

Determinants of Ecosystem Change

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Abstract. While global population has doubled in the last forty years and overall economic activity increased nearly seven times between 1950 and 2000, the income per-capita almost doubled. As income per-capita increases consumption structure is changing, with the potential to influence the state of ecosystems and thus their ability to provide services. In the last fifty years, there have been significant changes in the determinants of socio-political forces that influence decision making. Changing ecosystem services is almost always caused by multiple determinants, which interact with one another. In addition, changes in ecosystem services can have a feedback effect, in turn influencing determinants characteristics. In fact, it is unrealistic to believe that there is the possibility of building a single conceptual model to capture all these influences.

Keywords: ecosystem change, indirect determinants, direct determinants

1. Introduction

Determinants are represented by natural and human factors that directly or indirectly cause changes in an ecosystem. Direct determinant unequivocally influences ecosystem. The indirect determinant acts more diffuse, by altering one or more of the direct determinants. According to MEA (2005), determinants are grouped as follows:

- Indirect determinants: population (demographic), economic, social and political factors, scientific and technological factors; cultural and religious factors;
- Direct determinants: climate change, use of fertilizers, land conversion leading to habitat change, invasive species and pathogens.

2. Indirect determinants

Global population has doubled in the last forty years and raised by two billion within the last twenty-five years. Currently, the world's population is nearly seven billion inhabitants. Analyzing population growth from the territorial perspective, we may easily recognize the decisive contribution of the developing countries to global mainstream. However, global assessment is difficult, because we face an unprecedented diversity in the case of the demographic situations of different regions and countries (figure.no.1).

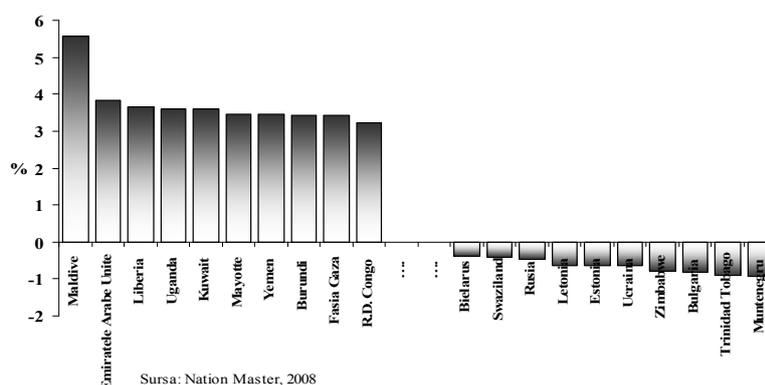


Figure 1. Countries with the highest and lowest growth rates in 2008

Some developed countries still waiting significant increases of their population (e.g. USA), while developing countries such as China, North Korea and South Korea recorded a downward trend of their growth rate. Regarding the average structural trends, the overall trend is the increasing of urban population. Since 2007, the urban population exceeded the rural population [Bran, 2007]. On the other hand, cities occupy less than 3% of the land, indicating expansion of congested areas. Regional rates of urbanization vary widely. In countries with high income urban population reaches 70-80% of the total. In some developing countries - such as the Asian countries - rural population predominates, while in Latin America is 75% of the urban population. Global population growth is expected to raise before the end of the twenty-first century some 10 million inhabitants. Global population growth rate peaked in the 1960s and is currently 1.18% (Table No. 1).

Table 1. World Population and average growth rates

YEAR	WORLD POPULATION (MILLION)	PERIOD	GROWTH RATE (%)
1950	2 516		
1955	2 751	1950-1955	1,77
1960	3 019	1955-1960	1,80
1965	3 334	1960-1965	1,94
1970	3 693	1965-1970	2,02
1975	4 076	1970-1975	1,94
1980	4 450	1975-1980	1,77
1985	4 837	1980-1985	1,76
1990	5 246	1985-1990	1,75
1995	5 713	1990-1995	1,54
2000	6 115	1995-2000	1,35
2005	6 512	2000-2005	1,26
2010	6 850	2005-2010	1,18

Source: Trebici, V. (1991), the population of Earth, Scientific Publishing House, Bucharest, page 61; 2007.

Within the next decades, the population growth will be concentrated in urban areas of the poorest Sub-Saharan Africa, South Asia and Middle East. Another process that becomes increasingly evident is the process of demographic aging. In the case of industrialized countries there will be the highest degree of aging, while in the case of developing countries will be an accelerated rate of aging.

Global **economic activity** increased nearly seven times between 1950 and 2000. Although in the same period there was a strong demographic growth, the income per capita almost doubled. This determinant strongly differs from the territorial perspective. As income per-capita increases, consumption structure is changing, with the potential to influence the state of ecosystems and thus their ability to provide services. Revenue growth reduces the proportion of expenditure on food and increased consumption of industrial goods and services. Also, consumers are changing the composition of their diet, by reducing consumption of starch (in the case of rice, wheat, or potatoes) and increasing the proportion of fat, meat, fish, fruits and vegetables.

Energy and material intensity, energy and materials consumed to produce one unit of economic result, tend to decrease with increasing of GDP per capita. In other words, energy and materials productivity increase, while improving macroeconomic productivity. However, from a historical perspective, productivity growth is lagging behind the economic growth. Therefore, energy and materials consumption increased in absolute terms.

Government intervention by domestic policy measures (taxes and subsidies) can have both economic and ecological importance in the case of the country that has been adopted them, but also in the case of other countries. Subsidies for conventional energy sources are estimated at USD 250-300 billion per year. In the period 2001-2003 agriculture was subsidized in the case of OECD countries with over 300 billion USD per year. OECD protectionism and subsidies have led to the cost of USD 20 billion, in the case of developing countries, determined by the loss of income from agriculture (MEA, 2005).

Policies that distort international trade flows may have negative economic consequences. Nations that have reduced trade barriers, having open economies, respectively and transparent government processes,

tend to have higher rates per capita income. International trade is an important source of economic gains as it allows the exploitation of comparative advantage and accelerates the diffusion of more efficient technologies and practices.

Socio-political determinants include forces that influence decision-making, including public participation in decision making, conflict resolution mechanisms, the state's role in relation to the private sector, the level of education and knowledge. In the last fifty years, there have been significant changes in socio-political determinants. This includes reducing the proportion of centralized authoritarian governments and increasing the proportion of democracy. Women's role in society is changing in many countries, the average level of compulsory education increases and civil society action intensifies (involving NGOs and other organizations in decision making).

The trend of institutions' democratization increased the power of local communities, women and poor households. There is an increasing involvement of nations in developing multilateral environmental agreements. The importance of the state in comparison with the private sector - as a supplier of goods and services, employer and as a source of innovation - is in decline.

To understand the **culture and religion** as determinants of ecosystem change, these must be seen in terms of values, beliefs and norms shared by groups of people. In this report, culture determines the individual perception of the world and influences what is important for people and suggests what the proper course of actions would be.

The formulation of generally accepted human behaviors had as starting point - in addition of facts and material evidence, beliefs and assumptions, forming the conception of the origin, organization, purpose and functioning of the universe - an external factor which requires a set of rules. Religion had and continues to exert a strong influence on individual and collective behavior, being the representation of the moral law "creator". Given such a strong influence, it is interesting to note how the human -environment relationship addresses the major religions practiced today.

Anthropocentrism of approaches from different religious cultures vary in significance in terms of "human being – environment" relationship from total domination to egalitarianism. Given the progress of science to identify objective relationships, religious perspective may seem obsolete, especially since the rationality became part of our way of being. However, religious faith should not be neglected. It is built into human conscious and subconscious, so that its influence remains strong today [Ioan, 2010]. The general comparisons of the cultures have not proved useful yet because they fail to capture the major differences of values, beliefs and norms. However, cultural differences have an impact on the direct determinants. Cultural factors can influence consumption patterns becoming a determinant with a decisive importance for the changes recorded in the services ecosystem.

The development and spread of **scientific knowledge and technologies** that exploit this knowledge has deep implications on ecological systems and human welfare. Twentieth century has witnessed great progress in understanding the physical, chemical, biological and social processes and applying this knowledge for the benefit of human being.

The increase of productivity by applying the research results and the new technology is estimated to be responsible for more than a third of the GDP growth in the U.S., the report is more favorable (up to two thirds), when taking into account OECD countries.

Science and technology impact on ecosystem services is most evident in the case of food production. Most of the increase in food production over the last forty years is due to improved yields and not to cultivated area expansion. The yields' benefits in the case of main crops are illustrative in this respect: 208% for wheat, 109% for rice, and 157% for corn.

Unintended effects of technological progress manifests stronger and stronger. This means in most cases, degradation of ecosystem services. The eutrophication accelerated by the use of chemical fertilizers, the occurrence of some extremely contaminated areas (as seen in Box No. 1), waste accumulation, marine fish and mammals populations' diminishing, changing hydrological regime, climate change are just some of the environmental issues that are associated with widespread application range of modern technologies.

- Mercury poisoning – the “*Minamata*” disease
 - Residents of Minamata Bay on the coast of Kumamoto (Japan) have used fish that lived and fed in waters contaminated with mercury. The concentration of mercury reached the toxic level only in the case of the final consumer: the human body
 - Bratsk, Russia: Chikanovskiy was released in 2001, life expectancy - 44 years
- Lead poisoning
 - Tianying, China: one of the largest producers of lead, where the lead concentration is 8.5 to 10.0 times the maximum permissible concentrations
 - Haina, The Dominican Republic: a reprocessing facility for lead-based batteries
- Cadmium poisoning, the “*Itai-Itai*” disease (“flaky” bones)
 - Contamination with cadmium within the river basin of Jinzu, Toyama Prefecture;
 - La Oroya, Peru: polymetallic smelter

Source: Blacksmith Institute (2007), The World's Most Polluted Place, www.blacksmithinstitute.org

3. Direct Determinants

For terrestrial ecosystems over the past fifty years the most important direct determinants of ecosystem change is land use change, particularly conversion of land for agriculture and application of new technologies, that have contributed significantly to increasing food supply services, timber and fiber.

Deforestation and forest degradation affect 8.5% of world forests; half of these areas are located in South America. Deforestation and forest degradation were more intense in the case of inter tropical area, although limited data on boreal forests creates difficulties on some global comparisons. About 10% of arid and desert lands of the world are considered degraded; most of these areas are located in Asia. Planted areas are 30% of the land.

For marine ecosystems and their services, the most important direct determinant from the last fifty years has been fishing. Improved fishing technology has made possible the extraction of a considerable marine fish biomass from the marine ecosystem. By some estimates of FAO, mankind has reached the maximum level of biomass that can be extracted without producing significant changes in the ecosystem. For example, in the Gulf of Thailand, there are no animals located on the upper tropic levels; the system is dominated by lower consumers. Research conducted in West Africa and North Atlantic show similar changes. FAO estimates that about half of the monitored fish stocks are exploited at maximum capacity and there is no possibility of increasing catches.

For freshwater ecosystems and their services, depending of region, the most important direct determinants from the last fifty years are the hydrological regime change, invasive species and pollution, particularly nutrient loading? The introduction of invasive exotic species is one of the most important causes of extinction of species in freshwater ecosystems. For example, estuarine waters of North America are strongly invaded by crustaceans and clams; their distribution is largely superimposed on commercial routes.

In the last four decades, excessive loading of nutrients has been shown as one of the strongest determinants of terrestrial, freshwater and sea ecosystems' change. Synthetic production of nitrogen fertilizers is the main determinant of increased food production. Application of nitrogen fertilizers has increased five times since 1960, but yield active substance used by cultivated plants is only 50%, so that half of mobile nitrogen reaches the river system.

Excessive loading of nutrients can cause algae flourishing, diminishing water resources and freshwater eutrophication, reduced oxygenation of coastal ecosystems, emissions of nitrous oxide, which is one of the greenhouse gases and pollution by urban emissions of nitrogen oxides.

Improving nutrient use efficiency can be achieved by technologies that provide greater congruence between crop requirements and the provision of different sources, without reducing farmers' incomes.

Many of ecosystem services is reduced when inland and coastal eutrophication.wwater from the eutrophic lakes is higher treatment costs. In this water fish species frequency decreases with higher commercial value and their use of non-extractable by tourism can decrease dramatically. Smell of decaying algae and the presence of toxins released by blue-green algae turns one of the biggest attractions - the surface

of the water - a factor of rejection. Climate change produced in the last century already has a measurable impact on ecosystems. This emphasize the global average temperature has increased by about 0.6 degrees Fahrenheit, changing rainfall distribution in territorial and annual sea levels rise by 0.1 to 0.2 meters and reduce the area covered with ice. In 2010 there were several temperature records. Among these mention that March and May had the highest average temperatures in the history of global monitoring.

Projections for global mean temperature evolution shows that this will increase from 1.4 to 5.8 degrees Celsius by 2100. Changes in rainfall will increase aridity regions already characterized by hydric deficit in this category and will pass new regions, especially in the Mediterranean and temperate area. Also, there will be increases in frequency and intensity of rainfall in other regions. In summary, in point of hydrological climate change can be described as follows: arid regions will become drier and wet regions rainfall will increase. These climate changes will also lead to increased surface geomorphological processes (erosion, landslides, mud leak, etc.). With extreme social implications. Ecological effects of climate change have been identified in certain regions. They appreciate the changes in the distribution of species, livestock populations, highlights the reproductive cycle and migration, the frequency of occurrence of pests and diseases in forest ecosystems.

Biological invasions are another determinant directly affecting ecosystems. The movement of species due to human activity led to a major alteration of the distribution of species (*e.g. container transport, water ballast, air traffic, agriculture and aquaculture*). In some ecosystems, exotic species invasion led to the extinction of native species. For example, the U.S. invasion of exotic species of plants, animals and microbes is considered responsible for reducing 42% of native species on the “red” list. The changed ecosystem services due to biological invasions are affecting particularly agriculture, fisheries and aquaculture, forestry and grazing capacity. On the other hand, exotic species can bring benefits by increasing food production potential.

4 The interaction between determinants

Changing ecosystem services is almost always caused by multiple determinants, which interact with one another. In addition, changes in ecosystem services can have a feedback effect, in turn influencing determinants characteristics. Among these we can mention the formation of new opportunities and constraints for land use, institutional changes in response to perceived and anticipated resource degradation. In fact, it is unrealistic to believe that there is the possibility of building a single conceptual model to capture all these influences. For example, deforestation in humid tropical regions is the result of combined effect of factors such as timber harvesting, cultivating permanent breeding and expanding transport infrastructure. The situation differs strongly from one geographical region to another (as seen in Table 2).

Table No. 2. Differentiation key determinants of deforestation in tropical wet regions

REGION	KEY DETERMINANT
South- East Asia	Extensive agriculture
Amazon Basin	Road Building
South America – wet meadows	Pasture
Africa	Firewood, subsistence agriculture

Source: MEA (2005) Ecosystems and Human Well-being: Current State and Trends, Island Press, pp.76.

Regional differences are due to different combination of economic, institutional, technological, cultural and demographic factors, which determine immediate causes of deforestation. Urbanization provides another illustration of the interactions. Although only about 2% of the land covered by buildings, effects on ecosystems are very large cities and experience on larger areas. Three urban change processes appear to be relevant to the changing ecosystem services: urban population growth (urbanization), increase built area (urban growth) and the spread of urban functions in peri-urban areas and linked to it, reducing urban-rural differentiation in terms of population density, price of land (urban sprawl).

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