generally increase in all the scenarios (MA *Scenarios*, Chapter 13). A major reason for a global increase in HWB is due to strengthened institutions at various scales (MA *Scenarios*, Chapter 11; MA *Current State and Trends*, Chapter 28). In particular, the strengthening of local governance can lead to avoiding loss of ecosystem services and biological diversity, through the implementation of effective monitoring systems (MA *Scenarios*, Chapter 14).

Strengthening institutions and governance is also positively correlated with improvement of performance within the private sector, service delivery sectors, and macroeconomic management (World Bank and IMF 2004). Achieving the 2015 targets, therefore, depends on the capacity of institutions and governance to effectively implement interventions that will most likely aid in achieving the 2015 targets (*high certainty*).

Addressing the goals collectively may require an integrative approach in which policy linkages are drawn horizontally and vertically, within ministries and agencies and across stakeholders from civil society, government, and private sector. (See Chapter 14.) It would also mean that the trade-offs and interventions associated with each goal are addressed by all stakeholders and endorsed into policy- and decision-making.

It is also well-established that achieving the 2015 targets will require existing institutions and governance structures in the developed world to address and execute immediate concerns affecting ecosystem services such as overconsumption.

## 19.5 Conclusion

The MDG chapter established the importance of ecosystem services to HWB in terms of specific goals, primarily poverty, hunger, gender, child mortality, disease, and water. Goals such as education, maternal mortality, sustainable development, and global partnerships have less direct links to ecosystem services.

The goal-by-goal analysis provided a qualitative assessment of how ecosystem services will respond to interventions. The list of trade-offs and synergies identified in the multi-goal analysis highlights the positive and negative impacts on ecosystems, services, and people of achieving the goals.

### 19.5.1 Specific Conclusions

- The achievement of targets 1 and 2, of MDG 1 (eradicate extreme poverty and hunger), is probably the best condition for maintaining ecosystems. Appropriate use and management of ecosystems requires the breaking of unsustainability spirals due to poverty.
- MDGs 2 through 6 are only indirectly affected by ecosystem services and ecosystem management. These indirect effects are, however, very important for the well-being of humans and that has considerable impact on the functioning of ecosystems and their continuity.
- MDG 7 is directly related to management of ecosystems. The chapter shows how various human activities such as energy use, transport, mobility, food production, etc., affect ecosystems. A drastic increase of efficiency in the use of land, energy, and natural resources is required to change the mega trend of enormous increase of the use of scarce resources. Many exam-

ples in the chapter illustrate the way ecosystems may be utilized to fulfill human objectives, but careful management and clear political choices at all integration levels are then required.

### 19.5.2 Key Messages

- The goals are inherently linked (whether directly or indirectly) to ecosystem services. The management of ecosystem services and the drawing of continuous links to HWB will therefore provide synergistic effects that will aid countries and regions of the world to get back on track to meeting the goals (*high certainty*).
- The interventions identified within the goal-by-goal analysis to reduce natural resource degradation and protect ecosystem services are key to achieving the MDGs. The final impact of fulfilling the goals will depend upon the specific menu of operational options (interventions) selected, and upon the ecological and societal local context. Some interventions, however, are more sustainable than others.
- The achievement of the MDGs will be dependent on the interventions used, the social and ecological context, and the consideration of spatial and temporal issues. For example, labor-intensive employment may lead to a reduction of poverty and extreme hunger in specific regions of the world such as Africa. The achievement of various MDGs is working in the same direction. To produce more with less is doable, but needs political will and support of the political leaders.
- Some interventions will provide considerable intensification. At present, there is no action plan to reach these MDGs. The various task forces that report next year may help, but for MDGs 1 and 7, the MDG panel is willing to take the lead.

Knowledge gaps are evident within the findings. Strengthening local and national institutions and governance is one way to ensure the implementation of monitoring systems that provide data on specific indicators of ecosystem services.

### 19.5.3 A Research Agenda

As a result of our findings, a research agenda is proposed with the following priorities:

- The relationship between the MDGs and the MA should be explicitly addressed in studies and research programs; there should be a clear responsibility at the highest level of the United Nations to achieve this.
- The industrial world should contribute more to investigations, analysis, and research programs in developing countries; they can do this directly through research organizations and also by building new alliances (InterAcademy Council Report 1 and 2 2004)
- The following specific research issues should be addressed: (1) analyses and quantitative methodology should be applied to further define the relationship between ecosystems, ecosystem services, and HWB; (2) the relationship of energy, transportation, and ecosystem services toward meeting the MDG targets should be further explored; and (3) research should be undertaken on the resilience of ecosystems under pressure from overpopulation and/or increasing human drives for material goods.
- Studies aiming at systems innovation, including all aspects of ecosystems behavior, should be initiated for the most fragile and most threatened ecosystems. Specifically, research is needed in international agricultural research institutions on further use and intensification of agroecosystems with minimization of environmental side effects.

- Many examples of applied technology introduced in the 1900s should be reintroduced. It is now time for a considerable increase in the introduction of appropriate technology.

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