IMPACT OF HUMANITY ON TROPICAL ECOSYSTEMS: AN OVERVIEW

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Contents

Summary

The relation between humans and environment has undergone many changes over time, evolving from a harmonious coexistence to an unreasonable and irresponsible exploitation of natural resources. This new Era, which began with the Industrial Revolution, resulted in negative impacts of large magnitude. Several human activities, including mechanized agriculture and urbanization, triggered off an intense environmental degradation throughout the world. The consequences of this process are well known. Climate change, global warming and extinction of species are themes that became part of our routine. In this introductory chapter, we discuss the main differences between natural and human ecosystems, the stages of human-environment relations, the main consequences of the accelerated growth of human population, cases of natural and human negative impacts, the main instruments used for evaluation of these impacts, the most significant environmental impacts caused by humans in tropical ecosystems, with emphasis on the effects of agriculture in the Cerrado Biome and the deforestation in the Amazon. We also present the main causes and mechanisms of human negative impacts on the environment and the latest strategies for the conservation of tropical ecosystems, evaluating the perspectives for the twenty-first century.

1. Introduction

Since remote times, human species changed the environment to meet their needs. At first, humans had a harmonious relationship with nature, showing an integration that can still be seen today in various primitive communities. But, with the development of pastoral farming practices, this interaction began to drift. The advent of agriculture marked the beginning of a more intense control of humans over nature. Then, the first artificial ecosystems were created. For many authors, it is a process with no return, which was driven by the Industrial Revolution in the mid eighteenth century. From the invention of new machines and techniques, the introduction of the molten steel and the creation of the steam, humans started to exploit natural resources in an unreasonable way and transformed nature into property and possessions. The process of domination has just started and would become common with the consolidation of capitalism. The way of life of modern humans began to require increasingly large amounts of natural resources for energy generation and for obtaining raw materials, essential to the maintenance of a dominant production system. The increase of production, accumulation of goods, generation of comfort and modernization have established themselves as the main targets of economic models and development. Thus, the socio-economic advancement of our society tends to be directly proportional to the length and depth of environmental impacts. The environmental degradation is now seen as a necessary damage associated with human presence. In fact, human activities have generated alterations of such magnitude that ecosystems are giving signs of exhaustion. The Earth is showing its limits and, why not say, its spirit of revenge. Climate change, global warming, greenhouse effect, desertification processes are just some of the many examples of the consequences of bad attitudes of humans towards the environment. All human societies, including those that have reached the highest levels of technological development (*e.g.* USA, Canada, Japan), are based on natural resources, known as the key means. These means include sources of energy (*e.g.* sunlight and fossil fuels), minerals, soil and living matter (from bacteria to plants and animals). However, every environment has a support capacity and it does not have an inexhaustible source of resources. Most of the necessary resources for the maintenance of our way of life consist of non-renewable resources, which are not regenerated (or have very slow regeneration). In view of this, few people or groups demonstrate a real concern with preserving the environment. Many people feel as if they are above all the natural laws, perhaps without realizing the fact that humans are and will always be just another species among all others in the biosphere. And as such, humans are interdependent on all parts that constitute this global system. It is also true that we do not have full perception about our real role in the structure and functioning of different aquatic and terrestrial ecosystems, but we have to assume our responsibilities to ensure the integrity of them. No other species has the capacity we have to modify the environment and to interfere in the destiny of the planet. The question is: Will we really accept this condition and promote actions that ensure the sustainability of life on Earth? Or will we continue to pretend not to understand what is going on, simply living with the alarming loss of biodiversity and the intense global change, as if it has nothing to do with us? It is for time to decide. Our survival as a species depends on this understanding and depends on the relations that we will establish with the environment.

2. Ecosystems

The term "*ecosystem*" was proposed by Tansley, in 1935, although, the idea around that

concept is far more ancient, and it is confused with other terms such as *biocoenosis* and *microcosm*. We can define an ecosystem as a functional ecological unit, including the community of a given area, its interactions with the physical and chemical environment (inorganic substances, organic compounds and environmental factors such as temperature and humidity), which produce well-defined biotic structures, by the flux of energy and cycling of materials between the living (biotic) and non-living (abiotic) components. Thus, ecosystems represent complex biosystems that may include up to millions of species interacting with each other and with the environment in which they live. These systems are open and energy flows in only one direction. It means that energy is processed, stored and released under control, but never reused in an ecosystem. On the other hand, nutrients (*e.g.* nitrogen, carbon, phosphorus) are recycled and can be reused several times. Another common feature of ecosystems is the existence of two trophic strata: 1. autotrophic (*i.e.*, self-feeder), in which complex organic substances (*e.g.* carbohydrates and proteins) are produced from simple inorganic substances (*e.g.* water, carbon dioxide and nitrogen), mainly through photosynthesis (but also by chemosynthesis); 2. heterotrophic (*i.e.*, powered by another), in which predominate use, rearrangement and decomposition of materials. Often, the physical limits of an ecosystem are not clearly defined, but the trading of energy and matter within an ecosystem will always be more intense than those found between an ecosystem and another. Both natural and human ecosystems (anthropic) are subject to the same laws and procedures that control the flow of energy, cycling of nutrients and interactions between species.

Natural ecosystems include terrestrial and aquatic ecosystems (freshwater and marine). Although there is no definitive classification for them, both energetic and physiognomic aspects can be used for this purpose. Terrestrial ecosystems, in particular, are largely classified as the type of climax vegetation. This indicates that the characteristic plant covering of a terrestrial ecosystem is the key to its recognition. Thus, we can identify ecosystems as forests, savannas, fields and deserts, among others. This phytophysiognomic approach can be applied for the identification of terrestrial biomes, which are intrinsically linked to the climatic distribution on the planet. In terms of aquatic ecosystems, we can identify different types of freshwater ecosystems: *lentic* ecosystems (*e.g.* lakes), *lotic* ecosystems (*e.g.* rivers) and *flooded* ecosystems (*e.g.* swamps and marshes) and also several types of *marine* ecosystems (*e.g.* reefs, estuaries, etc.). Terrestrial and aquatic ecosystems have the same basic components: an energy source, water, soil and / or sediment, nutrients and autotrophic and heterotrophic organisms, all in constant interaction. The differences between natural ecosystems are expressed in the composition of species that form the biotic component (structure), in the efficiency of recycling and in the scales of time and magnitude that nutrients are imported or exported from each system (operation). For example, comparative studies show that the time for restoration (biomass / net primary production) of matter is much lower in sea, in comparison to a forest (on the scale of days for the first and years for the second). But these differences are not limited to divergences between aquatic and terrestrial ecosystems. By comparing a tropical rainforest with a temperate forest, we will find that the first one accumulates less biomass of vegetation in the litter than the second one, (at least 10 times less), which shows a highest rate of decomposition in the tropics and the heavy dependence that tropical forests have on their own living biomass. In fact, only 25% of organic carbon of tropical forests is present in soil and litter.

Human ecosystems are those that include our species, all other living species, the physico-quimical environment that interacts with us in a same place, and its products and emerging properties. The human ecosystems can be distinguished from the natural ones by the following characteristics: 1. its functioning is controlled mainly by socio-economic and political factors, 2. their stability depends on the continuous input of resources (water, energy, machines, among others) and 3. changes in their balance are determined primarily by socio-cultural phenomena. These ecosystems are easily recognized and include two types of environments: an urban-industrial, represented by urban ecosystems (*e.g.* towns and cities) and a rural-agricultural, defined by agroecosystems or agricultural ecosystems (*e.g.* farms). In both cases, the main characteristic is the intense modification of natural environments. According to estimates and projections of the United Nations, from 2005, in a few decades, about 60% of the global populations will live in cities, which occupy space, both for maintenance of its architecture, as for the establishment of a dynamic movement of goods and services. Moreover, it must be considered that no urban-industrial environment is able to meet all their needs, which also requires the modification of the closest areas to obtain resources, mainly food. Pastoral farming and agricultural areas overlap the original vegetation cover, dominating the landscape. Thus, the natural ecosystem is replaced by both urban-industrial and rural-agricultural environment, especially through deforestation and burning, producing extremely harmful effects on the natural populations.

2.1. Tropical Ecosystems

Tropical ecosystems include a wide range of natural terrestrial ecosystems (tropical rainforests, tropical seasonal forests, caatingas (bushes), savannas, deserts) and aquatic ecosystems (rivers, lakes, estuaries and wetlands), distributed between the Tropic of Cancer (23° 28' N) and the Tropic of Capricorn (23° 28' S). About land, there are almost 50 million km^2, comprising much of Africa and significant portions of the Americas (mainly the South and Central America), and also include parts of Asia (Southeast Asia), Australia (north of the country) and some islands of Oceania. The tropical region is characterized by high averages of temperature and annual rainfall (cold winters are not observed) and includes the environments with highest productivity and diversity of the Earth.

Among terrestrial ecosystems, there are the tropical forests and savannas. Tropical rainforests (or wet) occupy areas of low altitude near the Equator, mainly in the basins of the Amazon and Orinoco rivers (South and Central America), Congo, Niger and Zambezi (Africa), and in parts of India, Malaysia, Borneo and New Guinea. The average rainfall is over 2,000 - 2,250 mm per year, and the annual average temperature usually exceeds 18º C, with the variation between winter and summer lower than the variation between day and night. The tropical rainforest is highly stratified, with tall trees up to 40 meters, known as emerging. They project themselves above the canopy, formed 25-30 meters above the soil, overriding the intermediary strata of forest. This architecture shows the great structural complexity of rainforests. The combination of several factors, including spatial heterogeneity, climatic stability and high productivity, makes the diversity of species in tropical rainforests extraordinarily high. In a few

hectares of tropical rainforest, as the Amazon, it can be found more plant species than in the whole of Europe. It is estimated that there may be more than 6 million species of insects only in this ecosystem. Another remarkable forest formation is the tropical seasonal forest, which also occurs in humid tropical climate, but is characterized by strong seasonality. There is a marked dry season, in which the trees lose totally or in part, their leaves, giving them the same aspect of deciduous temperate forests. They are found in many parts of the planet, for example on the monsoon forests of Asia and the tropical seasonal forest in Panama. The structure of tropical seasonal forests is similar to tropical rainforests. In turn, tropical savannas occupy areas of Africa, Asia, South America (where they are known as cerrado) and Australia, with annual rainfall of 1,000 - 1,500 mm, but with one (or two) strong(s) drought(s) period(s) in which fire represents an important parameter of population dynamics. The plant physiognomy is quite varied, including opened areas, savannas and forests and is characterized mainly by the occurrence of trees with twisted trunks, adapted to fire. The species richness found in tropical forests and savannas is extremely different from other terrestrial ecosystems (or biomes).

Among the aquatic ecosystems, there are the coral reefs, calcareous structures that occur in tropical clear waters clear (from surface up to about 60 m in depth) and that are inhabited by a great diversity of species. In fact, of coral reefs remain at least 25% of marine life, but occupy less than 1% of the surface of the oceans. It means an extraordinary richness, even compared to that observed in tropical forests. By comparison, the coral reefs remain 32 animal phyla against only 9 in tropical forests. The minimum temperature of the water needed for the formation of reefs is 20° C. Thus, the greatest diversity of these ecosystems is found between the parallels 30° N and 30° S (with rare exceptions, as the Bermuda reefs), mainly in the Caribbean Sea in the Indian Ocean and in the South Pacific. It is estimated that coral reefs cover about 284,300 km^2, with over 90% of them found in the Indo-Pacific region (Red Sea, Indian Ocean, Southeast Asia and the Pacific). The sparse distribution of coral reefs in the South Atlantic, probably is due to higher turbidity of water in this oceanic region, resulting from the launch of fresh water from major rivers like the Amazon. Coral reefs may be structurally classified into three types: fringe reefs, patch reefs and atoll. The first type is the most common throughout the world and can reach thousands of miles in extension, such as the Great Barrier Reefs, which extends for more than 1,600 km along the coast of tropical Pacific in Australia (Australian Northeast). The second type refers to small circular reefs or irregular reefs typical of lagoons. The last one is associated with undersea volcanoes and is usually circular or oval with a central lagoon and islands along the circle. Only in Inso-Pacific, there are more than 300 atolls, as the famous Bikini Atoll. The calcareous base of reefs is produced over thousands of years, by the action of several animal species, in special some coral species of Anthozoa (Cnidaria). Over the substrate, an entire food chain is established, based on the productivity of green algae associated with the corals (Zooxanthellae). This ensures a primary production equivalent to that found in tropical forests (20,000 $Kcal/m^2/year$) and support an enormous biodiversity, including small marine invertebrates (poriferans, mollusks, arthropods, etc.) and large vertebrates such as sharks and marine mammals. With tropical forests, coral reefs are some of the prior areas for conservation throughout the world.

3. Relationships between Humans and Natural Ecosystems

The relationship between humans and environment can be analyzed from the transformation of natural ecosystems in human ecosystems, according to the levels of interference on the environment, in different historical moments. It was proposed that human-environment relations can be viewed from different stages of development, known as anthropoeras. In the early stages - Collecting and Hunting and Fishing Activities - relations between humans and the environment were characterized by the submission of humans to the environment. The activities of livelihood depended primarily on food resources not grown, so people were under the direct influence of the environment. The human populations were dependent on the natural rhythms and usually did both activities: collecting, fishing and hunting of wild animals. Humans invented and employed instruments to meet their needs, but, even when they played as predators, they promoted actions that caused no environmental disturbances. They developed a deep respect for nature, which is reflected in religious events and art strictly related to nature. Around 12,000 years ago, people lived under that condition and testimonies of that type of relationship are given by the cave inscriptions found many places around the world (*e.g.* Lascaux, France), but also by the artistic expression of many primitive people, including those people who remain in this stage of development. Between these societies we can point out some traditional cultures of African hunter-gatherer, the Australian Aborigines and various indigenous communities in the Amazon. In such stages the human impact on the environment is nil or negligible. The advent of grazing marked an important change in human-environment relations. The domain of influence of humans over nature was beginning. The pastoral farming activities involved the dependence on domesticated animals, which came to represent a source of controlled resources. The acclimation of new species of animals and plants has changed considerably our relationship with the environment. Tibetan pastors are modern examples of that category. In this activity, humans were not totally independent of nature but they started to give samples of their power, transforming large areas of forests and savannas into pastures. With the emergence of agriculture (fourth stage), around about 8,000 years ago, a key step was given in the evolution of human societies, marking the control of humans over nature.

Agriculture can be understood as the deliberate alteration of natural systems to promote the abundance of one or more selected plant species. Originally at least three groups of cereals were grown in different regions of the world: wheat and barley in the Near East, Europe and India, millet and rice in China, Southeast Asia and parts of Eurasia; and maize in Central and South Americas. The intensification of trade was one of the consequences of agriculture. But the most significant change was the fact that the size of the human population no longer be limited by obtaining food. Higher growth rates began to be sustained by the agricultural productivity, which in turn could be increased with the expansion of agricultural lands and the development of new techniques for planting. This made possible the establishment of bigger communities, leading to large human concentrations and some of our major civilizations. The agriculture caused profound change in the landscape, causing, in many cases, extensive degradation of ecosystems. The human impact was expanded to the whole planet. A new era started, represented by Industrialization and Urbanization, trademarks of modern societies. With the emergence of Industry, a new system of production was opened up, characterized by

the production of surpluses and wealth accumulation. Small workshops were replaced by large factories, requiring large volumes of raw material and generation of energy in large quantity. In this context, the impact on the nature assumed gigantic proportions, producing disruptions in the rhythm of natural processes. The consolidation of capitalism has increased the speed of natural resources exploitation. The relationships of domination and extraction were followed by accelerating deterioration of the environment. The contradiction between ecology and economy has just begun, with the widespread of environmental problems that do not affect individual countries anymore (especially since the 1980s). The socio-environmental conflicts have increased throughout the world and humans began to revise their attitudes, to seriously consider the need of a return to the harmonious relations that they already held one day with nature.

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