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What Factors Influence the Life on Earth?

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Introduction

Ever since humans appeared and spread across the Earth some 50,000 years ago, they have been constantly on the move. It is worth reviewing the major stages in the evolution of human transportation and the impact these have had on our environment. Initially, a foraging lifestyle prevailed; later, hunting and fishing became the primary modes of subsistence, with travel conducted on foot. By this time, fire was already being used, resulting in localized environmental impacts.

Major changes occurred with the advent of agricultural production—involving the creation of cultivated lands—and the domestication and utilization of free-roaming animals (horses, donkeys, camels, cattle, elephants, dogs, reindeer, etc.) for labor 8,000-10,000 years ago. Harnessing animal traction represented a significant advancement. It was during this period that the environmental burden associated with agriculture began.

Rudimentary forms of water transport may have existed as early as eight to ten thousand years ago; boats were constructed in Egypt, for instance. The Phoenicians were master shipbuilders, utilizing timber from their own forests. With the adoption of sails, maritime transport continued to evolve, though this also led to increased pollution of the aquatic environment.

In Egypt, stone roads were constructed as early as 4,500 years ago during the reign of Pharaoh Khufu—a significant advancement—though initially, only sliding transport (or "sledding") was known, a method also used to build the pyramids.

The concept of rotational motion and the significance of the wheel were discovered in Mesopotamia only about 3,500 years ago, where the first wheeled vehicles were produced. This discovery revolutionized the field of transportation. Later, the Roman Empire developed an advanced road network, traces of which can still be found today. Paved roads not only facilitated travel but also had a degrading impact on the environment. Scheduled, horse-drawn mail coaches appeared in France in the 15th century, marking the beginning of organized public transport.

Thanks to the growth of scientific and technical knowledge, transportation underwent tremendous development during the 19th century. The first car powered by an internal combustion engine was built by Karl Friedrich Benz in Germany in 1886. This marked a major revolution in human transportation and signaled the decline of animal-based traction. From that point on, fossil energy sources (petroleum, coal, followed by gas and eventually electricity) took center stage; in other words, the era

of motorization—with all its associated harmful effects—began.

Regarding other sectors of transport, aviation took off with the Wright brothers' (Orville and Wilbur Wright) successful first flight in North America in 1903. The first civil aircraft to carry passengers on a regular basis took flight in the USA in 1914, and air travel has contributed to increasing air pollution ever since. Following Richard Trevithick's 1804 steam locomotive prototype in England, George Stephenson perfected the railway locomotive and opened the first public railway line in England in 1825. The widespread adoption of steam locomotives and their polluting impact are well documented. Steam-powered shipping began to develop following Robert Fulton's successful American steamboat in 1807, leading to widespread water pollution.

Specification	***Years*** ***Mass and average heat value of fuels; Quantity of CO_2 liberated from them***							
	1860	***1935+37***	***1958***	***1980***	***2000+05***	***2009+14***	***2017***	***2024***
Oil × 10^6t	1	279,5	809,8	3059	3590	4117	4365	5272
40,5 MJ/kg	$4,05\times10^{10}$	$1,13\times10^{13}$	$3,27\times10^{13}$	$1,23\times10^{14}$	$1,45\times10^{14}$	$1,66\times10^{14}$		
CO_2 m^3	$3,17\times10^{9}$	$8,86\times10^{11}$	$2,56\times10^{12}$	$9,69\times10^{12}$	$1,13\times10^{13}$	$1,3\times10^{13}$		
Coal **× 10^6**t	136	1280	1762	2805	5878	7823	7549	9150
20,35 MJ/kg	$2,76\times10^{12}$	$2,6\times10^{13}$	$3,58\times10^{13}$	$5,7\times10^{13}$	$1,18\times10^{14}$	$1,59\times10^{14}$		
CO_2 m^3	$3,12\times10^{11}$	$2,92\times10^{12}$	$4,05\times10^{12}$	$6,45\times10^{12}$	$1,37\times10^{13}$	$1,72\times10^{13}$		
Gas **× 10^9** m^3	-	71	400	1531	2778	3479	3768	4124
37 MJ/kg	-	$2,62\times10^{12}$	$1,48\times10^{13}$	$5,66\times10^{13}$	$1,02\times10^{14}$	$1,28\times10^{14}$		
CO_2 m^3	-	$1,37\times10^{11}$	$7,72\times10^{11}$	$2,95\times10^{12}$	$5,36\times10^{12}$	$6,72\times10^{12}$		
All together								
MJ/kg	$2,8\times10^{12}$	$3,99\times10^{13}$	$8,33\times10^{13}$	$1,8\times10^{14}$	$3,66\times10^{14}$	$4,53\times10^{14}$		
CO_2m^3	$3,15\times10^{11}$	$3,94\times10^{12}$	$7,38\times10^{12}$	$1,9\times10^{13}$	$3,01\times10^{13}$	$3,69\times10^{13}$		

Table 1: Data to the circlation of substances and energy on the World.

Table 1. illustrates the trends in the combined fossil energy consumption not only of the transport sector but of human society as a whole (industry, agriculture, households, the military, etc.) over the past few decades.

Werner von Siemens launched modern, eco-friendly urban public transport in Germany in 1881 by putting the first electric tram into service, followed by electric railway transport in 1899. From that point on, the importance of electricity in transport grew, while the role of coal and oil declined. High-speed rail transport (250 km/ or higher) began in Japan in 1964 with the Shinkansen train—envisioned by Hideo Shima—and its associated infrastructure; but the latter does not blend harmoniously with the natural landscape.

The next major leap was space travel. In 1961, Yuri Gagarin and his spacecraft from the Soviet Union reached outer space, and in 1969, humanity arrived at the Moon for the first time through American astronauts Neil Armstrong and Buzz Aldrin, thereby ushering in the era of space travel—while simultaneously increasing pollution in outer space.

As for the details, following the advent of Benz's motor vehicle, the number of cars stood at 9,504 in 1900, 1 million in 1910, 10 million in the early 1950s, and 60 million by 2010. A summary of production figures indicates that a total of 2.7 billion vehicles were manufactured over the 144-year period between 1886 and 2014. However, according to data from the International Organization of Motor Vehicle Manufacturers, a total of 96.4 million motor vehicles were produced worldwide in 2025 alone, representing an increase of approximately 4% compared to 2024. Of these, 71.3 million were passenger cars, while the remainder were commercial vehicles. Currently, 95% of vehicles run on gasoline or diesel and emit CO_2, CO, nitrogen oxides (NOx), hydrocarbons (CmHn), aldehydes (R-CHO), H_2O, additives, carcinogenic substances, and soot. Road vehicles worldwide currently consume approximately 1.45-1.50 trillion liters of fuel annually, accounting for about 45-50% of total crude oil production (see Table 1). The remaining crude oil serves other societal

purposes, such as the chemical industry and the others. Regarding the thermal energy released during fuel consumption: given that the average calorific value of a liter of gasoline is approximately 31-32 MJ/l and that of diesel is 35-36 MJ/l, these figures convert to roughly 8-9 kWh/l and 9-10 kWh/l of electrical energy, respectively. This means that the total thermal energy generated by all vehicles can be expressed in kWh by a number approximately ten times larger than the consumption figure—1.45-1.50 trillion—expressed in liters. This thermal energy may also play a role in climate change.

Following the Wright brothers' first successful flight, the first civil aircraft carrying passengers took off in the USA in 1914. In 2013, 3.1 billion passengers were transported on 37.4 million flights by 25,332 aircraft. In 2024, the total number of passengers (domestic and international) exceeded 9.5 billion. Global demand, measured in passenger-kilometers, increased by 10.4% compared to 2023. Based on the combined number of domestic and international departing and arriving passengers, the ranking of countries is as follows: USA 876 million; China 741 million; United Kingdom 261 million; Spain 241 million; and India 211 million passengers. A total of 60.8 million tonnes of cargo was also transported in 2024. Aviation consumed approximately 375-405 billion liters of jet fuel in 2024 and emitted significant quantities of CO_2, CO, NOx (burning 1 liter of jet fuel produces 11.8 g of NOx), H_2O, and various nanoparticles. The visible manifestation of these combustion products being released into the atmosphere is the contrail. Regarding the amount of thermal energy released during aviation operations, if the average calorific value of one liter of jet fuel is approximately 34.5-38 MJ/liter, this energy content—when converted to electrical energy—amounts to approximately 8.8-10.5 kWh/l; in other words, the total heat energy produced can be expressed as a figure in kWh that is roughly ten times larger than the consumption figure in liters (375-405 billion).

Depending on the type and quality of the fuel, vehicle operation generates 2.3-2.68 kg of CO_2 per liter.

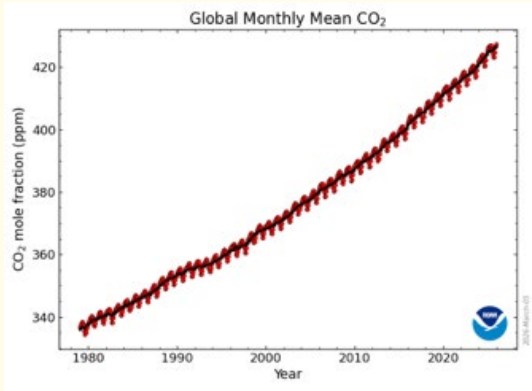


Figure 1: Concentration of CO_2 in the atmosphere by NOAA.

This means that 2.3-2.68 × 1.45-1.50 trillion liters of carbon dioxide are released into the atmosphere by road vehicles, and 2.3-2.68 × 375-405 billion liters by aircraft. In light of these data, the following graphs come as no surprise. Shown here is the increase in the atmospheric levels of the two most important greenhouse gases. Based on this, it can be concluded that transportation is one of the human activities that places the greatest burden on the environment—and this is without even considering the drastic impact of spaceflight, which affects the stratosphere, too.

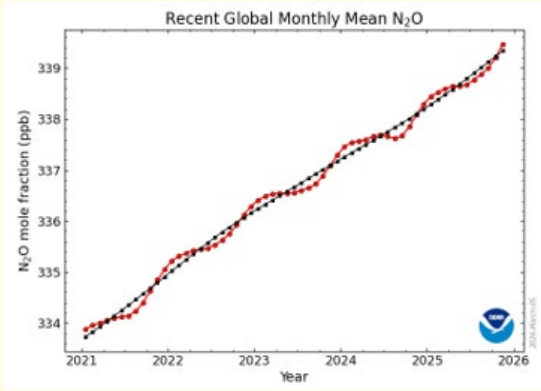


Figure 2: Atmospheric N_2O concentration based on NOAA measurements.

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